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Abridgment

Use of Mobile Communications in the Trucking Industry

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Mobile radio use has become a widely adopted component of modern transportation systems. Communication and transportation may serve as substitutes for or complements to transportation systems. As a substitute, communication can often replace a trip by accomplishing the trip's objective without direct personal contact. The telecommunications industry is developing extensive technology for information handling and transmitting. Thus, when the purpose of a trip is to move information rather than goods or persons, electronic communication may be substituted. Transportation and communication can also be complementary. As in most of the areas to be described in this paper, communication is used to increase the efficiency of vehicle operations. Routing and scheduling changes can reduce mileage, increase load factors, and bypass inclement weather or delaying traffic conditions.

However, the difference between the substitutive and complementary relationships of communication and transportation is not always clear-cut. For example, through the use of mobile communication, a freight vehicle can be dispatched to make a nearby pickup or delivery that was not requested in the original dispatch.

DEFINITION

Mobile communication has been defined as voice or signalling communications services between base stations and mobile units, either hand-carried or vehicular. This definition can be expanded slightly by adding that information transmission can occur between humans, between machines, or between humans and machines. The use of electronic signalling for automated control purposes, often encountered in the transportation area, could thus be included. Also included in this definition are mobile communications in the area of safety and special radio services. This area covers aviation; marine and land mobile radio use by state and local governments (e.g., police, fire, forestry, highway departments); industrial (e.g., in-plant manufacturing uses, construction site communications, service and supply vehicle links); land transportation (e.g., railroads, passenger buses, delivery trucks, taxis, automobile emergencies); disaster communications; and other experimental, hobby, and personal convenience uses.

APPLICATION

Any communication between vehicles or between vehicles and fixed stations by visual, electronic, or other signals generated or received by devices within the vehicles can be considered mobile communication. Extensive use of two-way radio communication has significantly increased efficiency and service quality. A reduction in the number of pickups and deliveries, increased shipment requests, and reductions in fuel consumption or the number of vehicles required have all been noted by mobile communications users in the transportation sector.

REGULATION

Land mobile radio use is controlled by the Federal Communications Commission (FCC) as part of the land transportation radio service sector of the Safety and Special Radio Services Bureau. Motor freight and passenger carriers, taxi operators, railroad radio users, and automobile emergency systems—including highway maintenance vehicles—are included in this sector governed under FCC Rules and Regulations (part 93).

Applications for broadcast frequencies are made to an officer of the FCC who coordinates them with existing users and other applicants before forwarding them for commission approval. The radio spectrum available for land transportation users is broken down for different services (e.g., rail, freight, passenger, automobile emergency). A further breakdown is made to ensure the compatibility of signal characteristics and message types.

The use of citizen-band radio by trucking companies is greatest where the spectrum is overcrowded. It is rare to find citizen-band radio used for dispatching in low-density urban or rural areas. Furthermore, most companies have one allocated frequency—and only a few have two or more (in each separate area of operation)—but frequencies must be shared with other users in crowded urban areas. Loading is generally high, i.e., 20-200 units/frequency, although this is low by police or fire standards. In all, there are 6000 licenses in the industrial radio services sector operating a total of 75 000-80 000 vehicles.

ASSESSING NEW TECHNOLOGIES

With the allocation of the 900 MHz band to land mobile radio use, as specified in FCC docket 18262, two new mobile communications technologies have been developed to promote efficient use of this spectrum. These are known as the multichannel trunked system and the cellular system.

In the multichannel trunked system with automatic control (MCTS), access to the several channels assigned to this system is controlled by a central computer unit. All users must request permission to transmit.

