FACTORS AFFECTING THE IMPACT OF E-ECONOMY ON TRANSPORT

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Abstract. This paper presents a methodological framework for Predicting the Impact of E-economy on Transport (POET). It includes a description of the Forces Driving Structural Change in the E-economy, their impact on communication patterns, the relevant actors and their decision making behavior. The state-of-the-art on the Impacts of E-economy on Passengers is then discussed. Research findings on telehopping, mobile work and impact of ITS on transport are presented. Results from an innovative Panel of Experts survey on the impacts of e-economy on freight transport are then presented. In the opinion of the industry panel for POET, although the e-economy is not the driving force of changes to freight transport, it is having some major impacts as an enabler.

Keywords: E-economy, Forces Driving Structural Change, Passenger Transport, Freight and Logistics Transport

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1 INTRODUCTION

The e-Economy is characterised by the ability to transmit and receive information, without regard to distance, at a relatively low cost. Developments in the e-Economy have the potential to affect the supply and demand for transport in multiple ways. Telecommunication technologies may impact the demand for physical transportation and offer improvements in the efficiency and safety of transport systems, leading to better environments through reduced travel, pollution and potentially savings in time and material resources. In this context transport substitution is the replacement of a journey by alternative types of communication and IT (ICTs). The goal of this research is to Predict the potential impacts of the e-Economy On the future demand/supply for passenger and freight Transport (POET), and identify the opportunities presented by this digital revolution for improving the quality of life of citizens by mitigating the adverse impacts of transport.

What is the“e-Economy”? 

There are several definitions of the e-Economy. Some define it to mean the economy based on the use of information and knowledge, whereas others define it to mean the economy based on network technologies. In POET we use the term in the broad sense, namely; an Economy and its derivatives influenced by ICT developments.

Although the e-Economy has been the subject of considerable attention, still not much is known about its impacts on passenger and freight transport. Furthermore, the path along which the e-Economy will develop in the future is also uncertain. In POET we develop a conceptual model integrating the physical elements of the transport system with behavioural aspects of transport and travel choices made by various actors (firms and businesses, households and individuals, and governments).
Section 2 presents the overall framework of POET. It presents the Forces Driving Structural Change (FDSCs), the possible communication patterns that exist between individuals and businesses, and the actors involved in various long-term, medium-term, and short-term decisions. Section 3 presents the findings of research on the impact of E-economy on passengers. Section 4 presents the results of Panel Survey of Logistics Experts about E-economy and its impacts on freight. Section 5 concludes the paper.

2 FRAMEWORK FOR STUDYING THE ECONOMY IMPACTS ON TRANSPORT

Figure 1 presents a methodological framework studying the impacts of the e-economy on transport. It presents the relationship between the FDSCs, communication patterns, actors’ decision making behavior, and final impacts on passenger and freight transport.

2.1 Forces Driving Structural Change FDSC for E-economy

This section presents the FDSCs (Forces Driving Structural Change) that are affecting the e-Economy and have an influence on the transport system. The FDSCs include ICT and other technological developments, macro-economic, legislative, and social developments.
ICT and other technological developments

The mutually reinforcing trends of increasing Internet use, globalisation and mobile communication are the primary drivers. Their joint effect is to stimulate activities like e-Commerce, tele-activities, tele-commuting, etc. The adoption and use of these numerous "e-..." and "tele-..." has potentially important implications for transport.
Globalisation refers to the ongoing process of increasingly open markets leading to more trade and correspondingly more freight and people moving around the world. Developments in information and communication technologies are one of the major enablers of globalisation.

The increase in the capacity to store and exchange information is restructuring the logistics processes. The availability and accessibility of real time information offers new opportunities (on the supply side) to increase the efficiency of the freight transport system by improving the design and control of the supply chains, Advanced Planning and Scheduling (APS) systems (e.g. route planning systems) are therefore of increasing significance (NEI/Bakkenist, 1999).

Besides the ICT developments, other technological developments such as in vehicle and transfer technologies also have the potential of bringing about changes in the transport system. The cumulative effect of all of these developments is not easy to predict.

**Economic growth**

Transport demand is growing almost in lockstep with economic growth. The volume of freight transport is increasing not just because of rising demand, but also because of supply side factors, such as the availability and quality of infrastructure, transport means and the user costs of and legislative conditions to utilisation of these means (CE, 1999).

The above trends result in several developments at the meso level, for example:

1. Shifting to high-grade freight
2. Specialisation in manufacturing and focusing on core competences
3. Increasing diffusion in production and consumption
4. Increasing complexity of the logistics chain

The economy's structure relates to possible changes in the composition and segmentation of freight. Developments that can be seen in this area are for
instance the shift from goods to services and the increased competition between companies.

Facilitating transport supply is not only based on transport demand, but also on governing logistics concepts and cost and service aspects. Transport costs have decreased over the last decades while inventory costs have increased. This change in the relation between storage and transport cost drives shippers and forwarders to increase delivery frequencies in order to keep stocks at low levels. This trend does not show from the number of tons or ton-kilometres, but only from the number of vehicle-kilometres travelled.

Institutional developments

Developments like free market competition, deregulation and liberalisation have manifested themselves within sectors with variable speeds. As a result of the liberalisation and deregulation, competition in the transport market has significantly intensified. However, many of the companies that are targeting e-commerce related transport and logistics are small or medium sized companies that are unable to bring about revolutionary changes in the logistics sector (Dialogic, 2001). This, however, could change as the sector goes through a process of consolidation and concentration of companies through a series of mergers and takeovers.

Social developments

(a) Demographic changes

The composition of the population is an essential determinant for the development of production and consumption. Two important demographic trends are an aging population and an increasing share of migrants.

