Information Technology for Freight Transportation Coordination

Barrie R. Nault

Graduate School of Management
University of California, Irvine
Irvine, CA, USA, 92697-3125
(714) 824-8796
Internet: brnault@uci.edu

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Abstract

The business of freight transportation is undergoing a technological revolution as it moves toward the 21st century. New technologies are being developed and adopted in each mode of freight transportation, such as a.c. power for locomotives. The one technology that affects all modes is information technology. Information technology related to the coordination of logistics and supply chain management, has the capability of affecting all the modes in a similar way. This technology in the form of electronic data interchange has begun to automate, and reduce the costs of, paper flow required to move goods from shippers, through carriers and transfer points, to consignees. This first step in automation has also enabled the implementation of more sophisticated production systems designed to substitute information about demand requirements for inventory, saving the costs of maintaining slack that used to be needed to respond to changes in demand. The current state of the art is for actors in the freight transportation sector to use information technology to manage shippers' and consignees' inventory as part of the transportation pipeline. This allows them to leverage information about these requirements together with higher visibility of their own operations to increase the utilization of large assets such as terminals and rolling stock. Integrating these applications of information technology together with freight transport operations can support the type of coordination required to make pick-up and delivery reliable, and the process of transport invisible to the shipper and consignee. To make this type of coordination a reality, an understanding must emerge from individual shippers, carriers, terminal operators, ports, third parties, and government agencies about what information is required, when this information is required, and how the information will be communicated, in order to move goods in a way that supports the modern enterprise.
1. Introduction

Modal freight transportation is the transport of freight from a point of origin to a destination using a single mode, for example rail. Intermodal freight transportation is freight transportation involving the use of two or more different modes of transport, for example motor carrier (truck) and ship. The source of additional complexity in intermodal transport as compared to modal transport is the occurrence of a transfer between modes at least once from when the shipment leaves origin to when it arrives at destination.

In modal transport, information must be exchanged between the shipper and carrier prior to when the shipment departs from origin. In intermodal transport, an information transfer between carriers, and possibly a terminal or port, must occur before the physical transfer can occur. That is, the receiving carrier, and possibly the operator of the transfer point, must be able to view information about the shipment before it is able to move the shipment onwards. The ability to share information between these parties, and to view information about the shipment while the shipment is in transit, is critical to improving the coordination of freight transportation.

This visibility of information is also the key to effective customer service, whether modal or intermodal. The combination of new technologies, global competition, and improved management techniques have caused new product introductions to be more frequent and life cycles to be shorter, creating the need for even more flexible supply chains. Global sourcing and marketing require special expertise in handling and security, time-definite delivery, efficient customs clearance, coordination of activities at domestic and foreign destinations, and so on. Visibility of goods in-transit throughout the supply chain is expected not only to reduce working capital and inventory levels, but also to be more customer-focused and responsive. Thus, today’s focus on timeliness and an increased number of business transactions, such as the selling of goods in-transit, requires that shippers can determine exactly where their goods are and when they will arrive. Availability of information about the shipment is exactly what makes it visible.
Our objective is to determine what types of communications and information technology (IT) applications are needed to enhance the service and reliability of freight transportation. We focus on how these IT applications can be used by different actors involved in freight transportation to fulfill their specific coordination roles. This is particularly important in intermodal transport where different modes, and possibly carriers, must coordinate their activities. The basic principle we follow is that, in addition to supporting the operational aspects, each actor has expertise in one or more essential roles, and IT can be used to provide incentives for the performance of those roles. Thus, IT is not only valuable for support, but also for coordination.

Our analysis unfolds as follows. First we present examples of successful use of IT in freight transportation to introduce the subject of our paper. Next we discuss estimates of the potential savings that straightforward applications of IT to transportation can have on freight transportation expenditures, and explain the microeconomic basis for these benefits. We then examine how and why future gains from IT are likely to come from the coordination of transportation and the supply chain, and outline the information components needed for this coordination. Subsequently, we study what type of organization and network arrangements are needed to support transport for the supply chain, and discuss the state of the most extensive IT initiative, electronic data interchange. Finally, we suggest ways in which government policy can be modified to increase the opportunities for increased efficiency in the transportation sector.