In a cellular system, a large service area is broken up into cells; within each cell is operated a subsystem functionally similar to that of the multichannel trunked system. The cells may be from 1.6 km (1 mile) to about 32 km (20 miles) in diameter, and the MCTS transmitters in adjacent cells operate on different sets of frequencies. The major purpose of the cellular system is to increase mobile communication capacity within a given spectrum allocation. Short-range transmitters and small cell size permit reuse of allocated frequencies in cells separated by a specified distance from the cell originally using those frequencies. Moreover, small cell sizes are naturally compatible with the limited range and unfavorable propagation characteristic of the frequencies now being made available for mobile communications. The major advantage of the cellular system is its vast potential capacity; it can accommodate millions of users. The capacity is not only proportional to the number of channels assigned, but is also inversely proportional to cell size. As cell size is reduced, the number of cells in a given service area is increased, thus increasing frequency reuse. Additional advantages are privacy and virtually unlimited effective range.

COMMUNICATIONS AND THE TRUCKING INDUSTRY

The freight transportation industry is very diverse and at the same time highly specialized. That is, many types of operations exist, although a number of firms will concentrate on a specific type of operation. A company can be considered a local or a long-haul carrier. In combination, these distinctions permit the development of the spiderweb network that permits complete coverage of a region. Local carriers are allotted a region to serve, and generally are centered around one or a few major cities. Each local carrier is responsible for the pickup and delivery of goods within its region.

Long-haul carriers link major service areas, transporting goods between cities for subsequent distribution locally. Terminals are located in each local region, and direct service between these terminals becomes the function of these over-the-road operations.

Routing arrangement also characterizes the diversity of the industry. These types of operations are of major importance in describing the communications needs of a carrier. The Interstate Commerce Commission recognizes five distinct types of routing: regular route/scheduled service; regular route/nonscheduled service; irregular route/radial service; irregular route/nonradial service; and local cartage service.

Carriers can also be classified according to the following economic criteria:

1. Class 1 carrier, annual gross of a firm in excess of $3 000 000;
2. Class 2 carrier, annual gross between $500 000 and $3 000 000; and
3. Class 3 carrier, annual gross under $500 000.

In the United States in 1970, there were 3632 class 1 and 2 carriers and 11 468 class 3 carriers. Because classes 1 and 2 employ a much larger number of vehicles, however, the difference in terms of total equipment is much smaller. Approximately 50 percent (about 1800 companies) of the class 1 and class 2 carriers use radio equipment, whereas only 5-8 percent of the class 3 firms employ mobile technology (about 700 companies). Two factors seem to be responsible for this: the capital expenditure necessary to obtain radio equipment and the reduced problem of communication when only one or a few trucks are involved. A stratification of the industry is completed by considering two other classifications: by type of "contract arrangement" that refers to the ownership of the cargo being transported and by type of commodity transported. The basic distinction is between for-hire carriers (providing freight movement for other businesses and industries) and private carriers (fleets owned by a business or industry that transport the industry's cargo).

The most important need of the long-haul trucker is one of control, especially in cases where many terminals are maintained and a large vehicle fleet is maintained. Control of transferred cargo as well as knowledge of vehicle arrival time at each terminal (for more efficient loading) is essential. Because of the long time that a truck may be out of communication with terminals, control could also be used to aid in emergency situations and to monitor the performance of the driver.

Local service, typically serving irregular routes, relies more on communications for relaying new assignments to drivers. In an ideal situation, a truck coordinates several successive pickups and deliveries before returning to a terminal. To accomplish this, some form of communication with the driver is needed.

To meet these communication needs, a wide variety of systems are available and in use. These include various conventional telephone arrangements, on-line data transmitting and teletype systems, and mobile technologies such as two-way radios and digital equipment.

EFFICIENCIES AND IMPACTS OF COMMUNICATIONS TECHNOLOGY

The use of mobile radio has two kinds of economic benefit: increased revenue and decreased cost. Immediate relay of incoming requests to an available vehicle enables a larger number of customers to be served per day (increased revenue). Not only can more customer requests be handled, but fewer trucks are needed to service a particular area if they are radio-equipped. Four radio-equipped trucks may be able to perform the task of five trucks without radio equipment. Fewer trucks or truck-hours mean that a company can, for example, decrease driver wages and fuel consumption.

