MANAGING 'DEMAND AMPLIFICATION' IN THE SUPPLY CHAIN: THE THAI FORWARDERS' EXPERIENCE

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ABSTRACT

'Demand Amplification' is a well-known phenomenon in the supply chain. The 'Beer Distribution Game' is the simulation model that is used to experiment and study amplitude of variation in a supply chain. The purpose of this paper is to verify the validity of the 'Demand Amplification' concept within the freight forwarding industry as well as to study how the industry copes with the problem of 'Demand Amplification'. Thai freight forwarders are taken as an illustrative case study. The finding shows that the concept is not unknown amongst the forwarders and that it is referred to as 'Customer Panic' or 'Delivery Demand'. The problem is dealt with on two levels in Thailand. The aggregate solution is through vertical integration of transport services with an active involvement in the Thai national Electronic Data Interchange (EDI) service provider, known as TradeSiam. A disaggregate solution is also provided through the use of emergency channels networks. Information flow in the supply chain must be maintained at all levels to minimise or prevent the effect of 'Demand Amplification'. Freight forwarders must be able to design supply chains that are flexible enough to absorb amplitude within the chain, while still providing high customer satisfaction.

Keywords:

Demand Amplification, Supply Chain Management, Freight Forwarders, Thailand, TIFFA, EDI, TradeSiam

1. INTRODUCTION:

The phenomenon of 'Demand Amplification' (or the Bullwhip Effect) in supply chains is widely recognised. A well-known demonstrator of this phenomenon is the MIT-developed 'Beer Distribution Game', which simulates the 'real world' by getting participants to game-play different echelon in a supply chain. It is widely claimed that this phenomenon does exist in the real world and that it causes considerable difficulties for companies in terms of increasing their total logistics costs.

The purpose of this paper is to examine the validity of the concept of 'Demand Amplification' within the freight forwarding industry as well as to assess the degree of success; freight forwarders have had in seeking to control or to cope with demand amplification in the supply chain.

Supply chain management is seen as the logistic discipline of the 1990s (Taylor, 1998). The logistics costs associated with the distribution of any product can account for a high proportion of its sale price. There is therefore potentially considerable scope for reduction in these costs, which in turn will be reflected in the price of a given product. This reduction cannot be implemented without complete control over the supply chain.

Supply chain management is an integrative approach for planning and controlling the material flow from suppliers to end-users (Carter & Ferrin, 1995). It is used as a technique to create and maintain a firm's competitive advantage. The management of inventory or raw materials is important to ensure not only that customer demands are met but also to prevent excess in stocks leading to high holding costs or losses through obsolescence. The goal of supply chain management is to meet customer service objectives while simultaneously minimising inventory and associated costs.

These customer service objectives are rarely fully met because of the individual behaviour of decision-makers in firms' when managing stocks. Their behaviour is neither optimal nor rational (Parnaby, 1979). Due to the dynamic nature of the supply chain, amplification and fluctuation occurs, from suppliers all the way down the chain. The interaction between material flows arising from demand, and the information flow arising from perception of future demand, has largely led to this amplification and instability in the supply chain. What is needed is a good control system to counteract any disturbances in the supply chain.

Freight forwarders, as transport service facilitators', play an important role in supply chain management. An increasing number of firms outsource their logistic function. These third parties logistic providers are now becoming more involved in the design and management of firms' supply-chains[1].

1.1 DEMAND AMPLIFICATION

As part of the manufacturing firm's logistic function, supply chain management is a central concern. It is very important for manufacturers to strategically manage and integrate their logistic function to be able to establish a competitive advantage (O'Neil & Iveson, 1991). The manufacturing firm's logistic function must integrate its behaviour with corporate strategies, marketing, production, and other business functions, if it is to be successful. The main purpose of this integration is to create value-added products and services that will satisfy customers' requirements. This competitive advantage is derived from, but not limited to, supply chain management.

The supply chain designer will have to take into account the transportation-inventory decisions jointly from an integrated logistic perspective (Tyworth, 1991). This integrated logistic perspective encompasses logistics trade-offs, where the task of the supply chain designer is to determine transportation alternative, manufacturing firm re-order level, and order size that will maximise the efficiency of the supply chain. These decisions are trade-offs moulded by external operational constraints. These trade-offs will then be reflected in the firm's stock management policy.

According to Sterman (1989), one of the most common dynamic decision-making tasks is stock management. In such a task, the manager will seek to maintain a certain stock quantity at a particular target level or at least within an acceptable range. Stocks are not controlled directly but rather 'managed' by changes in their inflow and

[1] *Managing the supply chain*, in; Lloyd's Shipping Economist, October 1998, pp. 8-9

outflow rates. The manager must set the inflow rate so as to compensate for losses and usage, and to counteract disturbances, which pushes the stock away from its desired state. Often there are time lags between the initiation of a control action and its effect. The duration of these lags may vary and may be influenced by the manager's own action.

Since the manager does not take into account the whole material flow within the supply chain, and only relies on local information, decisions made will create instability in stock orders and stock flows. This instability, which is symptomatic of irrational behaviour, leads to 'Demand Amplification'.

'Demand Amplification' is created by the misinterpretation of feedback by decision-makers in the supply chain. Managers, when making decisions, become insensitive to the presence of feedback from their decisions to the environment. They also often under estimate the time lag between action and response, and fail to account for activities in the whole supply chain (Sterman, 1989).