2. Supply Chain Examples That Require IT-Aided Transportation Support

We provide two industry examples to introduce and illustrate the use of IT-aided transportation support of distribution and production. The supply chain refers to the set of actors, and their activities, involved in moving goods from their original source to retail.
Procter & Gamble and Continuous Replenishment

In the 1980s Procter & Gamble (P&G) determined that it needed to move products to market faster, and cut the cost of moving goods from the original source to the consumer. This required redesign of how it goes to market in two dimensions: efficiency improvements and pricing policy. Forward buying where distributors and retailers buy several months worth of goods when they are on promotion (price deals) created spikes in P&G's demand. As a result P&G was forced to hold extra inventory and then ship large quantities on short notice rather than as a smooth flow. Thus, uncertainty about total demand and large changes in periodic demand increased manufacturing, inventory, and transportation costs.

The effort focused on continuous replenishment (CRP) where the retailer (the first of which was Wal-Mart) used electronic data interchange (EDI) to transmit daily data to P&G on distribution center (DC) shipments to the retail outlets. EDI is the electronic exchange of documents between organizations for the purposes of commerce or trade and has been touted as having great potential to advance and facilitate commerce. P&G then computed the order quantities, arranged transportation and shipped the stock to the DC. The retailer benefited from lower inventory, higher customer service and labor savings. P&G also instituted "value pricing" to remove the incentive for forward buying on the part of its customers, thereby stabilizing order patterns.\footnote{Value pricing is similar to an "everyday low price" (EDLP).} Further improvements have occurred by transmitting point-of-sale (POS) data from the retail outlet directly to P&G. P&G computes and generates the order for the shipments necessary replenish the DC via computer-assisted ordering (CAO), forwarding the order information to the retailer. The retailer is left to take care of individual store replenishment, a process that has traditionally been efficient.

Chrysler and Just-in-Time Inventory Management

In the late 1980s Chrysler Corporation needed to streamline production and reduce inventory levels in order to compete. Since its first implementation in 1989, Chrysler has used just-in-time (JIT) inventory management to achieve these goals. To implement JIT, Chrysler employed both EDI with its suppliers and redesigned vehicle
components to reduce manufacturing complexity. JIT production also required changes in the way Chrysler did business - internally and externally. Internally, Sales and Marketing had to forecast demand to provide information for precise production schedules. Externally, Chrysler had to offer longer term contracts and special cost incentives to suppliers.

Not all suppliers were candidates for JIT deliveries - just those that delivered at least one full truckload per day to any Chrysler plant. IT support for JIT was straightforward: after receiving production targets from the demand information, material requirements were calculated. Part orders were computed and transmitted daily to suppliers. The benefits of JIT included massive reductions in inventory (up to 75 percent), improved relations with suppliers, and more efficient use of production assets. The success of JIT depends on the balance between the stability of Chrysler’s production schedule and the manufacturing flexibility of its suppliers. Thus, the system had to move together in order to maintain this balance.

In both of these examples, there were concurrent developments of new business processes and information systems - changes in the way business had been done were needed to take advantage of IT. Moreover, in both cases transportation could be used in a way to make the balancing between production and demand dynamic through quick response and use of the transportation pipeline as inventory. Using these examples as a template, we see that in order to participate in a seamless supply chain, actors in freight transportation must be able to receive electronic information about demand (e.g., the order), organize the transport capacity to achieve the pick-up and delivery guidelines, transmit this information to the other parties in the supply chain, and provide updates in-transit (visibility) and confirmation upon delivery. Without these IT-based coordination developments on the transportation side, neither of these supply chain examples can achieve their predicted efficiency gains.

Conclusions From These Examples

These examples illustrate that major changes have occurred in logistics practices, and in individual cases the changes have resulted in large payoffs. Key to these advances has been the applications of IT together with a willingness to redesign the logistics process to take advantage of these applications. These cases also highlight that
transportation is only one element of the logistics system, and that this system must be treated as a whole in order to understand where the efficiencies are coming from.

3. The Importance of Freight Transportation and the Coordination Potential of Information Technology

With trade barriers between countries falling and the emergence of free trade agreements such as the North America Free Trade Agreement (NAFTA) and reduced-barrier trading zones such as the European Economic Community (EEC), global trade and competition are increasing. These pressures are driving the modern enterprise to be more efficient than ever before. The key to a country’s economic future is a national freight transportation system that is timely and reliable, and integrated with the country’s production of goods.

There are many estimates of the costs of freight transportation. One source estimated distribution costs as 16 percent of the net value of goods. Transportation itself is 40-60 percent of a shipper’s distribution cost (Andel 1996). This is consistent with the measurement of freight transportation expenditures as 6 percent of Gross National Product (GNP) in the U.S. in 1992 (FHA 1995). The United Nations has estimated the costs of data flows associated with international trade to be between 4-7 percent of the value of the goods (UNCID 1990), which is roughly consistent with estimates of administrative costs as 10-15 percent of the price of products (Brousseau 1994).

