

The Impact of the e-Economy on Transport

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ABSTRACT

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 highly uncertain. This paper presents an overview of the methodology and main findings of the EU project: “Prediction of the impact of e-economy on transport (POET).”

The methodology involved the following steps: (1) Development of System Diagrams; (2) Development of future scenarios; (3) Actual case studies; (4) Virtual case studies; and (5) City transport simulation modeling.

The system diagrams depict along which lines the e-economy, together with other factors, influences transport and transport-related outcomes. The scenarios allow for different rates of uptake of Information and Communication Technologies (ICT’s) and potential developments in the e-economy by 2010 or 2020. The actual case studies give examples of applications (often ‘best practice’) of the e-economy in transport, whereas the virtual cases investigate the likely behaviour of individuals and organisations under different assumptions about the availability and quality of ICT and related institutional arrangements). Existing regional transport models for five specific urban areas in Europe were applied with new models estimated on the virtual case study data to produce forecasts of the impacts of the e-economy on transport and transport-related indicators (e.g. emissions) under various scenarios.

More information about POET can be found at <http://www.poet-eu.org/>.

Key words: E-economy, ICTs, System Diagrams, Stated preferences data, modeling traveling behavior, cities and regions modeling

1. INTRODUCTION

Developments in the e-economy have the potential to affect the supply and demand for transport in many ways. The goal of the POET project¹ was to estimate the potential impacts of the e-economy on the future demand for and supply of passenger and freight transport and similarly to understand the opportunities presented by the digital revolution for improving the quality of life of Europe's citizens by mitigating the adverse impacts of transport.

Although the e-economy has been the subject of considerable attention, still not much is known about its impacts on passenger and freight transport or about the path along which the e-economy will develop. The most researched applications of the impact of ICT on travel are related to the influence of travel information on passenger behavior/freight logistics, teleworking and e-shopping activities (Golob and Regan, 2001).

Research on telework mainly focuses on the direct effects on travel demand by forecasting the number of telecommuters, the quantity of telecommuting occasions, the substitution of commuting and the potential travel savings (Arnfolk, 1999; Golob and Regan, 2001; Mokhtarian and Salomon, 1997; Niles, 1994; Mokhtarian et al., 1995; Salomon, 1998). Forecasting the range of telecommuting is based on studies of attitudes toward telecommuting (DeSanctis, 1984; Duxbury et al., 1987; Mokhtarian and Salomon, 1996a; Handy and Yantis, 1997), preference for telecommuting (Mokhtarian and Salomon, 1997; Stanek and Mokhtarian, 1998), choice of telecommuting (Bernardino et al., 1993; Bernardino and Ben-Akiva, 1996; Mahmassani et al., 1993; Mokhtarian and Salomon, 1996b; Yen et al. 1998), and characteristics of telecommuters (Yap and Tng, 1990; Hartman et al., 1991). A growing body of literature recognizes some indirect impacts of telecommuting on the timing of trips, modes of travel, and activity programs, including the possibility of increasing travel for non-work related trips as a consequence of reduced opportunities to travel (Handy and Mokhtarian, 1996; Shen, 2000; Giuliano, 1998). Furthermore, several studies investigate the actual relationship between transportation, communication, and spatial structure (Shen, 1999; Shen, 2000; Nazem et al. 1996; Black, 2001); telecommuting and residential choices (Ellen and Hempsted, 2002; Mokhtarian et al., 2004). However, as Mokhtarian et al. (2004) mentions, very little is known about the long-term effects of telecommuting on activities such as residential location, although a later analysis of the same data makes a much stronger statement on causality i.e. the residential relocation causes the telecommuting (Ory and Mokhtarian, 2006).

E-shopping allows internet users to purchase goods and services via the Internet without physically reaching any shop. So far, analysis of e-shopping behaviour relies mainly on Revealed Preferences (RP) data (see for example Chang et al., 2005 for a review of such empirical studies). These studies focus on understanding consumer e-shopping adoption as a function of several factors such as attitudes and perceptions of individuals (Frag et al. 2005b, Ferrell, 2005); socioeconomic characteristics (Frag et al. 2005a); web-based attributes and consumer product characteristics (Chang et al. 2005). A growing body of research also focuses on the impacts of e-shopping on traditional shopping trips (Handy and Yantis, 1997; Casas et al., 2001; Ferrell, 2005). The expected benefit of e-shopping on transportation demand is

¹ The acronym is a contraction from "Prediction of the impact of the e-economy on transport". POET was funded by the European Union under its 5th Framework programme on "Competitive and Sustainable Growth". The POET consortium consisted of the following organisations: RAND Europe (coordinating partner), Transek, ITS Leeds, ARPA, Hebrew University Jerusalem, PRODOS, Kessel + Partners, TRAIL and Solving International.

the reduction of shopping trips (substitution effect) and the possible reuse of the saved travel time for other purposes/activities and trips (complementarity effect) (Ferrell, 2005). However, the substitution and/or complementarity effect of e-shopping varies among case studies and the impact of e-shopping activities on transport network conditions is still unclear (Handy and Yantis, 1997).