1.2 SIMULATION MODEL

Simulation models have been used to analyse situations that could exist in practice with regard to managing the supply chain. The possible inefficiencies that could occur in practice can be seen in the Beer Distribution Game simulation played at the

Sloan School of Management in the Massachusetts Institute of Technology (MIT) since the early 1960s.

This experiment is a simulation of inventory management operations in a brewery where the retailer, wholesaler, distributor, and the producer are the players in the supply chain.

It is shown that managers' perceptions do not match the actual material flows with the information flows. Managers do not take account of the time lag for previous orders that were already in the supply chain pipeline. When orders are placed and stocks are low, managers feel that they are under threat or in actual backlog, thus leading to higher orders. From an initial steady state, therefore, this leads, to 'Demand Amplification' that results in higher orders along the chain and higher stock build-up. Stocks are then building up to an excess or even unmanageable level as earlier orders are being delivered. This creates severe frustration among the various players in the game as all the player are blaming each other for the failure to manage the simulated supply chain.

The result of the experiment was that the subjects blamed external factors for this amplification when, in fact, the orders from the customers were actually constant. Almost every manufacturing firm experience the phenomenon observed in the Beer Distribution Game (Evans, Towill & Naim, 1995). The subjects argued that the amplitude of variations in the system was exogenously induced. But, during the debriefing, it was shown that the subjects never took into account the volume of goods that was already in the pipeline. This leads to an over-ordering, by the

subjects, that in turn creates instability in the supply chain. All the subjects involved in the Beer Distribution Game are in fact responsible for the 'Demand Amplification' that occurs in the Game's supply chain.

Berry and Towill (1995) said that internal fluctuations in stocks and production are greater, often considerably greater, than the external fluctuation in customer orders. They observed that there were similar behaviour patterns between actual managers, when managing 'real' stock, and the subjects in the Beer Distribution Game. The findings from the Beer Distribution Game were used to determine behaviour patterns in the real world, but in the real world managers have access to market information and are aware of external constraints. On the other hand, information in the real world is often out of date, contradictory, and ambiguous. Managers are struggling to balance competing demands on their time and must make many additional decisions besides the quantity of goods to be ordered. The typical response is not to recognise the true supply line situation. The adjustment of the order rate is based on pressure between the actual and desired level of stocks.

It is interesting to note that Whitbread has recognised the problem of 'Demand Amplification' and are currently looking to reorganise their supply chain by reducing the number of links/parties to a minimum. They aim is to directly link the retail outlets to the brewery, thus bypassing distributors and wholesalers.

1.3 FREIGHT FORWARDERS

The role of freight forwarders in the international supply chain has become more important in recent years as they have expanded and diversified their operations worldwide. Initially, freight forwarders were just agents for their clients without any control over their clients' supply chain. The advent of containerisation and information technology has led them to increase their responsibility toward supply chain management. Today, the vast majority of big freight forwarders are evolving into multimodal transport operators. It is their duty to make the supply chain competitive and to improve the efficiency of their clients' logistics function.

In theory, if a firm is able to provide a fully integrated logistics service, it will be able to effectively gain competitive advantage. This is due to the fact that the integrated firm will be able to control the sourcing process, the manufacturing or assembly process, and the distribution process. This can be done with the help of the freight forwarders. The challenge for the freight forwarding industry is to have a more co-operative relationship with their customers in order to maximise the information flow while trying to manage the material flow. The result will be, in theory, the avoidance of 'Demand Amplification'.

Adversarial relationships are suppose to be a thing of the past as the survival of all the players involved is based on strategic alliances which are sometimes called 'partnership sourcing' (Towill & Naim, 1993) with each player complementing the other in order to maintain competitive posture.

It is supposed to be a win-win situation for everyone but the pressure for freight forwarders to deliver is very high, as customers' requirements become ever more demanding. If the supply chain is an international one, mishaps will be dealt with less effectively due to the greater distance involved (Beresford, 1999). The freight forwarder will have to rely on his network of overseas agents who may be less capable and this may increase the effect of 'Demand Amplification'. This is because the overseas agent is best able to control the supply chain within his own national boundaries. The overseas agent also receives only a limited amount of information concerning the client's total supply chain needs.

2 THE THAI SOLUTION:

Thailand, which is an emerging country currently, facing a deep economic crisis, is taken as an illustrative case study:

2.1 BACKGROUND

The rapid expansion of Thailand's economy was in large part due to the growth in the country's exporting and importing sectors. Consequently, the freight forwarders in Thailand took on a more active and important role as their customers (both exporters and importers) integrated themselves into global supply chain networks.

Competition among those involved in the business became fiercer but the direction of this growth was haphazard. This was because there was a lack of regulation in the form of a controlling body to oversee the operation of the freight forwarding industry. As part of the strategy to regulate the industry, on March 10, 1987, the Thai International Freight Forwarder Association (TIFFA) was formally registered (TIFFA, 1993).