Recent research in The Netherlands indicates a 20% growth in the number of kilometres driven in the decade from 1985 to 1995 (OECD, 2001). More than a third of this growth (38%) is attributable to population growth and "baby boom"
generation drivers. The remaining 62% of this growth is attributed to an increase in the number of daily kilometres driven per motorist.

(b) Education

Despite their imperfections, measures of educational attainment are the most commonly used proxies for human capital, in the OECD area, 65% of the population aged 25-64 has completed upper secondary schooling. The share in the United States and Japan is more than 20 percentage points higher than in the European Union.

(c) Human resources in science and technology

Since the focus of POET is on the effects of the e-Economy on transport, especially the human resources in science and technology (HRST) are of importance. As measured here, HRSTs encompass workers in highly skilled S&T-related occupations. The definition goes beyond R&D by including workers actively involved in technological innovation and diffusion. In 1999, there were about 38 million HRST in the European Union, or about 25% of the labour force. In 1999, the European Union had about 8 million workers classified as scientists and engineers; in 1997, the United States had 10.6 million\(^1\). The share of scientists and engineers in the total labour force is highest in the United States (7.7%).

(d) Individualisation

An important societal development is the increasing individualisation. As a result there is an increase in single person households and people within multi person households are increasingly creating their personal freedoms. Single’s households are expected to increase by 50%\(^2\) by 2025. Another result of individualisation is an increasing diversity of and within groups of people. The following factors illustrate the individualisation trend.

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\(^1\) The definitions of EU HRSTs and US HRSTs are not exactly the same, causing those numbers not to be fully comparable.

\(^2\) In the Netherlands
(e) **Changing lifestyles**

Developments in the demand for mobility should be viewed in the context of modern lifestyle developments (OECD, 2001). With the rise in two-income families, a private car facilitates a variety of activities requiring travel. Daily trips involve diverse commute patterns that combine trips to school and school-related activities; child and elder care; recreation; and shopping. Higher incomes and the increase in car ownership, among other factors, have led to a substantial increase in the demand for leisure activities. Many trips are often practical only by car, and in today’s highly mobile society, the car fulfils a number of useful purposes. To many, the car symbolises a sense of freedom and independence and provides convenient access.

(f) **Changing household structure**

Demographic and social changes have resulted in a decrease in the size of the average household over time. As a result, more dwellings are required, thus leading to larger cities. These demographics have also had a more direct impact on travel through changes in the total number of individuals and households.

(g) **Increased car ownership**

Research shows that as real income increases, car ownership increases. Over the past 20 years, the number of cars owned in European Union countries has grown, on average, by 4.2% per annum. Levels of car ownership per capita have also increased. Research indicates that the number of household journeys increases substantially when a car is acquired; consequently travellers modify their mode of choice to the car (OECD, 2001). Access to a car is also often associated with a considerable increase in distance travelled.
(b) Changing preferences

As a result of individualisation, people's preferences tend to change more rapidly. This consequence forces manufacturers and distributors to increase their responsiveness to changing conditions. This can be achieved by gathering more information on buying and customer behaviour and by introducing shorter communication and transportation lines in the distribution system. As a result, the balance of supply and demand is shifting in the direction of demand, i.e., towards the customer. Corporate response to this shift includes the gathering of point-of-sale and consumer preferences data and the adaptation of their logistics concepts.

The FDSCs affect the transport system both directly and indirectly. Sometimes, a FDSC does not directly affect the transport system, but a derivative of that FDSC will. POET focuses on the effects of these derivatives, the e-Economy, on transport. In other words; POET focuses on FDSCs that influence the transport system by bringing about changes that are typically considered to fall within the domain of e-Economy.

2.2 Communication Patterns

This research classifies communication patterns on the bases of the type of end-users. Consumers (C) are individuals who use communication system for the private or domestic purposes. Businesses (B) are establishments that use communication systems for connecting with consumers (B2C) or with other Businesses (B2B). Businesses are broadly defined to include not only the business sector but also government (G) agencies, Non-Governmental Originations (NGO's) and other institutions.
1. **C2C (F2F, Telephony: POTS, cellular; Email)**

The most common form of inter-personal communication is the face-to-face (F2F) type, which relies upon transportation technologies to bring people together. The importance of F2F communication must not be underestimated. There are many situations in which people will insist on using F2F and will not substitute it by any ICT-based option. The preference for F2F depends on the nature of the information to be conveyed. In social contexts, it is widely preferred, as well as in some business contexts where sensitive information is involved. The role of non-verbal communication is an important factor supporting F2F use. The main application of C2C includes personal-social and personal-business communication.

Another widely popular C2C (as well as B2C and C2B) communication form is the electronic mail (Email). This generally free service is used for social and business purposes. It allows real time as well as asynchronous communication.

2. **C2B (telework, teleshopping, teleservices)**

Consumer to business communication includes three main forms: person-to-person, person-to-computer, and computer-to-computer communication. Teleservices are a series of consumer or business oriented services which are provided through ICT-based systems. For example, information provided by public services, tele-shopping, telebanking, telemedicine (Bashshur et al., 1997), tele-education (French et al., 1999), tele-entertainment etc. Most of these services are hosted by the Internet web.

3. **B2C (teleservices)**

Communications between business establishments and their customers is usually initiated by the customer. However there are cases where the direction is reversed, i.e., businesses initiate contact with their customers (B2C). Internet based marketing and advertisement is an example of B2C communication. This form of
communication has the advantage that businesses can target very well defined market segments. Another example of B2C is the provision of public information services by private companies or government. Traffic information provided to drivers in an attempt to alleviate congestion falls under this type of service (Golledge, 1997). However, such B2C information services are useful only to those who have access to the particular technology used.