Perhaps more astonishing is that, accounting for subcomponents, the average product going through the supply chain is handled thirty-nine (39) times and crosses an ocean four (4) times (Richardson 1996) - meaning that the percentages quoted above are incurred repeatedly as the production process converts raw materials to finished goods. These percentages suggest that somewhere between one quarter to one half of freight transportation costs are information flows - meaning that information flows in the transportation industry can consume up to 3 percent of GNP.

That the freight transportation percentage of GNP is not higher is a testament to the current efficiency of the nation’s freight transportation system. Nonetheless,
significant advances are still possible through the use of IT. For example, it has been estimated that automation and dematerialization of inter-firm information exchange could reduce the administrative costs by half (Brousseau 1994) - or between one eighth to one quarter of transportation industry expenditures. With the freight transportation expenditures accounting for $367 billion in 1992, this implies a reduction of roughly between $45 billion and $90 billion.

As a proportion of total freight in the transportation system, intermodal freight is becoming increasingly important. The early 1990s saw some types of intermodal traffic grow at rates in the 10-20 percent range, and the American Association of Railroads (AAR) forecasts that the number of containers, trailers and RoadRailers handled by railroads will increase by 20-40 percent from 1995-2000 (FHA 1995). Several of these shifts are a result of institutional changes. For example, some of the recent increase in intermodal traffic is partially due to the teamsters settlement in 1994 whereby unionized trucking firms can now shift 28 percent (rather than 10 percent) of their freight onto rail. This change alone opened up $2 billion worth of new business for the railroads (Bowman 1995). Nonetheless, further efficiency gains are available here as well. Container space utilization by volume is only 61 percent, and by weight is 68 percent. Similarly, trailer utilization by volume is 52 percent for 40ft trailers and 68 percent for 45ft trailers (Muller 1995). IT can track the excess capacity, and reallocate loads - or find additional shipments, which can be used to increase the utilization and revenue stream from these assets. An interesting example of IT used to generate additional demand is the National Transportation Exchange (NTE), a central electronic marketplace for time sensitive less-than-truckload (LTL) and truck-load (TL) shipments. This electronic marketplace provides an interactive and real-time load matching service for shippers and carriers, whereby shippers put their requests into the market and pre-qualified carriers look for shipments that allow them to use their excess capacity (Andel 1996).

3.1 Economics of Transportation IT in the Supply Chain

IT is both a complement and a substitute for other transportation inputs. In general, IT is a complement to the larger assets in the transportation system, such as the infrastructure (ports, terminals, rail yards) and movement capacity (ships, rolling stock,
trucks, containers), because it increases their utilization, leveraging the assets to make the transportation system more efficient. A good example is Maher Terminals Inc. which employs information systems that track the location of individual containers in their terminal, plan the routing of the containers, and electronically notify drivers of the container location for pick-up (Saccomano 1996). Similarly, in general IT is a substitute for other variable expenses such as labor and fuel - expenses that are reduced in efficient operations such as those in the container terminal example above. IT in the form of EDI also substitutes for the costs of paperwork, dramatically reducing variable costs per transaction.

In addition, inter-firm coordination efficiency gained from better information is a substitute for inventory. This coordination depends in large part on transportation timeliness and reliability in making sure that goods are picked up from shippers shortly after they are produced, and delivered to consignees in time to be used in the next stage of production. Examples using on-time reliable delivery as a substitute for consignee inventory include the CRP system used by P&G and JIT system employed by Chrysler. Coordination that reduces both shipper and consignee inventory results from IT that integrates the carrier as the essential connection in the supply chain, employing the transportation pipeline itself as the primary inventory.

Improvements in intermodal transportation which provide more reliable and timely door to door pick-up and delivery has caused some firms to spend more on transportation. This is because the ability to depend on the transportation system, even at an increased cost, is more economical than stockpiling inventory. Thus, firms require less slack in the form of inventory if the movements of goods can be synchronized with production. Uncertainty, such as unexpected fluctuations in demand, in the value chain (that is, the activities that convert raw materials to finished goods) is visible in the inventories between activities. This uncertainty increases for activities further back in the value chain, creating a bullwhip effect whereby small uncertainties at the retail level cause greater effects further back, partly because of the need to build inventory buffers to hedge against transportation delays. IT helps the transportation system react to changes in the flow through the supply chain more quickly, reducing the size of these buffers.
4. Information-Intensive Logistics: Freight Transportation and the Supply Chain