All of TIFFA's members are transport service providers and all play an essential role in the supply chain. They cater for the transport needs of their clients and they are usually the only transport service providers that deal directly with customers. Much of the services offered by Thai freight forwarders are common to any other forwarder

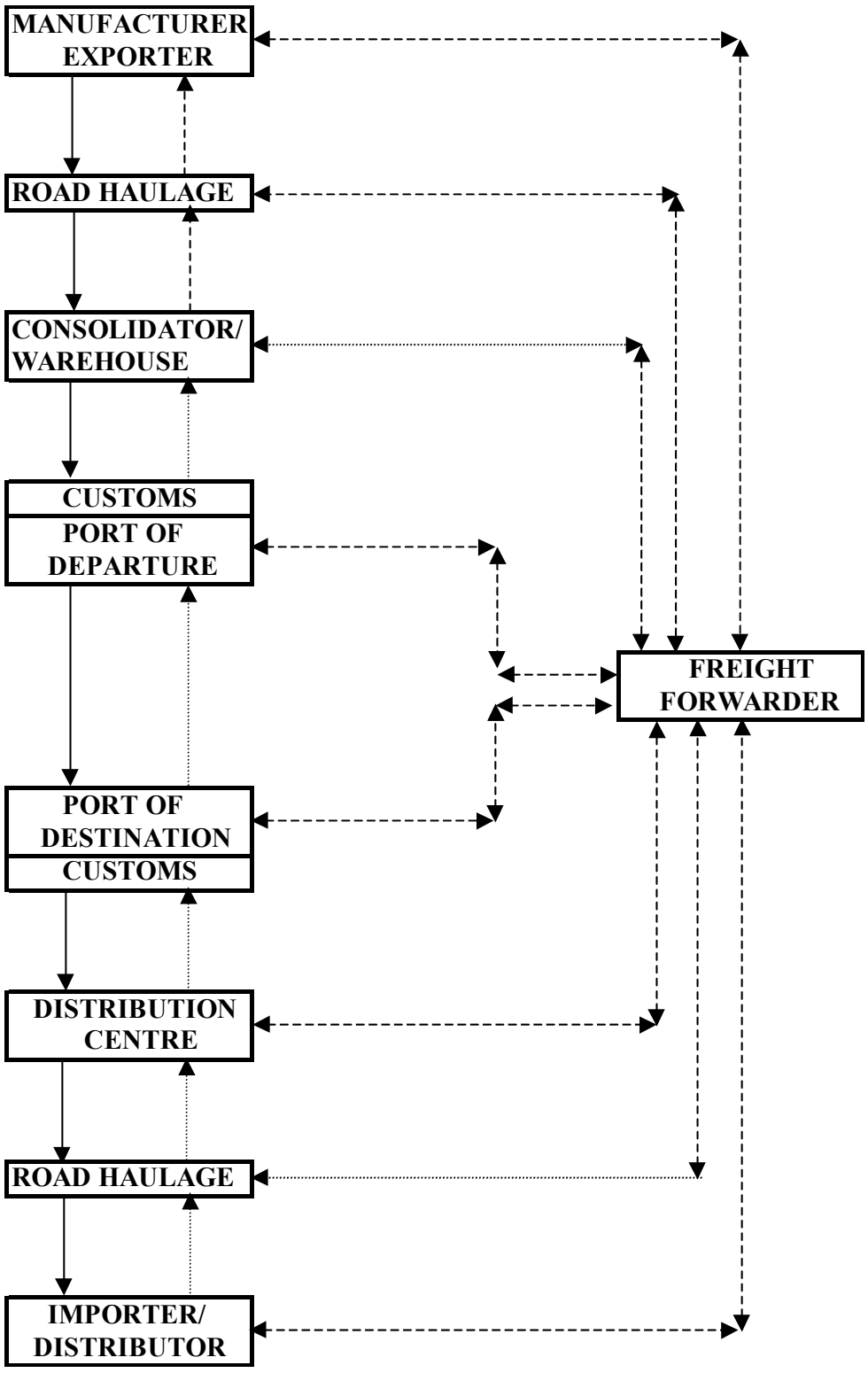
in any region of the world. Today, in the era of globalisation, Thai exporters are just a link in the international supply chain of Multinational Enterprises (MNEs). To be able to maintain their competitiveness, they must be able to have access to a sufficient supply of transport services.

The forwarders' duties are to provide the link to the next segment in the supply chain. As the distance between the manufacturer (i.e. the exporter) and the distributor or retailer is often quite considerable (and vice-versa for imports), there exist problems in both the material and information flows (TIFFA, 1996). The manufacturer has to respond as quickly as possible to the various requirements within the specified time frame. If he cannot, the MNE will probably choose another supplier. This creates a number of problems for the manufacturers, as not only do they have to manufacture the goods on time; they also need to deliver them on time. The problem of delivering the goods on time is a very crucial one when many MNEs are using just-in-time (JIT) management techniques. Forwarders can play a pivotal role in designing and providing an integrated supply chain that will respond to their customers' needs.

The forwarder's role is to deliver the goods on time but on many occasions, because of limited resources and various operational constraints, forwarders are not able to deliver and thus rendering their clients' non-competitive. The limited resources and operational constraints are not unique to Thai freight forwarder operations. In each region or country in the world various resource limitations and operational constraints exist. It is the duty of the forwarder to make the best use of his resources within the physical and non-physical framework of that region or country.

According to TIFFA, most Thai forwarders tend to respond reactively to surges in demand to their transport services and seem unable to forecast accurately these increases, especially seasonal cyclical variations. This is a very big problem, as a majority of Thai forwarders do not have their own transport. They rely on the services of various sub-contractors such as road hauliers, stevedores, consolidators, etc. to provide the physical aspect of the transport service (see Figure 1). Nevertheless, among ASEAN forwarders, Thai forwarders have a high reputation when it comes to solving operational problems.