Probably the most obvious B2C influence on transport is door-to-door delivery. The net effect, however, of this trend is still to be determined. Customers can be expected to generate fewer trips to stores. However, what is not known is whether the new trips generated by this door-to-door service provided by retailers will be more or less than the reduction in trips to stores.


B2B communication usually involves a wide set of technologies, starting with conventional paper-based mail, F2F interactions, telephony, fax, and computer-based communications. In the business context the choice of alternatives is made based on the suitability of the channel for the type of information to be conveyed, cost, security considerations, urgency and so on (Carlson et al., 1998). Travel substitution by telecommunications in the B2B pattern has been studied by Plaut (1997).

Recent research has demonstrated that there is an intrinsic value for travel per-se beyond the need to reach a specific location (Mokhtarian and Salomon, 2001). Such a desire can often affect the business decision maker's choice among the communication alternatives, and lead to a choice of F2F over ICT-based alternatives.

A very direct but so far quite limited effect of e-commerce on transport is the substitution effect. Some types of goods (for example periodicals, cd's, bills and courses) are amenable to digitisation and can be sent via the Internet instead of by regular mail.
A larger impact comes from Internet portals that can be accessed by actors in a supply chain to place their orders. These portals have a twofold effect on transport: on the one hand physical or ‘bricks and mortar’ points of sale disappear and this results in less transport. On the other hand transport, trip distances increase since consumers are able to order goods from anywhere in the world, and manufacturers centralise their production and storage within this global network.

2.3 Actors

The actors involved in the E-economy develop patterns of ICT usage that are tailored to their specific needs. Table 1 'maps' the main activity that each of the actors performs and the consequent decisions that the respective actors make in short, intermediate and long term horizons. These decisions emphasize the time and space dimensions of the actors' behavior, and involve both direct and indirect implications regarding transport and ICT.

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Table 1: Actors' Activities and Decisions
3 E-ECONOMY IMPACTS ON PASSENGER TRANSPORT

IT products and teleservices are expected to impact individuals' activity and travel behaviour since telecommuting, telerescervations, telepurchasing, teleconferencing, type services are becoming ever more widely available. Research conducted on user response to IT has shown that it may affect a wide range of individuals' activities and travel decisions, such as:

1. Consumer purchase behavior (e-commerce, online shopping, e-ticketing);
2. Work-related arrangements (tele-commuting, mobile working, etc.); and
3. Travel-related activities (effect of intelligent transport systems such as Advanced Traveler Information Systems and Advanced Public Transportation Systems and information provision on travel response such as route, departure time, mode, etc.)

Most of the research conducted so far has focused on categories 2 and 3. However, research is needed on all three categories in order to identify the impact of e-modes and electronic revolution on transport.

3.1 Consumer purchase behaviour

Tele-shopping (e-purchase, e-shopping) provides consumers with the possibility of purchasing goods or services online (Koppelman et al., 1991). Shopping refers to a set of activities, in which consumers search for and obtain information about products and/or services, conduct a transaction transferring ownership or right to use, and spatially relocate the product or service to the new owner (Mokhtarian and Salomon, 2001). Teleshopping in turn, refers to a case in which one or more of those activities are conducted through the use of telecommunications technologies (Nagurney et al, 2002). In this case, shopping trips are made via the Internet.
On-line shopping for household products, consumables, and specialist items such as books and publications has important connotations for travel behaviour, since this activity is more repetitive and regular than other types of shopping (Golob & Regan, 2001). There is some evidence to suggest that tele-shopping serves more for collecting information than for actual purchases (Teo, 2002). However, on-line sales (in the US) are increasing 25% a year and they have the potential to constitute an even larger percentage of total retail sales (now only 1.3% in the US, but likely to continue to grow).

The assumption that customers are cost minimizers and therefore substitute tele-shopping for store shopping must be qualified. It is possible that tele-shopping results in excess travel. If customers derive utility from shopping, they could go to the mall, even though they make their purchases via the internet (Cyber dialogue, 2000).

The main interest in teleshopping builds upon the hypothesis that delivery by the provider is more efficient in terms of vehicle kilometrage, pollution and energy than delivery based on consumer travel (e.g. Cairns, 1996). A number of parameters describing the delivery level of services warrant additional research to test the above hypothesis. These include temporal reliability, perishability of products, urgency and of course the geographical distribution of the customers.

There have been several attempts to model the phenomenon of e-shopping versus shopping, but none of them deals yet with the impact on transportation (Nagurney et al. 2001, 2002; Dholakia et al. 2000). A few researchers have conducted simulation analyses of the transportation impacts of B2C e-commerce under various assumptions (Marker and Goulas, TRR 1725, 2002; and Mathews et al. TRR 1763, 2002).
Future research on e-shopping

The topic of teleshopping is a newer concept in the state-of-the-art; especially its impact on transportation issues has received little attention to date. Given the increasing use of Internet and the percent of e-shoppers around the world, there is a strongly need for further research in this topic.

A next research related to the impact of e-shopping on travel behavior should include further data collection and analysis of cases of e-shopping and decision model development. In any case, modeling e-shopping and not e-commerce, doesn’t reflect the whole effect on travel (shopping, purchasing and delivery).

3.2 Work Related Arrangements

Flexible working arrangements refer to the spatial and temporal flexibility of working at home or at a remote centre. Home-based and mobile information technology has also improved the ability to be self-employed by increasing efficiency of communication with clients, suppliers and collaborators. As the number of people working in the service sector increases, home computers and Internet access has increased the possibility of flexible working arrangements (Golob and Regan, 2001).