The key contributors to firm success in today's economy are shorter product life cycles, reduced product costs, and improved customer service. To achieve these goals, freight transportation has to become increasingly efficient. Much of the future gains in freight transportation efficiency from IT will come from integrating the information systems of shippers and actors in the freight transportation sector so that pick-up and delivery are timely and reliable, and the transportation activities are invisible to the different actors in the supply chain. Investing in transportation support for the supply chain is important because of the large proportion of freight transport that is regular repeat business, such as Procter & Gamble shipping to Wal-Mart or Chrysler obtaining parts from its suppliers. An important role for carriers to fill is the management of more than simply the transportation aspect of a shipper's business. There are several cases of carriers or terminals that extend their reach into the supply chain by managing shipper and consignee inventory, and managing the information flow between shipper and consignee. A good example is Britain's Transport Development Group (TDG), a logistics contractor owning 4,500 trucks that is moving into customer supply chain management. Starting from the design of information systems to manage the customer's process of ordering from suppliers, TDG is able to determine the supplier's shipments from the customer's orders, coordinate transportation using its own fleet or subcontracting to another fleet, and manage the inventory flows in and out of the customer's distribution center (Parker 1997). This is similar to vendor managed inventory (VMI) where the vendor rather than the retailer is responsible for all the costs of holding and replenishing inventory at the retail locations.

Attempts to get integrated solutions with in the freight transportation sector by vertical integration across modes or horizontal across geographical coverage areas is evidenced by the many mergers in rail, trucking and global shipping (Richardson 1996). Large motor carriers have signed contracts with most railroads so they only need direct control at the beginning and the end of the move (Bowman 1995), and can provide door to door service. Express air carriers are already expanding to provide full logistics services including transportation, warehousing, customs clearance, freight tracking, order processing, inventory control, and merchandise assembly (Conley 1996).
In cases where integration is not occurring by ownership, alliances are forming around complementary expertise. For example, although deregulation has allowed intermodally integrated direct carriers to compete against facilitators, those carriers that are non-integrated can work together with facilitators as a virtual network organization.\(^2\)

### 4.1 IT Coordination Components for Transportation in the Supply Chain

The supply chain’s IT support needs correspond with phases in commercial trade:
- **Pre-contractual**, where requirements are determined, sources are discovered, offers are made, and negotiation takes place;
- **Contractual**, where purchase orders are issued and other conditions are agreed upon;
- **Logistic**, where transportation and distribution details are planned and executed;
- **Post-delivery**, where invoicing, settlement, and reporting to industry associations and government is completed.

The Supply Chain Council, an industry group whose goal is to improve supply chain operations, has developed a framework called the Supply Chain Operations Reference (SCOR) model (SCOR 1996). Part of the "deliver" process from this model is the transportation link in the chain. IT components for coordination of transportation in the supply chain need to support the following activities.

#### Demand Management

Information visibility is important not only for goods in transit, but also for information about the (expected) demand for transport - information that needs to pass through the supply chain. For example, in the packaged goods industry POS data, often in

\(^2\) Facilitators are defined as actors that serve both shipper and carrier by consolidating small shipments into larger consignments, prepare shipments and issue documents for intermodal movement, sometimes take legal responsibility for goods in-transit, provide through rates, perform pick-up and delivery, and other functions to facilitate intermodal transport (Muller 1995).
summarized form to ensure privacy, is electronically sent to the supplier and carrier, which in turn use the data to forecast, analyze, plan for, and sometimes execute actual orders. Thus, IT required by the carrier to manage demand must be able to collect the aggregated POS data, determine what orders are expected (or generates the order automatically), and passes this information on to systems in order management, and transportation and warehouse management. The information created and passed on for transportation purposes includes:

- Logistics plan: Cargo fees, Pickup information, Delivery point, CTA, Spot, Carrier identification
- Cargo information: Cargo type, Shipment condition, Hazmat information, Safety handling

**Order Management**

These IT applications are the most routine, but need to be integrated with the demand management systems. The applications include invoicing, accounts receivable and payable, credits, and collections. They may also require accounting specific to transportation such as invoicing on complicated intermodal moves and transfers between carriers, such as accounting for the use of one railroad's cars by another. These systems are the most amenable to EDI standards because they process generic business transactions.