Figure 1: Freight Forwarder's role in traditional segmented supply chain



Material Flow: ——→
Information Flow: ·····→ Supply chain control by Freight Forwarder ←·····→
Source: The Authors

This contracting-in means that in time of increase in demand for transport services, many forwarders will have to bid for the sub-contractors' services, but there are only a limited number of reliable sub-contractors. This is due to the fact that in Thailand, there is only seventeen authorised and licensed road hauliers that can transport cargo to and from the port of Bangkok.

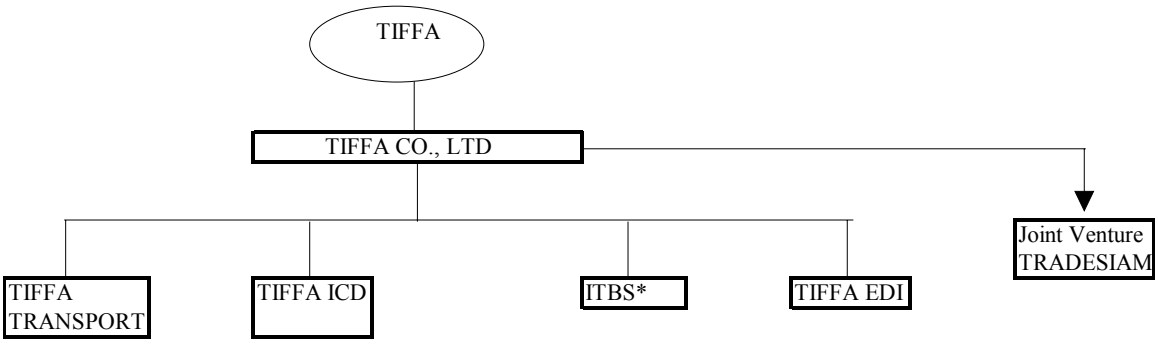
The term 'Demand Amplification' is unheard of by TIFFA's members but the concept is not unknown. It is more commonly referred to as 'Customer Panic' or 'Delivery Demand' as customers generally over-react or act in a 'panic' when transport services are in short supply. Sub-consciously, customers and freight forwarders are involving themselves in 'Demand Amplification'.

Thai forwarders have tried to secure their sub-contractors with long-term service contracts but this is often resisted, as the forwarders become committed to costs when they may not be able to fill the sub-contractors capacity. This increases in turn their overall operating costs, which will at the same time increase the forwarder's rates due to the extra burden of under-utilisation of sub-contractor's capacity.

2.2 TIFFA'S SOLUTION

TIFFA's members felt that there was a need to get tighter control of clients' supply chains and to protect themselves from the uncertainties of the freight market. The members of the association decided to set up a private limited company. The purpose of the company is to help its members to better control the transport chain, through strategic investment in various transport-related ventures, in order to offer the highest quality services possible to their clients (see Figure 2).

Figure 2: Organisation Chart of the TIFFA Group



ITBS: International Transport and Business School

Source: TIFFA

2.2.1 Inland Customs Clearance

The first aim of the TIFFA Company was to gain a concession to operate an Inland Clearance Depot (ICD) from the State Railways of Thailand (SRT) at Lad Krabang. The reason was that the Port Authorities of Thailand (PAT) had forbidden access of freight forwarders in all but one of the marshalling yards in Bangkok Port. This left them with no place to consolidate or stuff containers for their clients. It was a big problem, especially for smaller freight forwarders who did not have access to their own private warehouse. This policy has resulted in the overcrowding of the only available marshalling yard in Bangkok Port.

Lad Krabang is located on the outskirts of Bangkok and offers block train services to the deep-sea port of Laem Chabang. The ICDs at Lad Krabang were created to help relieve traffic congestion around Bangkok Port and also to deal with the port's problem of over-utilisation. The Lad Krabang ICDs complex is consistent with the Thai Government policy to shift cargo from Bangkok Port to Laem Chabang.

The ICD serves as a warehouse, marshalling yard, and consolidating location for all its members at a reduced privilege rate. Customs clearance is also carried out on the premises (Beresford & Dubey, 1990). With more than a hundred members' companies, this ICD acts as a buffer and helps in coping with the surges in demand for transport services, as this facility operates on a 24hour basis.

Even if the TIFFA ICD capacity is filled, the Lad Krabang Complex also offers 3 more privately owned ICDs. Exporters and forwarders will not have to worry about

finding or securing subcontractors for packaging, consolidating and haulage to Laem Chabang where the main shipping lines operate their around the world services. In spring 1998, TIFFA won the concession to operate the Lad Krabang ICD for a period of 10 years.

2.2.2 Road Haulage Services

Another purpose of the TIFFA Company is to operate a fleet of licensed trucks to serve their members when transporting customers' goods. In 1997, TIFFA was granted the licence to transport goods in and out of Bangkok Port under the name of 'TIFFA Transport'.

This licence is only given to companies with a minimum of 10 million baht[2] paid-up capital and a fleet of at least 100 trucks. With its licensed truck fleet, TIFFA's members do not have to bid or compete among themselves to secure the services of licensed trucking companies. They also do not have to invest in long term trucking contracts, as the trucks are made available to members on a priority basis and at competitive rates. If the truck fleet is not sufficient, then it will be the duty of 'TIFFA Transport' to broker-in additional capacity. Pooling the resources of TIFFA's members who operated road haulage services constituted the 'TIFFA Transport' fleet.