Besides economic savings, there are a number of more subtle impacts. Many customers prefer to do business with mobile radio users because of the greater speed and quality of service provided. In cases where trucks are in the vicinity when a customer phones in a request, immediate contact with the driver via the terminal dispatcher can provide service in a matter of minutes. Any questions arising during business transactions that cannot be answered by the driver also can be clarified immediately.

A certain degree of safety is also provided through the use of radio equipment. In cases of breakdown, accident, or other emergency, the driver is able to get aid through the local terminal or from other company vehicles in the area, if mobile-to-mobile capabilities exist. Less reliance on outside help results in greater security for driver and cargo. Communications can reduce the danger of hijacking.

POTENTIAL MARKET FOR NEW TECHNOLOGY

A market for new technology in the trucking industry will depend on one of the following three abilities of a cellular or multichannel system:

1. The ability to decrease congestion and hence transmission delays,
2. The ability to provide dispatching service at a lower cost than present mobile equipment, and
3. Capabilities not now present in dispatch and communications equipment that would aid trucking firms.

Radio users interviewed for this study did not view radio congestion as a major problem. Yet in metropolitan areas, where radio channels are shared by a number of users, congestion of the airwaves can mean inefficiency in the trucking industry as in any other type of dispatch service.

HIJACKING AND MOBILE COMMUNICATIONS

The U.S. Department of Transportation noted that the total cost of cargo theft and pilferage exceeds $1 billion/year—with the trucking industry experiencing the largest percentage of that total. Theft usually occurs during loading and unloading, in the terminal yard (about 85 percent of stolen cargo goes out the front gates of transportation facilities during normal operating hours and in the possession of persons and in vehicles authorized to be on premises for legitimate reasons), or in transit between terminals.

Hijacking has recently become more prevalent. Increased terminal security has reduced the first two types of loss, but the problem has moved to the road.

CONCLUSIONS

This paper has attempted to identify the significant role that mobile communications plays in the operation of pickup and delivery and over-the-road service in the trucking industry. A number of specific instances of operational and safety improvements due to the use of communications devices have been identified. Very little doubt remains that improved mobile communications technologies, such as the ones briefly described in this paper, and a more widespread adoption of available and future devices will further increase the performance of the trucking industry.

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Estimating Service-Differentiated Transport Demand Functions

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This paper develops a methodology for estimating the demand for freight transport based on a model of the shipper's decision-making process. Conditions of optimality are used to specify a choice model—subject to some assumptions about the shipper's response to the risks incurred by using the transport system. This model is expanded to allow for testing for imperfection in the goods markets. If such imperfection exists, a technique is proposed that involves generating a posterior on shipment size, conditioned on alternative choice from a prior on shipment size and the estimated choice model. The resulting expectation of the posterior, when used in combination with industry supply functions, produces demand equations. Finally, market equilibria—where demand equals supply—are computed.

Estimating the demand for freight transportation has been a favorite pastime of many transport economists (1-12). Approaches have varied from gravity models to logit analysis (13). A major advantage of a gravity model is that it actually predicts flows. Its major disadvantage is that it is not based on any economic theory and thus is generally not sensitive to microeconomic parameters such as market prices, transport rates, and service levels. An advantage of a choice model, such as probit and logit analysis, has been its responsiveness to microeconomic parameters, although its estimation has usually been performed without regard to microeconomic theory (5); notable exceptions to this are found in Allen (1) and Beuthe (3). The estimated choice probabilities are then used to separate some given total quantity to obtain estimates of shipment size for each alternative. This method is clearly limited because the total amount shipped depends on the firm's decisions regarding alternatives and shipment size.

This paper develops a consistent methodology for estimating demand equations by starting from a microeconomic model of a shipping firm, estimating a choice model dependent on both alternative and shipment size, and then producing demand equations that reflect choice of market and mode, prices at the market, transport rates for the different modes, and service characteristics of the modes. This paper also presents a theoretical analysis of the shipping firm, develops the basic approach for deriving transport demand, estimates logit models for market-mode choice,