**Transportation and Warehouse Management**

The transportation function is itself a moving warehouse, shifting inventory management onto the carrier. Thus, in a seamless supply chain warehousing is absorbed into the supply chain rather than dissolved, giving suppliers access to production schedules. Information systems required to support transportation management have to incorporate logistics planning, cargo information, the Bill of Lading, regulatory and customs requirements. It also has to manage the in-transit

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3 The definitions of most of these items can be found in the TRB Circular "Communications in Intermodal Freight Operations" (TRB 1995).
operations and final delivery notice. If inventory management is also part of the function, then additional information systems are required to capture the loading, receipt and stocking of goods. Much of the input information comes from the demand management systems, and some of the output information is communicated with the order management systems. Information components required for transportation management are:

- Logistics plan: Routing plan, Co-loading, Load dock status, Location of handoff, Time of handoff
- Cargo information: Container identification, Container condition
- Bill of Lading: Cargo value, Charges for transport, Conditions for carriage and liability
- Regulatory/customs information
  - Regulatory information: Cargo permits, Trip permits, Credentials, Certification
  - Customs information: Spot, Port identification, Date/time of crossing, Vehicle identification, Vehicle profile, Driver identification, Driver visa, Driver travel log, Driver medical certificate, Customs fees
- In-Transit Information: Routing management, Time in/out, Time/location, ETA, Route change, Location change, Time of handoff change, Status
- Destination Information: Delivery acceptance

Intermodal has special information needs in each of the groupings, needs that are generated by two intermodal features. First, there is at least one additional actor (usually an additional carrier and/or a facilitator) that requires information about the shipment. Second, there is one or more additional handoffs which need to be coordinated. Thus, the elements most critical to intermodal are those related to the additional handoff(s): the logistics plan and the in-transit information in transportation and warehouse management.

5. Transportation System Organization and IT

To obtain the future gains in freight transportation efficiency from IT the information systems of shippers and other actors must be integrated to support a supply chain in which the activities during transport are invisible to the shipper and consignee. There
are two organizational structures that actors in freight transportation can use to support the supply chain in this manner. The first is to integrate via ownership, for example a single carrier owning assets to transport in different modes, possibly also owning the terminals for intermodal transfers. Federal Express, for example, has successfully integrated air, road, forwarders and warehousing by employing a hub-and-spoke system and using IT innovatively for coordination and control. However, the success of integrators such as Federal Express has not been replicated internationally. Moreover, the type of cargo transported, along with the manner in which it is transported, does not lend itself to the transport of the majority of freight, freight which does not conform to the uniform standardized processes used by the integrators.

Surprisingly, not all integration has worked. For example, several railroads have had poor performance from their trucking subsidiaries (Muller 1995). We suggest this may be because the relevant assets of carriers are specific knowledge about their operations and location. When one carrier purchases another, and then directs the new acquisition as part of its own operation in order to integrate its overall operations, the new acquisition is no longer free to employ its specialized assets as before. As a result many of the potential benefits from owning these assets are not exercised. Thus, it may be of little benefit to own (and direct) what you don't know.

Another approach has been for carriers to remain non-integrated, but to integrate aspects that would allow them to coordinate, such as information systems to coordinate intermodal movements. Systems built to replicate the information systems of the integrators, often referred to as Cargo Community Systems, have consistently failed in practice (Forster and King 1995). The problem is that these systems, as constructed, do not have the incentive structures in place that compel the participants to provide the services necessary to gain the advantages of integrated transport. An example of this approach in passenger transport is computerized airline reservation systems (CRS) which allow the coordination of multiple flights on different airlines to support travel from origin to destination. Recent attempts (although unsuccessful) have been made to expand these systems to include hotel and rental car partners to further integrate travel support.

The alternative organization structure is the network organization. Although the network organization was originally conceived as a vertical combination of brokers,
designers, marketers and distributors, producers and suppliers (Miles and Snow 1992), there are many versions of horizontal network arrangements, such as franchises and alliances between health services organizations. An example of one such network is Pacific Pride Systems which coordinates a franchise network of independent commercial fueling stations to serve motor carriers and other commercial vehicles (Nault 1997a). A customer’s vehicle fleet can be served at any location on the network and Pacific Pride uses IT to track purchases so that it can divide the proceeds between the serving station and the one that recruited the customer to use the fueling network, thereby rewarding both stations. The networks possible in freight transportation could incorporate different modes of transport, different regions, intermodal terminals, ports, third parties, and warehouses to serve shippers and consignees.

In an integrated firm the controls over activities by different units is provided by ownership and employment relationships within the firm. In addition to the characteristics of the freight they carry, this has been the reason why integrators have been able to develop information systems that so precisely coordinate and control their operations. In networks of independent organizations, contracts guide the activities of the different parties. These network arrangements are characterized by spillovers, whereby the actions of one party effect the outcomes of another or of the whole alliance. The contracts have to be designed to provide each party with an incentive to act in the interest of the network. With intermodal transfers for example, the inbound carrier must be rewarded for providing cargo information to the terminal and outbound carrier prior to the arrival of the cargo, and the information system must be able to support the transfer and verify that the inbound carrier fulfilled its information responsibilities. IT can help horizontal networks of independent entities operate as though they were more integrated by tracking the actions of the parties (for example, determining when the cargo information was provided), and rewarding these actions based on the terms of the contract (Nault 1997a, 1997b). It is in this way that contracts and IT must be intertwined to allow a network of independent parties to coordinated as an integrated operation.