[2] 1£ is roughly equivalent to 60 baht, Spring 1999

2.2.3 TradeSiam

A third purpose of the TIFFA Company is to control the information flow between itself and its clients. This is done by:

1. Becoming a shareholder in TradeSiam, the national Electronic Data Interchange (EDI) service provider, as they have been able to influence trading methods, procedures, and policy concerning electronic commerce and EDI in Thailand.

Presently TIFFA company holds 6% of the shares. TradeSiam is a joint venture between certain governmental agencies and private sector investors (see Table 1). As the national EDI service provider, TradeSiam will provide services such as validation, split billing, security, and audit trails and message logs to satisfy legal requirements. This will enable TIFFA's members to benefit from EDI technology facilitating the continuous flow of information not only between the forwarder and his client but also to all related parties in Thailand concerned with international trade such as the Customs Department, the PAT, banks, insurance companies, carriers and so on (see Figure 3).

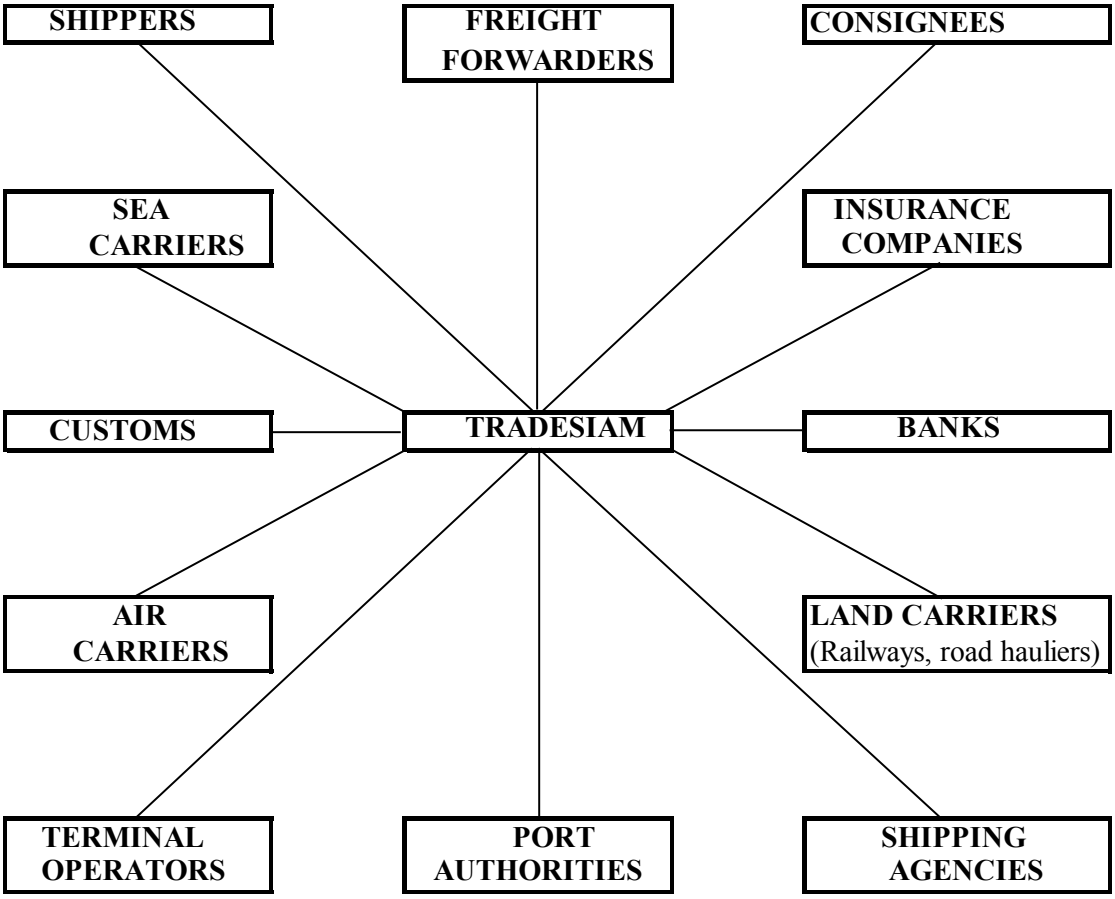
2. Setting up TIFFA EDI, a Value Added Network (VAN) provider with the purpose to implement an EDI pilot project at TIFFA ICD in Lad Krabang, in conjunction with TradeSiam.

Table 1: Shareholding structure of TradeSiam

The Ministry of	12%
The Ministry of	12%
The Ministry of	12%
The Ministry of Science, Technology &	13%
The Crown Property	6%
Thai International Freight Forwarder	6%
Bangkok's Shipowners	6%
The Federation of Thai	7%
The Thai Chamber of	7%
The Thai Banker	8%
The Thai Insurance	5%
	100%

Source: Banomyong (1997)