There is a considerable literature on emerging and expected logistic trends (e.g. ELA and A.T. Kearney, 2001; Eurocase, 2000; Runhaar, 2002; Skjoett-Larssen, 2000; van Hoek 1999). Also, freight transportation planning models are regularly used by regional national and international authorities, such as the European Commission, for transport policy and infrastructure planning (for an overview, see de Jong et al, 2004). But very few studies have tried to quantify the impact on freight tonne-kilometres, or vehicle-kilometres, that developments in electronic communication might have through changes in logistics behaviour (Brown, 2001; HOP Associates, 2002; Pouloudi et al. 2001).

In order to extend the current knowledge of the impacts of ICT on transport, POET developed a methodology which included five main steps: (1) Development of system diagrams; (2) Development of future scenarios; (3) Actual case studies; (4) Virtual case studies; and (5) City transport simulation modeling.

POET used a systems approach as a starting point for understanding the impacts of the e-economy on the demand for passenger and freight transport. Specifically, it developed comprehensive and detailed *system diagrams* that integrate physical elements of the transport structure with behavioural aspects of transport-related choices made by various actors (firms and businesses, households and individuals, and governments).

In order to understand the potential impacts of the e-economy on the future demand for passenger and freight transport in cities and regions, the external factors driving these impacts were identified. Since forecasting these factors, called Forces Driving Structural Changes (FDSCs), and the impact thereof was complex, POET developed several *scenarios* (coherent pictures of plausible futures) describing different potential futures. The scenarios, which focus on the years 2010 and 2020, described exogenous variables that may influence the volume of freight and passenger transport. These scenarios helped us to conceptualise the impacts of the e-economy on passenger and freight transport and provided an input for the virtual case studies and modelling work conducted in later stages of the project.

POET developed and analysed *actual case studies* to shed light on the way that the various actors are currently responding to developments in the e-economy. For freight transport, case studies were selected to cover the different types of company involved at different stages in the complete transport chain and supply network. For passenger transport, case studies were selected to cover a range of initiatives influencing the volume and manifestation of travel demand.

An innovative aspect of POET was 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 built on and go beyond what is done in stated preference surveys by not just asking questions about hypothetical choices, but by using alternative briefing texts to test the robustness of the respondents' opinions. Various actors (firms and businesses, households and individuals) were presented - in-person or via the Internet - with realistic future scenarios describing new technologies, transport infrastructure and market conditions. The actors were then asked to indicate their preferences

or forecasts of behaviour under these scenarios. The data from these choice experiments were modelled to identify the impacts of the e-economy on the demand for passenger and freight transport.

The scenarios and the virtual case studies provided the inputs to *models* used to forecast the impacts of the e-economy on urban transport. The outputs from these models were translated into the relevant impacts (such as congestion, level of emissions and energy use) for future time horizons such as 2010.

This paper presents an overview of the main concepts and methodologies developed within POET. It also summarises the findings from the actual case studies, the virtual case studies, and the city transport modelling and, based on these, presents recommendations for policy making.

The remainder of this paper is composed by 6 sections. Section 2 presents the system diagrams developed. Section 3 presents the scenarios for future development in an e-economy context. Section 4 describes the actual case studies and highlights the results found. Section 5 describes the virtual case studies and presents their main findings. Section 6 presents the application of the transport models in cities, and Section 7 presents the recommendations for policy making.

2. SYSTEM DIAGRAMS

POET's methodological framework included the development of system diagrams for passenger and for freight. These diagrams describe the functioning of the transport system in general and identify the choices made by individuals/households and businesses. The passenger transport system (see Figure 1) can be seen as a series of markets in which the desires of households and individuals (i.e. the demand side) are constrained by the opportunities offered to them (i.e. the supply side). The traffic pattern of households and individuals result from the exercise of all these choices and, in aggregate, result in a set of traffic patterns with associated transport, environmental, economic and social outcomes.