Probably the most researched application is that of telework3 the potential substitution of the journey to work' thereby reducing congestion and negative environmental impacts had drawn much attention since the 1970's (Armfield, 1999; Golob and Regan, 2001; Mokhtarian and Salomon, 1997).

The most obvious effect of home-based working is a decreased trip frequency to work. However, it is possible that the trip-chaining pattern as a whole are changed in response to a temporarily, spatially or omitted trip to work. If the work trip never takes place, activities that previously were performed in connection to

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3 The American use the telecommuting for work performed at home or at a neighborhood center, using ICT and substituting or altering the journey to work. The European use the term telework for telecommuting but in fact telework represents a broader spectrum of work done from a distance, using mobile telephony or client-based facilities.
the trip to work might generate new travel. On the other hand, new destinations might be found closer to home. Long-term affects on land use, would also influence travel pattern (Mokhtarian 1997).

Other hypothesised effects of flexible working arrangements concern the temporal changes of trips and travel mode. The ability to avoid making trips during rush hour is likely to have an effect on travel duration as well as travel mode (Mokhtarian 1997 and Mokhtarian et al 1995).

The overall travel mode split for work trips might also be affected if workers that are going to work by public transport or by bike are more likely to telecommute. On the other hand, mobile communication devices, which allow communication to take place during a trip, can perhaps make transit travel less strenuous (Golob and Regan 2001, Mokhtarian 1997 and Mokhtarian et al 1995).

Most research in this area has addressed the advantages and disadvantages of working at home and provided some forecast of the number of telecommuters, translating these forecasts into travel savings (Niles, 1994; Mokhtarian et al., 1995; Salomon, 1998). Many studies have examined attitudes toward telecommuting (DeSanctis, 1984; Duxbury et al., 1987), preference for telecommuting (Bagley and Mokhtarian, 1997; Mokhtarian and Salomon, 1997; Stanek and Mokhtarian, 1998), choice of telecommuting (Bernardo et al., 1993; Mahmassani et al., 1993; Mokhtarian and Salomon, 1996b), and characteristics of telecommuters (Yap and Tng, 1990; Hartman et al., 1991).

Koenig et al. (1996), have investigated the impacts of telecommuting on travel behavior and personal vehicle emissions for participants in the State of California Telecommuting Pilot Project. Henderson and Mokhtarian (1996) provided the first analysis of the impacts of center-based telecommuting on individual behavior and emissions, using travel diary data from the Puget Telecommuting Demonstration Project. Varma et al. (1998) studied the impacts of telecommuting on the demand for equipment and services as well as the demand for travel. They examined, in the context of center-based telecommuting, how often individuals
telecommute, the duration of their telecommuting participation, and causes of attrition among telecommuters.

Mitomo and Jitsuzumi (1999) argued that the existence of positive externalities suggests that the social marginal benefit of telecommuting is greater than its private marginal benefit. They estimated the effect of telecommuting based on the forecast that the use of this new style of work will soon begin to accelerate, with from 14.5 to 28.3% of the total workforce telecommuting by 2020.

Optimistic forecasts of the impact of telework on transportation may be attributed to two factors. First in many cases the research focuses on users’ stated preference as opposed to revealed behavior, was a stated preference is poorly phrased. Second, in many cases a head count of telecommuters is investigated rather than a count of telecommuting occasions. The former assumes that telecommuters substitute a fixed and high share of their work trips, whereas the latter is based on findings showing that the average telecommuters in the United States does so only 1.2 days a week (Mokhtarian, 1998). Varma et al. (1998) suggested that there is underestimation a third factor. That is, many who start telecommuting don’t continue to do so for very long. Critical assessments of telework are suggesting a very limited adoption rate (Mokhtarian and Salomon, 2002).

**Future Research on Work Related Arrangements**

Major questions about telework remain unanswered and warrant more research. For example research questions of interest concerning flexible working arrangements can be formulated as:

- How many people that have the possibility to telecommute or have more flexible work times (which might depend on such as technology access, job suitability and the employees' attitudes).
- How will trip frequency, travel mode and travel time to work be affected?
• How do such effects depend on personal, environmental and the available technology characteristics?
• How is non-work travel affected?
• How is residential location affected?

3.3 ITS and Travel Behavior

Intelligent Transportation Systems (ITS) apply information and communication technologies to collect, process, and utilise, traffic and transportation related information in the form of control and guidance. By utilising concise information on the state of the transportation system, ITS offer the promise to enhance mobility, safety, and traveller convenience. Traveler information can be used not only to improve trip-related decision-making, but also to influence driving behavior during the trip (Polydoropoulou and Ben-Akiva, 1999; Lappin, 2000).

Different aspects of traveler behavior which are likely to be impacted by the availability of ATIS:

1. ATIS Awareness and Usage
2. Travel Response
   a. Pre-trip choices
   b. En-route adjustment/diversion
3. Learning

We present selected research conducted on each of the topics to demonstrate trends in analyses and findings.

(1) ATIS Awareness and Usage

Awareness and usage rates of ATIS can be obtained from the general public in markets where ATIS services are commercially available. Polydoropoulou (1997) proposed a behavioral framework for awareness, trial usage and repeat use of the
SmarTraveler ATIS in Boston. The study showed that individuals who have cellular phones and perceive information as important are more likely to be aware of and access traffic information. Polydoropoulou et al. (1998) introduced a methodology to model consumers willingness to adopt really new products and services such as ITS. Trial users' willingness to adopt was significantly affected by their level of satisfaction with the service, while for non-users perceived benefit is an important determinant of adoption.