Figure 3: TradeSiam information network

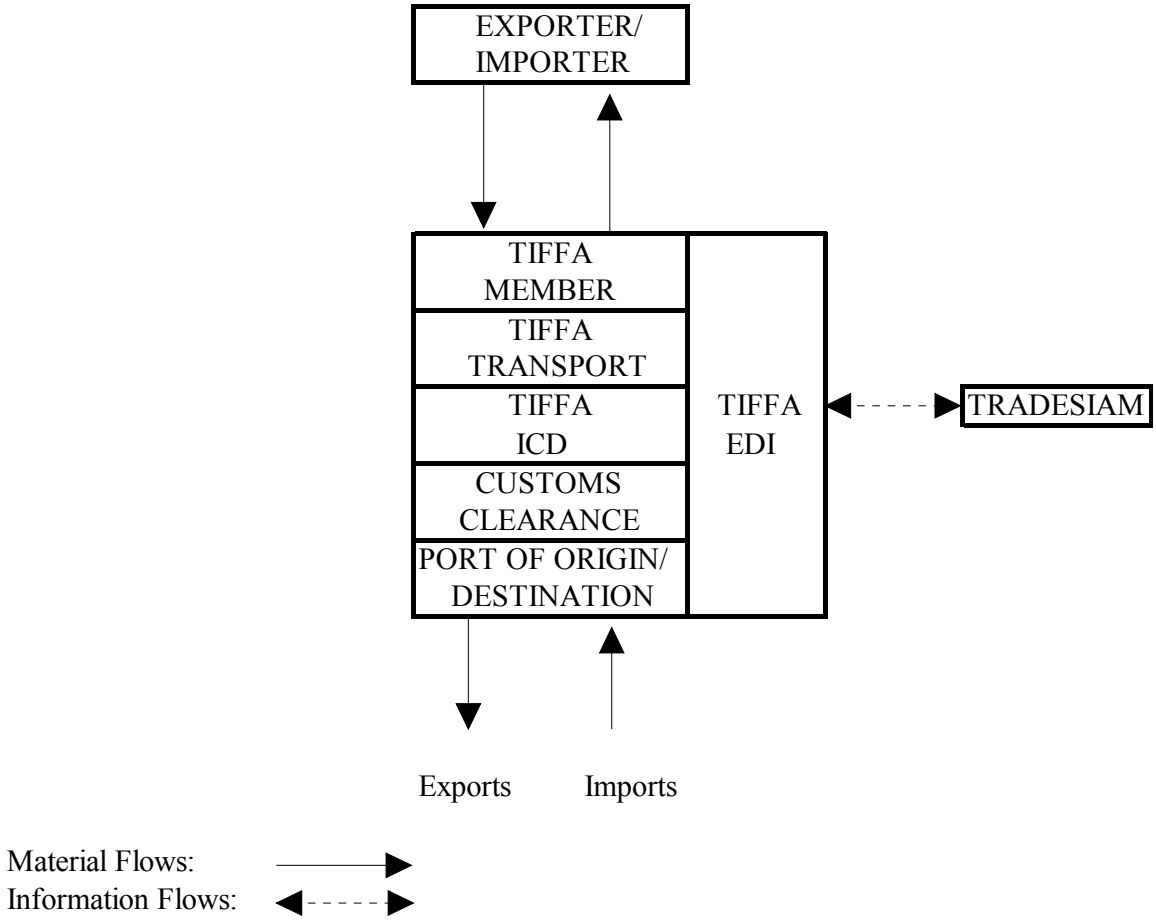


Source: The Authors

During the summer of 1997, TIFFA members decided that they needed to integrate their activities vertically so as to be able to cope with the various surges in demand for transport services. This integration may not be a direct result of 'Demand Amplification' as transport services are derived and may not be subject to the same effects as are manufacturing processes. Nonetheless, integration gives TIFFA a better control over clients' supply chains. The vertical integration is not a rigid one as the members are able to contract-in if the company's services are not fully competitive.

Nevertheless, by integrating the transport chain, the company is able to fulfil members' demand at the most competitive price. This demand is, of course, derived from the members' own customers demand which in turn is subject to the buyer's demand. TIFFA's members are now able to control not only the information flow, through TradeSiam, but also at the same time the material flow, through their own facilities at Lad Krabang ICD (see Figure 4). This is how Thai freight forwarders try to cope with 'Demand Amplification' or 'Customer Panic' in order to meet clients' expectations on an aggregate basis.

Figure 4: TIFFA integrated supply chain network



Source: The Authors

2.3 A DISAGGREGATED SOLUTION: EMERGENCY CHANNELS

As a transport service provider, the freight forwarder sees his function in the supply chain as a distributor. His role is to move the goods from one end of the supply chain to another within the constraints imposed by the clients and the commercial environment.

A situation of ‘Customer Panic’ or ‘Delivery Demand’ occurs when the client is faced with a difficult situation in his supply chain (such as stock-outs) and over-reacts in order to rectify the situation.