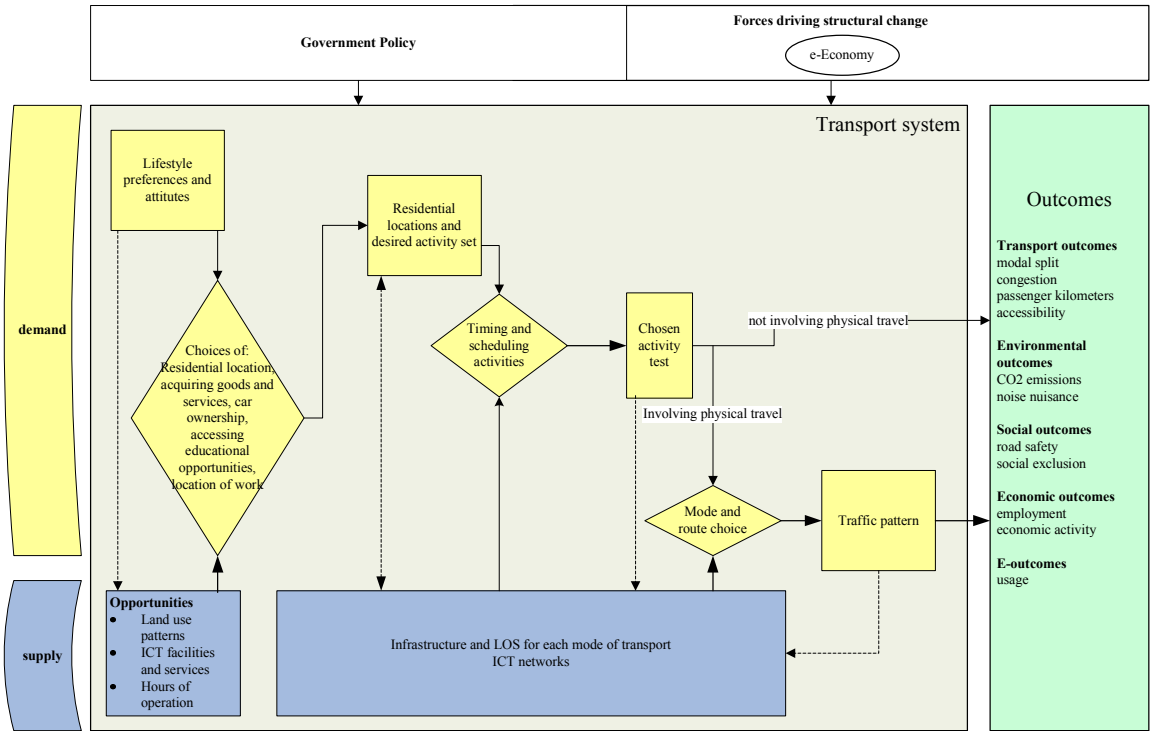


Figure 1: Passenger System Diagram

The freight system diagram (see Figure 2) shows that the decisions regarding freight transport can be placed in three markets: for distribution locations; for distribution networks and for distribution traffic. In each of these markets the demand and supply conditions help determine the nature of freight flows. Together, these three markets could be termed a distribution structure. Elements that are determined by the logical processes outlined in the diagram include: the location of distribution facilities, the choice of mode and equipment, the scheduling and planning strategy (resulting in a preferred volume/frequency balance, scheduling and timing preferences) and the routing strategy. The diagram also shows that there are three main types of goods to consider: equipment, consumables and parcels. These goods are moved by different collaborative configurations of manufacturers, retailers and logistics service providers. The collaborative outcome determines the shape of a logistics concept (indicated by the dotted box) for the distribution structure. The final outcome of the logistics concept is determined by a set of choices related to three main elements: distribution location, distribution network and distribution traffic.