A survey addressing the users of Washington State Department of Transportation Traffic Conditions Web Site (WSDOT) (Lappin and Peirce, 2002a) showed that WSDOT web site is heavily used for commute trips. In particular, commuters overwhelmingly accessed the web site for trips from work or school. In addition, those who had less flexibility in the trip to work or to school were more likely to use the site, than those who had more flexibility. People also, emphasized avoiding traffic congestion and traffic savings as their main reasons for making changes to their trip from work or school. Nearly 97% of commuters who used the site for this type of trip said avoiding traffic congestion was a very important reason for making the changes they did.

A consumer satisfaction survey for traffic information web page users, in Los Angeles region (Lappin and Peirce, 2002b) revealed that customers who learned about traffic problems before going to work/school, were just as likely to change the time they leave (41%), as to take a whole different route (41%), or to make small changes to their normal route (41%). When learning about traffic congestion before they traveled from work/school, customers are more likely to change the time they leave from work/school (71%), to make small changes to their normal route (70%), and to take a whole different route (60%). The percentage making stops that they otherwise would not have made are significantly larger for the afternoon commute (33% vs. 12% pre-work/school).

The Puget Sound Regional Council (PSRC) (Peirce and Lappin, 2002) conducted a large-scale survey over 3000 Seattle-area residents in order to investigate the use of traveler information sources and to examine the impacts of information acquisition on travel behavior. The diary entries of this survey indicated that
respondents used some form of traveler information on 3.2 percent of their total trips. Information usage proved to be higher for trips that took place during the peak congested periods and on those trips—such as to work or to the airport—that are more arrival time-sensitive. Regarding the behavioral response to information, this survey confirmed earlier results, which have shown that effects on mode choice appear to be minimal.

(2) Travel Response

Most research based on ATIS focus on the impact of radio traffic reports, Variable Message Sign Information (VMS), telephone services and in-vehicle on drivers' route choice behavior. Some surveys have asked interviewees to recall an incident-induced travel delay and the effect of information on their route choice decisions, while others have obtained detailed diaries of daily trip behavior, information acquisition and usage for a designated period of time. The latter type of survey consisted of identical questionnaires to be filled in on consecutive weekdays, with each questionnaire related to that day's commute. The questions asked related to pre-trip and en-route traffic information acquisition, their influence on the travelers' decisions, and the updating of perceptions for system and trip characteristics.

a) Models of Pre-Trip Choices

Khattak et al. (1999) conducted mail questionnaire surveys as part of the San Francisco-area TravInfo project and asked respondents about the effects of pre-trip travel information (available from television, radio or telephone sources) on their trip making decisions. Abdel-Aty (2001) studied the case of transit information systems and their potential influence to the commuters’ behavior. Two sets of variables were found significant: 1) variables that represent the commute attributes and the socioeconomic characteristic and 2) dummy variables representing levels of each transit attribute provided by the information system. The results indicated that 38% of non-transit users might consider transit use if appropriate transit information was available to them and about half of them were
likely to use transit if their preferred transit information were provided.

b) En-Route Adjustment/Diversion

Al Deek et al (1998) developed a modelling framework for evaluating the effect of ATIS. The framework used a composite assignment model, which combined a probabilistic traveller behavior model of route diversion and a queuing model to evaluate ATIS, impacts under incident conditions. The model considers three types of travellers: 1) those that are unequipped with electronic device, 2) those who receive delay information from radio only and 3) those that access ATIS only. Results from the composite assignment model showed reduced average travel times with increased radio and ATIS penetration. The benefits of ATIS under incident conditions are expected to be marginal when there is more information available to travellers through their own observation or radio. This is because radio causes people to divert earlier resulting in network conditions closer to system optimal than user equilibrium.

Lianeras and Lerner (2000) conducted a survey on ATIS traffic information acquisition and travel response. The study involved in-vehicle ATIS which provided basic descriptive and qualitative information, on incidents and congestion, as well as details about alternate routes. Hato et al. (1999) conducted a survey targeting drivers traveling, on the Tokyo Metropolitan Expressway network, where drivers can actually make use of traffic information from multiple sources when choosing their route. Dia (2002) conducted a survey with mail-back questionnaires that were distributed to peak-period automobile commuters traveling along a traffic commuting corridor in Brisbane, in order to investigate the individual driver behavior under the influence of real-traffic information. Decisions that were investigated included pre-trip response to unexpected congestion information; en-route response to unexpected congestion information; and willingness to change driving patterns. Chatterjee et al. (2002), conducted a study on driver response to VMS in London. Two questionnaire surveys were developed and distributed in 1997. The first questionnaire investigated the attitudes of drivers to VMS. The second questionnaire asked drivers how they
would respond to different VMS signs and collected SP data on diversion
decisions. Bonsall and Palmer (2000) used VLADIMIR route-choice simulator to
study the response of drivers to VMS.

(3) Learning

Mahmassani and Liu and (1999) presented both a model framework and an
empirical analysis of tripmakers' indifference band for departure time and route
switching behaviour in response to real-time information. The analysis focuses on
the day-to-day dynamics of commuter pre-trip departure time and route choices as
well as en-route path switching for morning commutes. The specifications of the
departure time and route consist of the following components: (1) initial band, (2)
user characteristics component, (3) information reliability component, (4) myopic
component, (5) schedule delay component, incorporating individual preference,
and (6) unobserved component. The model parameters were estimated using a
special purpose maximum likelihood estimation procedure that relies on Monte-
Carlo simulation to evaluate the MNP choice probability.