The general approach to designing information systems to support this type of coordination is to determine which information assets are vital for coordination across the network and those that are not vital for coordination. The former must be shared in some way between the actors in the transportation chain and the latter should remain
private. Once this step is completed, the timing of information sharing can be incorporated with the terms of the contracts in such a way as to motivate the independent actors to coordinate their activities as though they were integrated.

Consider a simple example of the transfer of intermodal cargo between two carriers through a terminal. Ignore the effects of regulations or customs. Using the information components we outlined in a prior section, much of the information created from the demand management and the transportation and warehouse management activities must be provided by the inbound carrier to both the outbound carrier and terminal well before the shipment arrives. Examples include the logistics plan and cargo information. While the shipment is underway, the logistics plan and cargo information must be updated by in-transit information from the inbound carrier, and communicated to the terminal and outbound carrier. Information between the three parties must be updated and exchanged at the time of the handoff. Although the terminal may only require notification about the final delivery, the outbound carrier must also constantly update the in-transit information from the second stage of the movement and provide this information to the inbound carrier - the one with the contract with the shipper. This latter information may also have to be communicated to the consignee if timely delivery or special notification is required, as would be the case if the consignee was operating a JIT system.

The best way to design and implement IT that can not only support the operations, but provide an incentive to carriers and other actors to coordinate complex freight movements is a current area of study, both in practice and in research institutions.

5.1. State of Use of Electronic Data Interchange

The objective of EDI was to standardize the content of a reasonably complete commercial transaction set - the set of documents required to execute a variety of different types of business transactions. Using this transaction set a firm could do business electronically with any other firm that could receive and send messages using this transaction set. Thus, EDI is an initial step in the use of IT in transportation, automating the exchange of business documents. The transaction set was
operationalized as a set of protocols for different messages -- that is, how the message was organized so a computer could be programmed to recognize and access the appropriate fields of information, and as a set of rules defining what the messages mean. In early stages EDI achieved significant successes. For example, in the late 1980s some organizations increased sales up to 50 percent with electronic ordering (La Londe and Cooper 1989). Moreover, there were predictions of rapid growth in EDI usage for the future (Walton and Lewis 1995).

Two practical problems have emerged. The first problem is one of standards. As with many attempts at setting standards, more than one standard emerged. The North American standard is ANSI X12, and the rest of the world has adopted the United Nations sanctioned EDIFACT standard. The ANSI X12 and EDIFACT transaction sets are not perfectly compatible. This means that although some of the basic business transactions can be translated between the two standards, the more detailed messages and transactions from one standard cannot be translated into the other standard without some loss of content. The analogous situation arises with business processes - on the surface, transactions between firms have a consistent structure, good examples are purchase orders and invoices. However, even these transaction documents differ between industries, and an electronic standard cannot capture the industry-specific (or firm-specific) aspects.

The second practical problem with EDI is that it has been costly and time consuming to integrate EDI into firms’ existing information systems. When EDI is connected to existing internal systems, it typically automates existing business processes. Unfortunately, most of the gains from IT come from the integration of this technology into business processes, changing how firms do business. To support the redesigned business process, it is often necessary to incorporate IT into processes, requiring specific information in a firm or industry-specific form - exactly what EDI was designed to avoid.

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4 Other examples include the Beta and VHS standards in video cassette recorders, and different bandwidths of Integrated Services Digital Networks (ISDN) standards between North America and Europe. In the former, the product which was inferior on most technological dimensions (VHS) prevailed because of the proliferation of VHS machines, and the different standards have been part of the reason why ISDN has been so slow to develop commercially.
Surveys of the freight transportation industry indicate that the adoption of EDI has not been nearly universal in any dimension. Those carriers that have adopted EDI have only used a limited amount of the transaction set. Specifically, increased use of exception type sets - messages designed to communicate status and instructions to deal with non-routine situations, has not materialized (Crum et al 1996). Because exception reporting is more firm and industry-specific than what is needed when transactions are routine, the lack of use of these sets may be due to that type of reporting not being compatible with standards. Moreover, of those that had adopted EDI, only 28 percent had "integrated" EDI into their other systems prior to 1994 (Walton 1994). This indicates that EDI has not been incorporated into internal systems, but rather has automated existing manual processes. Supporting this view, it was found that the truckload industry usage of EDI was much more than the less-than-truckload industry, possibly because it is simpler to integrate EDI into truckload industry operations. In addition, there were more direct EDI linkages to internal systems, such as customer service, finance and operations, than intermodal EDI links, suggesting that it is easier to enforce standards internally (Crum et al 1996).