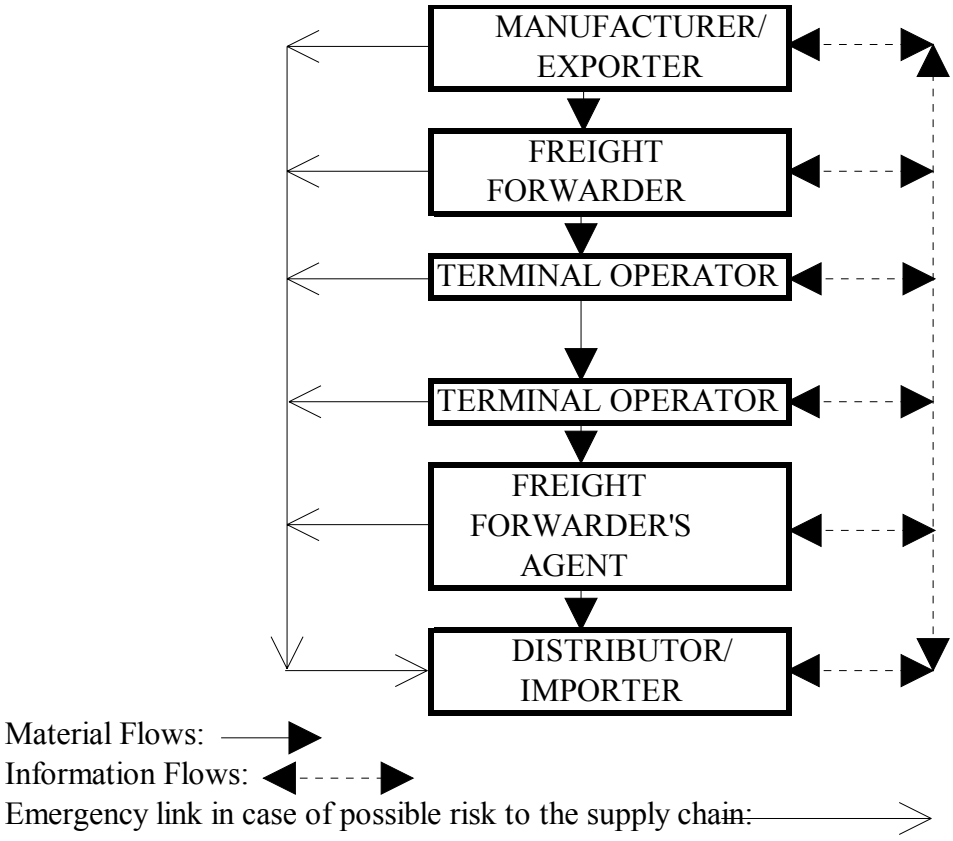
When a break in the supply chain occurs or is going to occur, there is a very strong risk that the whole supply chain will be immobilised, generally for a longer period that it took the break to occur. The analogy may be drawn with traffic jams along the motorway. Typically, it takes three times longer for a traffic jam to clear than it takes to build up.

When all the players in the supply chain are rendered non-operational, costs increase massively and major penalties are incurred. There is no choice left for all of the players involved, as they must be able to find someone who is able to solve the problem of immobilisation in the supply chain. That is the freight forwarders’ responsibility; they must be able to find solutions to the problem no matter the costs involved.

This can be done through the freight forwarder’s network of overseas agents to monitor foreign manufacturers so as to be able to have complete control over clients’ supply chains. The freight forwarder will act as a buffer by creating an emergency network, so that the goods will arrive on time, as requested. The role of ‘the emergency channel’ is to minimise the effect of ‘Customer Panic’ or ‘Demand Amplification’.

The only prerequisite for the freight forwarder to be able to activate his 'emergency channel' is that the freight forwarder or a member of his network must have the goods physically in their possession (see Figure 5).

Figure 5: Freight Forwarder's emergency channel solution



Source: The Authors

If the goods are not in the freight forwarders or his agent's possession, then it is almost impossible to find a solution. When the goods are "in their hands", a solution is feasible and can be worked out at the most reasonable cost to the client. The freight

forwarder's role is not only to organise the supply chain but also to service it. A freight forwarder can be described as an 'engineer' or 'architect' of the supply chain. They have to prevent 'Customer Panic' or 'Demand Amplification' whenever possible. This leads to a mixture of proactive and reactive measures. Proactive in the sense that the company must try to forecast what types of services the client will want for the future and reactive because the company is always faced with the unexpected.

The freight forwarder cannot be successful on his own; he has to rely not only on his agency network and sub-contractors but also on his clients. A close partnership has to be formed between the freight forwarder and the client. This in turn facilitates the creation of more realistic supply chain designs and modes of operation.

3. CONCLUSIONS:

Supply chain management is fundamental to transportation efficiency. The basic problem is how to attain a smooth flow of material at minimum cost, without being subject to the effect of 'Demand Amplification'.

In choosing a supplier for particular goods, the tendency is to choose the supplier with the minimum cost without really assessing his reliability or quality. With a large demand for a particular good, the result will likely be that the capacity of some suppliers or transport links is exceeded for some or much of the time thus creating the 'Demand Amplification' phenomenon. According to Wikner *et al* (1991), this is due to misperception of feedback by all the players involved in the supply chain.

To control the situation, various solutions have been suggested (Towill *et al*, 1991, 1993, 1995). Towill referred to 'partnership sourcing' to smooth the supply chain and he stressed the need of an 'integrated information' supply chain between all the players involved. This seems an appropriate solution but other factors need to be included in the control and monitoring of the supply chain.

The design of the supply chain needs to be analysed in term of trade-offs between transportation, inventory, and production costs. Within the supply chain all costs must be considered simultaneously without regard to how these costs are allocated as all have an impact on a given firm's competitiveness. Cost is just one aspect;

operational constraints will also determine the smooth flow of material and information and ultimately the quality of service provided.

Freight forwarders have played an increasing role in the management of supply chain. It is because of their operational expertise that the other players in the supply chain tend, in some cases, to rely more and more on them. This increase in responsibilities has led many forwarders, especially in TIFFA's members, to evolve into Multimodal Transport Operators where they can provide a one-stop door-to-door service to their clients with one price and one liability (UNCTAD, 1990), offering both the physical and the administrative capability.