Ozbay et al. (2001), proposed the use stochastic learning automata (SLA) to
analyze drivers' day-to-day route choice behavior. This model addresses the
learning behavior of travelers based on experienced travel time and day-to-day
learning. In order to calibrate the penalties of the model, an Internet based Route
Choice Simulator was developed. The calibrated SLA model was then applied to
a simple transportation network to test if global user equilibrium, instantaneous
equilibrium and driver learning have occurred over a period of time. It was
observed that the developed stochastic learning model accurately depicts the day-
to-day learning behavior of drivers (Lappin and Bottom, 2001).
Future Research on ITS

Current research has relied on incomplete information about traveler choice profiles, has focused on driver behavior, and specifically on pre-trip and en-route usage and travel response while few studies have addressed market penetration issues of ATIS. Further research should:

- Capture travelers’ response to alternate types of ITS: web-based traffic information, television, radio in different metropolitan areas, VMS;
- Address all stages of user response to ITS; and
- Model the complexity of travelers behavior to evolving technologies and network’s stochastic nature:
  - consideration set formation;
  - learning;
  - change in attitudes, perceptions, and preferences over time

Furthermore, more research needs to be conducted on the traveler services information, ride matching and reservation, electronic payment services, and emergency notification and personal security information systems. Finally, further research should focus on the impact of ITS on transportation network.

4 E-ECONOMY IMPACTS ON FREIGHT

4.1 Introduction

An industry panel of Logistics experts was conducted to gain insights of the future and illustrate the likely impacts, identifying “state of the art” practices from leading companies. The aim was to understand the practical industry application
that supports the dynamic nature of business strategy, and specifically what structural supply chain change is taking place or envisaged for the future.

Forty participating senior managers, from companies with significant supply chain operations (pharmaceutical and healthcare, food/beverage, electronic and technology, clothing/textiles, automotive, general merchandise), were asked to complete a comprehensive supply chain questionnaire. Analysis of the participant list shows that the panel has representation from all aspects of the supply chain:

- **Users (42%)**: Companies requiring and using transport services (e.g. retailers and manufacturers);
- **Providers (36%)**: Companies providing transport services (such as logistics service providers);
- **Enablers (22%)**: Companies providing services to enable transport services (e.g. software houses)

Of the participants classed as "Users" there was representation from many industry sectors. Providers and enablers typically represent a variety of industry sectors.

### 4.2 Main findings

A key observation from the survey results is that the e-economy is recognised predominantly to be an enabler of restructuring and change, but rarely the driver. The key driving factors are reducing costs and improving customer service and responsiveness. The following section summarises the opinions regarding the impacts of e-economy on transport-related issues.

**Transport modes / vehicle sizes**

Views on transport modes and vehicle sizes were broadly split into 3 categories: inbound primary transport, secondary B2B transport (e.g. warehouses to retail outlets) and home delivery transport.
For inbound transport, the related impacts of supply chain restructuring (see above) results in an unavoidable change in transport mode – predominantly using more sea freight in the upstream supply chain. Additional comments also suggest that there is a trend towards larger vehicles for primary distribution, for example, double-decker trucks. However, cost and reliability issues are still a barrier for many when considering rail as a viable transport alternative and there is little expectation of an increase in the use of this mode. That said, there are a number of examples where rail is used – one notable example being primary distribution to Scotland for a leading UK retailer.

Transport modes for secondary B2B transport is not expected to change. Increased frequency, resulting in smaller order sizes, may potentially result in smaller vehicles being more cost effective, but increased usage of shared user transport (see later) is likely to negate this impact.

Home delivery transport is seen to be the major impact. It has not introduced a new mode of transport as home delivery in small trucks already existed, but there will be much more of it. Theoretically there will be a change in mode as small truck commercial deliveries replace private car journeys.

*Demand for transport*

Demand for transport is very much related to some of the supply chain structure and customer demand changes already described.

With more global and consolidated supply chains, goods will travel further. Similarly, expectations of increasing order frequencies and shorter lead-times will increase the proportion of part-load deliveries. Unfortunately, there was not a relevant sample of participants from sectors where dematerialisation of goods transported may have an impact (e.g. postal services, music and video) to draw any firm conclusions. However, one participant with extensive postal service experience stated that there is some evidence that postal services are beginning to see a reduction, but it is not significant. He added that from a transport perspective, there is minimal impact on the need for the trip (as there will not be a total removal of the "hard" media), the trip is just less efficient (smaller drop size without a reduction in the cost of the drop).
Procurement

50-60% of participants believe there will be more use of shared-user transport. This is generally consistent with 2 other factors already discussed, namely the increased use of shared-user warehouses and the changing role of warehouses (to consolidation centres).

The remainder, who expect no change or a reduction, typically relate to larger enterprises where significant scale economies in the internal transport exist within the organisation. These organisations will continue to use single-user transport operations, using the e-economy to improve the performance internally rather than use it to enable performance improvement from easier access to shared-user transport. Another barrier to shared-user usage is competition – a number of respondents stated that shared-user often implies sharing with competitors and that a number of larger organisations would never consider this a viable option. Even the development of 4PL companies appears to have no impact in this area.

The procurement of transport is undoubtedly being centralised in organisations, either nationally or internationally depending on the size and geography of the organisation.

The e-economy has a direct impact on transport procurement through freight exchanges and e-procurement portals. The general conclusion is that freight exchanges will be used for smaller organisations where transport is not "regular" and they provide easy access to available capacity for all routes and modes. However, these tools are not relevant to the larger organisations where transport is "regular" and predominantly single-user.

The use of e-procurement tools for tendering for transport contracts is expected to increase, but not significantly. 16% disagree strongly that sourcing transport will be done in this way, again attributable to the larger single-user respondents.

Planning & management

E-economy and technology developments will have a significant impact on the planning of transport. Although 55% perceive that planning will be easier, interestingly 23% think it will be more difficult as there will be more information available and more complex networks to plan. Presumably, the 55% who think it
will be easier believe the technology developments are advancing at a faster rate than the increased complexity.