The driving force behind adoption of EDI in the freight transportation sector has been the exercise of shipper channel power, rather than carriers attempting to attain greater efficiency (Crum et al 1996, Walton 1994). These powerful partners force EDI on carriers, which are faced with paying surcharges or losing business otherwise (Walton 1996). Shippers benefit from EDI because they are able to implement their own plans to improve the efficiency of their supply chains using EDI to automate the order and transport process. This is consistent with the finding that reducing different demand uncertainties is the key reason why marketing channels (as opposed to logistics channels) adopt EDI (Walton 1994). This helps explain why carriers find that their EDI advantages are marketing-based, such as service, competitiveness, differentiation, as opposed to operational efficiencies (Crum et al 1996).

Thus, instead of internal stakeholders, external stakeholders have the most influence over EDI adoption. As a result, initiators of EDI adoption in organizations are not corporate offices, but line departments such as purchasing (Walton and Lewis 1995). Management information systems departments, which would be expected to support EDI, are not proactive because of their backlogs on other systems. Therefore,
EDI is not being organizationally initiated or controlled.

The EDI technology itself was not found to be the deterrent, rather the deterrent was bringing EDI into the business process (Crum et al 1996). As we hypothesize, the large gains from IT are in the redesign of business processes, and this redesign is more difficult for firms to implement than the automation of existing business processes with EDI. EDI requires organizational standardization -- standardization that would reduce many advantages of successful firms, such as barriers to entry, know-how and specialization.

6. Public Involvement

Government involvement in the national freight transportation system should be based on what the private sector can be expected to do, and what it cannot. In general, the private sector cannot be expected to invest heavily in "public goods" - that is, items that many parties have access to such as the National Highway System. There are two reasons why the private sector does not have incentives to invest in these items. The first is that a given private party may wait until other private parties invest, hoping to free ride on their investment. As a result, everyone waits and there is no investment. The second is that a given party may not be able to capture the full return on joint investment, and thus underinvests.

This means that government should invest in items that can create a common benefit. There are several areas where government policy and involvement can be modified to accelerate efficiency and coordination gains from IT in the freight transportation sector:

IT Infrastructure For Transportation

The most basic requirement to support IT in the freight transportation system is investment in IT infrastructure. Underlying most of the examples in this paper has been reliable and relatively inexpensive communication within the transportation sector, between the transportation sector and the production sector, and between the transportation sector and government bodies. The communications infrastructure used in these examples has either been proprietary, as with Chrysler using its own EDI
network (Chrysler Telecommunications Exchange), or pay-per-use with value-added-networks, or even simple modem transmissions over normal telephone lines.

In order to ensure the participation of all the actors in the freight transportation sector, a next generation Internet or some other public communications backbone is needed to ensure connectivity and bandwidth. Interestingly, Internet EDI has been considered the "killer application" (the software application that makes something commercially viable) to usher the Internet into mainstream information systems (Nash 1996). The existing Internet is congested, is not secure, and has intermittent failures, and as a result cannot provide this connectivity in its current form. Standardization and development of an architecture are needed so that future data handling systems will be interoperable -- the standardization of infrastructure and connectivity. In this domain government can play an important leadership role (TRB 1995). For example, government can begin by determining, in concert with the transportation sector, the levels of security and bandwidth required in a communications network exclusively serving freight transportation. Government may also take the lead in designing such a network to be self-funding. Precedent for this activity is the government’s critical involvement in the development of the Internet.

**EDI "Standards"**

As we have seen from our examples of current trends in the use of IT for coordination, intelligent communications need to enable business processes that go across the supply chain, allowing plans and activities to be synchronized across firms. In spite of a great deal of effort in development, protocol standards such as EDI ANSI X12 are not sufficient for this type of communication because they cannot incorporate the richness of information transferred between firms. Moreover, these standards will always lag the newer innovations in inter-firm coordination because it takes time to establish the standard after a particular kind of communication has been shown to be useful.