The example of Thailand has been taken to illustrate how forwarders can maximise their information flows through EDI. The introduction of EDI networks worldwide and the explosion in the usage of the Internet have facilitated the expansion of information flows and improved both the speed and accuracy of information exchange.

With improved communication facilities, forwarders are now able to manage the supply chain 'on-line' and in 'real-time' for their clients. The forwarders' sub-contractors, who are in constant contact with the Mother Company (i.e. the 'principal' freight forwarder), are dealing with the physical aspect of the supply chain when the forwarder does not have the capacity.

Information flow is therefore maintained at all levels of the chain thus ensuring prompt response to any situation that might occur. This reduces the risk of 'Demand

Amplification' or 'Customer Panic'. Subject to operational constraints, if information flows freely along the chain, then the material flow will also be smooth.

This paper has looked into 'Demand Amplification' in the supply chain and how it is dealt with by freight forwarders. As the research method is purely qualitative, many shortcomings arose. It was not possible to quantify the cost of solving logistics problems or to independently validate the findings. However, this could be the object of future research.

Nevertheless, this paper provides and insight into the 'Demand Amplification' problem from a service provider's point of view. Freight forwarders are faced with the daunting prospect of balancing cost minimisation with customers' almost infinitely variable requirements. The outsourcing of the logistic function, and JIT management techniques, has forced forwarders to design more dynamic and efficient supply chains within various operational constraints. It is the physical aspect of the supply chain that will shape the supply chain dynamics.

In future studies, it would be profitable to examine how transport service providers are able to optimise their supply chain networks, taking account of shipment size, quantity and value as well as operational constraints such as finite vehicle capacity, drivers' hours limitations, speed limits and varying levels of traffic congestion.

Bibliography

- Banomyong R. (1997) *Country Overview: Thailand,* in: Banking on a Secure Payment System Freedom to Export and Use Encryption Algorithms and the Role of the trusted Third Party, Telecommunication Monograph, Wakefield (Ed), Wilde Sapte, London
- Beresford A.K.C. (1999) *Modelling Freight Transport Costs: A Case Study of the UK-Greece Corridor* in: International Journal of Logistics: Research and Applications, Vol.2, No.3, pp 229-246
- Beresford A.K.C. & Dubey RC (1990) *Handbook on the Management and Operations of Dry Ports*, UNCTAD, RDP/LDC/7, Geneva, Switzerland
- Berry D. & Towill DR (1995) *Reduce Costs-Use a More Intelligent Production and Inventory Planning Policy* in: BPICS Control, November, pp 26-30
- Blummenfeld DE, Burns L.D. & Diltz DJ (1985) *Analysing Trade-offs Between Transportation, Inventory and Production Costs on Freight Networks* in: Transportation Research, Vol. 19B, no. 5, pp 361-380
- Carter JR & Ferrin B.G. (1995) *The Impact of Transportation Costs on Supply Chain Management* in: Journal of Business Logistics, Vol. 16, no. 1, pp 189-212
- Cooper DR & Emory WC (1995) *Business Research Methods*, Irwin, Chicago
- ESCAP/UNDP (1993) *ESCAP/UNDP Manual on Electronic Data Interchange (EDI*), United Nations, New York
- Evans G.N., Towill DR & Naim M. (1995) *Business Process Re-engineering the Supply Chain* in: Production Planning & Control, Vol. 6, no. 3, pp 227-237
- Naim M. (1997) *The Book That Changed the World* in: Manufacturing Engineer, February, pp 13-16

- O'Neil B.F. & Iveson J.L. (1991) *Strategically Managing the Logistics Function* in: Logistics and Transportation Review, Vol. 27, no. 4, pp 359-373
- Parnaby J. (1979) *Concept of a Manufacturing System* in: International Journal of Production Research, Vol. 17, no. 2, pp 123-135
- Sterman J.D. (1989) *Modelling Managerial Behavior: Misperceptions of Feedback in a Dynamic Decision Making Experiment* in: Management Science, Vol. 35, no. 3, pp 321-339
- Taylor S. (1998) *Supply Chain Management - It's the Discipline of the 1990s* in: Freight Management International, January/February, pp13-14
- TIFFA (1993) *Freight Forwarding Handbook*, Cosmic, Bangkok
- TIFFA (1996) *Freight Forwarding Handbook*, Cosmic, Bangkok
- Towill DR (1989) *The Dynamic Analysis Approach to Manufacturing Systems Design* in: Advance Manufacturing Engineering, Vol. 1, April, pp131-140
- Towill D.R. (1993a) *System Dynamics- Background, Methodology, and Applications* in: Computing & Control Engineering Journal, October, pp 201-208
- Towill D.R. (1993b) *System Dynamics- Background, Methodology, and Applications* in: Computing & Control Engineering Journal, December, pp 261-268
- Towill D.R. & Naim M. (1993) *Partnership Sourcing Smooths Supply Chain Dynamics* in: Purchasing & Supply Management, July, pp 38-42
- Tyworth J.E. (1991) *The Inventory Theoretic Approach in Transportation Selection Models: A Critical Review* in: Logistics and transportation Review, Vol. 27, no. 4, pp 299-318
- UNCTAD (1990) *Information Material for Shippers to Make the Most Efficient Use of Multimodal Transport*, UNCTAD, Geneva, TD/B/C.4/330

- Wikner J., Towill DR, Naim M.(1991) *Smoothing Supply Chain Dynamics* in: International Journal of Production Economics, Vol. 22, pp 231-248