Increased shared-user operations and the available technology are enabling more centralised planning of transport that is managed across multiple enterprises. Transport plans are likely to be updated using real-time traffic status information – continually rescheduling to optimise utilisation and costs (e.g. as trip requirements change or trip times are affected by congestion).

From a transport management perspective, an increasing use of telematics (e.g. digital tachographs, vehicle diagnostic tools) will improve the day to day management of the vehicle fleets and drivers, with information collected and analysed automatically.

Service delivery

Customers are expected to be kept informed in real-time of the status of deliveries (specifically variations to plan), enabling corrective planning and rescheduling with minimum disruption. Enabling technology includes the use of sensors, such as RFID tags, to automatically provide the information on status and location in the supply chain. Vehicle tracking has been around for many years but in addition, such sensors will be used to track both individual transport units (e.g. pallets, cages, etc.) and individual products.

The data provided by the sensors will not only supply customers with information regarding order status but will also feed real-time information back into the planning and scheduling systems to optimise supply chain performance.

As a result of this tracking capability there is a unanimous agreement that the security of transport operations will increase and that the availability of accurate and timely data will reduce errors throughout the supply chain, thus reducing the occurrences of inefficient and expensive re-delivery.

Efficiency & utilization

Participants were asked to consider the impacts of the e-economy on efficiency and utilisation of transport in isolation from other factors.
The e-economy is expected to reduce delivery times overall, a combination of reduced waiting, significantly reduced administration and potentially a marginal improvement in the physical loading / unloading times. Waiting times are expected to reduce as information flows improve, providing accurate data on arrival times so that resources are ready at the right time. Administration times will benefit significantly from the use of information such as advanced shipping notes (ASNs), electronic PODs (proof of deliveries), electronic invoicing and funds transfer. Physical loading / unloading is only expected to improve marginally (or stay the same) through the use of sensors that potentially remove checking activities. The use of "assumed receipt" (receiving deliveries without checking assuming the paperwork is correct), especially for internal transport legs, has already had an impact in this area.

The 2 main measures of vehicle utilisation are time utilisation (active hours versus total hours available) and fill utilisation (volume / weight used versus capacity for forward and reverse trips).

68% of responses think time utilisation will increase (but not significantly), 21% think there will be no change and 11% believe it will decrease.

58% of responses think that vehicle fill utilisation will increase, 21% no change and 21% think there will be a decrease. Again, nobody believed the changes would be significant.

The main drivers for increases in utilisation are the increased use of shared-user transport supported by the improvements to scheduling through more information and better systems. Shared-user operations have the opportunity to combine flows from multiple operations to increase utilisation, whilst companies using single-user transport have improved utilisation through increased use of supplier collections on return trips from outbound journeys (backhaul).

The responses indicating a decrease in utilisation suggest that although they agree with the improvements just stated, external factors (e.g. more demanding customers) and regulations (e.g. restrictions on vehicle size or access times in town centres) will cancel out (or even reverse) the improvements.
Environment

In the final section, participants were asked their opinions on the environmental impacts that the e-economy is having on freight transport. The responses were consistent with 2 main impacts.

Firstly, the increasing use of home shopping has a detrimental impact, putting more freight vehicles on the roads in residential areas. Participants also agreed that home deliveries are predominantly small drops and as such are not the most efficient operations. (Participants were not asked their views on the impacts on the use of personal vehicles in this survey.)

Secondly, the e-economy is a key enabler of improvements to transport operations. More information and better technology all theoretically enable higher utilisation and less "like-for-like" tonne-kms. However, there are a number of non e-economy factors that are either barriers to a widespread improvement or simply cancel out the improvements achieved. The key factors are:

- Increasing customer demands (e.g. more frequent smaller orders, tight delivery windows);
- Increasing legislation (e.g. working time directive, regional access hours, etc.); and
- Competition barriers to shared-user solutions and collaboration.

The overall impacts on the environment are illustrated in Table 2.
<table>
<thead>
<tr>
<th></th>
<th>Significantly decrease</th>
<th>Decrease</th>
<th>No change</th>
<th>Increase</th>
<th>Significantly increase</th>
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<tr>
<td>Road congestion</td>
<td>0%</td>
<td>11%</td>
<td>17%</td>
<td>44%</td>
<td>28%</td>
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<tr>
<td>Vehicle-kms</td>
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<td>33%</td>
<td>50%</td>
<td>17%</td>
<td>0%</td>
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<tr>
<td>Pollution</td>
<td>0%</td>
<td>66%</td>
<td>28%</td>
<td>11%</td>
<td>5%</td>
</tr>
</tbody>
</table>

Table 2. impacts of Freight Transport on the Environment (N=40)

For road congestion, the e-economy is considered both a driver of increased congestion (through home shopping) and an enabler of decreased congestion (through improved efficiency).

For vehicle-kms, the e-economy is considered both an enabler of increased vehicle-kms (mainly through resulting supply chain restructuring) and an enabler of decreased vehicle-kms (through improved efficiency).

Accidents and pollution are generally related to the other factors (such as congestion), and participants do not believe the e-economy has any direct impact on these.

These results confirm that the general feeling is that, despite the e-economy enabling more efficient transport on a like-for-like basis, other changes are having a bigger impact and the net result for the environment is an increase in congestion and an increase in total vehicle-kms.

Applications

Impact on transport

Participants were asked their opinions on the impact of a range of e-economy applications on transport scoring each application as significant, partial or none.
Figure 2. Impacts of application on transport

Advances in the capabilities of advanced transportation planning systems are expected to impact transport the most. The capability of these systems incorporate multi-country, multi-site, multi-fleet routing and scheduling taking into account real-time traffic flows, congestion and delivery/collection patterns to optimise routes and vehicle utilisation from plants to distribution centres, distribution centres to stores, and so on.