There are areas of organization-to-organization communications that can be routinized, a good example of which is customs documentation. The U.S. Customs Service’s Automated Manifest System and Singapore’s TradeNet, both which allow for the automated clearance of imported shipments, are excellent examples of successful
government initiatives using EDI. Efforts in developing EDI standards might be better focused on customs and regulatory interactions - most of which are routinizable - rather than within or between industry interactions which tend to be more specific because they are more deeply integrated with the individual participant’s internal business processes.
Customs and Regulation Systems

Some centralization of information systems is needed for coordination between different actors in the transportation sector and between these actors and regulators/customs. One success noted above is the Automated Manifest System from U.S. Customs Service. Other initiatives include the North America Trade Automation Prototype (NATAP), the Federal Highway Administration's Commercial Vehicle Operations Vision (CVISN), the American Association of Railroads Interline Service Management (ISM SM), and various projects in the Department of Transportation's Intelligent Transportation Systems (ITS) program (TRB 1995). The common thread through these activities is the need for coordination between different actors with different motivations.

The success of these and other systems may require simplifying international trade agreements and other government-based institutional arrangements. Each of the initiatives listed above has required both applications of IT and changes in fundamental processes. For example, NATAP - a system to allow non-stop movement of freight across borders using radio frequency devices - requires the United States, Canada and Mexico to follow through on their North America Free Trade Agreement commitment to harmonize the substance and electronic communication of customs documentation. Similar common agreements are required to implement the coordinating IT for the other initiatives. Support for these initiatives can be direct, where government is one of the participants, or indirect where government is not an active participant.

Education

With the trend towards increased electronic communication to support transportation, there are many concerns amongst those in the transportation sector regarding the ease of use of new IT and security of information in the communications. It is difficult for single organizations to continuously upgrade their knowledge in these areas because in-house education is expensive and experts are hard to obtain. Other reports have also suggested that outreach education for corporations and individuals is needed to answer concerns about privacy and useability (TRB 1995). In fact, lack of education
and expertise is a serious impediment to using IT to improve the efficiency of the freight transportation system. Government can play an important role helping firms overcome these obstacles by supporting education in this domain through direct outreach programs and through support to industry groups.

There is a related problem whereby the freight transportation sector has produced much redundant software and other technological components (Andel 1997). In the face of fast changing technologies, the process of innovation is bound to produce some redundancies. Nonetheless, government can certainly play an important role in technology transfer by maintaining information on IT innovations used in the transportation sector, and diffusing the information to potential developers and users.

7. Conclusion

This paper has examined the contributions of IT to efficiency gains in freight transportation. Even ignoring operational efficiencies, we found that IT applied strictly to inter-organization information exchanges had the potential of reducing total freight transportation industry expenditures by one eighth to one quarter, some $45 to $90 billion in 1992 in the United States. We have found that EDI has created gains associated with automation for individual firms. However, progress towards further gains has been partially stalled because of the difficulty of integrating globally standardized business communications into the information systems of firms that maintain business processes that are specific to the relationships they hold with other firms. Moreover, many of the earlier gains were marketing-based as opposed to operations-based.

The prospects of additional gains from IT, some of which are presently being captured by transportation firms on the cutting edge, come mostly from using IT to coordinate transportation and the supply chain. Better information on the demand for shipment capacity (derived from demand for the to-be-shipped goods) allowing transportation to be planned and executed more reliably, has made the substitution between information and inventory feasible. In addition, reliability and real-time visibility of shipments in the transportation pipeline has made it possible to use this pipeline itself as inventory. There are also associated gains from IT directly in transportation operations that allow terminals, ports, and carriers to better utilize their large
transportation assets. These benefits are essentially because information systems tracking makes both the assets and shipments more visible, meaning pick-ups, transfers, customs and regulatory reporting, and deliveries can be handled more efficiently.

Obtaining all the potential gains is being hindered by the difficulty of coordinating activities between the different actors in the freight transportation sector. Vertical integration has only been successful in limited settings, for example integrators such as Federal Express and UPS. Building information systems to support the different independent actors in non-integrated transportation has suffered because of the lack of incentives to jointly develop these systems. We argue that different types of approaches to organize different actors in individual transportation and supply chain relationships, where the specific character of the business processes in those relationships can be supported, is necessary.

We suggest that efforts to extend EDI standards need to be carefully targeted to those communications where the underlying processes are or can be routinized. Efforts at further standardizing electronic communications for business processes are unlikely to yield expected benefits as these processes differ between industries and even between firms - and these differences may in fact be part of a firm's competitive advantage.

However, we indicate that public policy has a significant role to play in providing IT infrastructure as an electronic platform for communications to coordinate freight transportation activities, in providing systems initiatives for firms' routine documentation exchanges with customs and regulatory bodies, and in providing outreach education and support for technology transfer in the freight transportation sector.

8. References


Andel, T., "Information supply chain: Set and get your goals," *Transportation &