The three applications relating to track and trace/visibility have the three highest percentages for having some impact on transport. The fact that these applications provide the data for the transport planning systems means they are an integral part of delivering transport optimisation.

Similarly, the range of telematics applications are all expected to have significant impacts. Mobile communications, navigation systems and GPS all score highly
and fleet management is also in the top 12. These systems also provide some of the data key to the transport optimisation process.

Freight exchanges come lower in the impact rankings, consistent with the perception that they are only applicable to a certain category of transport user (see previous category).

Two applications with indirect links to transport fall into the top 12 rankings. The inclusion of decision support systems supports the argument that "if you can measure it, you can manage it", whilst supply planning systems are successfully developing integrated supply chains, including transport.

**Level of adoption**

Participants were asked the status of implementation of e-economy applications, both currently and what is predicted within 5 years.

![Graph showing the implementation status of various applications](image)

**Figure 3. Implementation of applications with high transport impacts**
Interestingly, the track and trace / visibility applications are expected to be adopted in businesses more than any other applications. Parcel carriers have been using these systems for many years now and the benefits are clear – both in providing service to customers but also feeding information into the whole supply chain process. With proven benefits, companies across all sectors are beginning to implement these applications.

Currently, there is very low adoption of advanced transport planning systems - the application expected to have the most significant impact. However, this category of applications does have the most significant growth in terms of implementation, very much linked to the anticipated benefit.

Differences in the telematics category of applications perhaps explain some of the trends in the adoption of applications. Both navigation systems and GPS – and to a degree fleet management – are relatively new technology, and potentially, companies are waiting for compelling evidence of the benefits and suitable return on investment (ROI) before implementing these systems. On the other hand, mobile communications are relatively cheap and easy to implement and this may be a key factor in the relatively high level of implementation currently.

The level of adoption of most applications within 5 years retains this differential with the relatively higher cost / difficult to implement applications lagging behind the proven ROI applications. For specific applications, such as freight exchanges, adoption by businesses is related to their relevance to each company.

**Summary**

In the opinion of the industry panel for POET, although the e-economy is not the driving force of changes to freight transport, it is having some major impacts as an enabler. But there are two opposite characteristics to the impacts of the e-economy on transport.

Firstly, there is a detrimental impact on transport in both B2B and B2C markets. In B2B, the e-economy has enabled customers to become more demanding, resulting in increased pressure on lead-times, increasing delivery frequencies and smaller order sizes. In B2C, e-economy developments have promoted home delivery as a shopping option to everyone, resulting in an increase in the use of small drop, residential deliveries to the majority of residential areas.
Second, contrary to the negative impacts, the e-economy is also helping to improve transport by enabling greater and greater optimisation of the resources. Cheaper access to accurate, real-time information across the supply chain is used by advanced planning systems to optimise both internal and shared-user transport operations.

However, one key output from the industry panel is the mixed level of adoption of e-economy related applications and the reasons behind this. The consensus is that home delivery is an increasing distribution channel and customer demands are increasingly pressurising transport systems. Conversely, progress in areas where the e-economy should improve transport efficiency is not so rapid, and the reasons are not restricted to how quickly the relevant applications have been developed.

Theoretically, the technology is available, but in reality there are a number of reasons why many applications are not implemented in businesses as standard. From an economic point of view, transport is not always necessarily one of the significant costs for a company and savings from implementing transport technology does not necessarily provide a better return than other potential investments. Also, many companies are not prepared to collaborate with their competitors – they either have significant transport scale in their own organisation, or despite recognising that there are savings to be had, the threat to competitiveness prevents any progress.

Finally, constraints out of the control of companies mean that even the pioneers of supply chain management advances believe that they are only managing to maintain the status quo. Legislation with no direct link to the e-economy, such as city centre exclusion times and the working time directive, are posing additional constraints on the transport system and, at best, supply chain developments are enabling companies to keep pace with the new demands.

Taking all impacts into consideration, when asked what the overall change in vehicle-kms would be, 72% of responses estimate an increase or significant increase, with only 11% predicting a decrease. There is obviously much work to be done.

Businesses are primarily focussed on delivering value to their customers and stakeholders. Transport efficiency and the impacts on the environment are not
always recognised as being a priority in delivering company results. As one member of the industry panel suggested, "legislation will have a role to play in encouraging companies to adopt e-technology that supports efficient and environmentally friendly transport systems".

5 CONCLUSIONS AND FURTHER RESEARCH

This paper presented a methodological framework for Predicting the impact of E-Economy on Transport (POET). Major ITCs and communication patterns among actors were identified. Findings from the State-of-the-Art on the effect of teleshopping, teleworking, and ITS applications on passenger transportation were presented. Finally, the results from an innovative survey of a panel of Logistics experts showed that e-economy may have significant impact as an enabler on freight transport.

Further research involves the analysis of actual case studies offering a way to learn about how the various actors identified in this paper are currently responding to developments in the e-Economy. An innovative characteristic of POET is the development of virtual case studies to gather information about the possible responses of actors to future situations, situations that do not yet exist. The virtual case studies build on and go beyond what is done in stated preference surveys by not just asking questions about hypothetical choices, but actually placing respondents in realistic virtual settings in order to make their choices, using Information Acceleration simulators. Finally, POET will model the impact of the e-Economy on transport (mode share, temporal distribution of trips, energy use and other environmental impacts) and the resulting impacts on energy use, emissions, social exclusions, and the competitiveness of five European cities and regions.
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