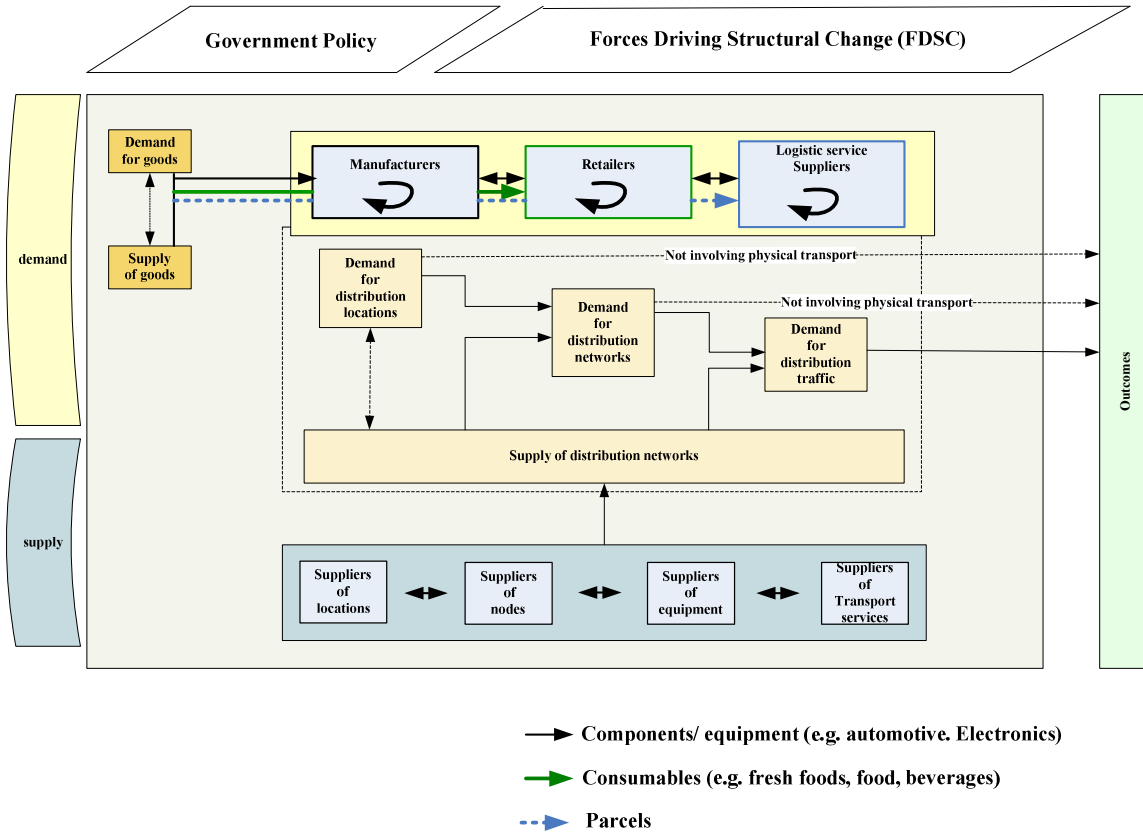


Figure 2: Freight System Diagram

3. SCENARIO DEVELOPMENT

In the design of the scenarios, we have followed a systematic approach consisting of the following three steps:

Step 1: Identification of the forces driving structural change (FDSCs)

FDSCs are forces outside the system that act on the system and can lead to structural changes in the system. The following categories of FDSCs were included: demographic, administrative, spatial, economic, technological, social, business and transport developments.

Step 2: Classification of the FDSCs

The identified FDSCs were classified according to their degree of uncertainty (predetermined or uncertain) and their relevance to the outcomes of interest (high impact or low impact). Although, there may be a great deal of uncertainty about an external change, its occurrence may have little effect on transport demand or supply.

Step 3: Design of the scenarios

In the design of the scenarios, uncertain and predetermined FDSCs in the high impact category form the basis for the scenarios, whereas uncertain FDSCs in the low impact category are ignored. FDSCs placed in the predetermined category were included in all scenarios. The uncertain FDSCs were used to identify the most important and relevant structural uncertainties that were taken into account in the scenarios, i.e. they formed the key dimensions of the scenarios.

These three steps led to the design of three scenarios each describing a plausible and coherent picture of the future of urban areas. We called these, perhaps rather unpoetically, “Stagnant City”, “Intelligent City” and “Networked City”.

The “*Stagnant City*” (SC) provides the reference scenario. In the stagnant city, although there is a large potential for usage of ICT the uptake of these technologies is low; despite encouragement from government organisations, businesses and individuals are hesitant to make use of these opportunities due to poor conditions in security, privacy and availability of products and services. Fragmented and contradictory regulation in areas such as spatial planning, and a lack of focus in policy, has led to dispersed and non-coherent housing patterns which do not allow for the development of efficient transport networks. These spatial characteristics together with a hesitant attitude towards technology result in a low uptake of ICT-applications and people preferring to live close to their work.

The “*Intelligent City*” (IC) is characterised by its large number of inhabitants and high population density. Extensive use is made of the available ICT, for example individuals use it as a complement to face-to-face contact with family, friends and colleagues. IC is a pleasant to live; people live close to their work, recreational facilities (such as shops, theatres, cinemas, restaurants, etc.), and friends. In passenger transport this has resulted in the implementation of advanced, high capacity public transport networks that seamlessly connect to inter-city transport systems, both public transport and road transport. Information on these systems is available in real-time through dynamic travel information. In freight transport, developments in communications (tracking and tracing, electronic consumer response systems) and planning technology (inventory and route planning) enable new logistic concepts to spread very fast.

The “*Networked City*” (NC) is characterized by urban sprawl because its inhabitants have a preference for living in suburban areas and in the city outskirts where they can take advantage of more spacious housing and more opportunities for outdoor recreation (such as parks, golf courses, etc.) combined with the facilities offered by the urban environment (such as theatres, shops, entertainment). People in the Networked City make extensive use of the available information and communication technologies to sustain this city structure. Information technology has become part of everyday life and people are using ICT applications in their working and leisure environments as well as for transport and shopping purposes. As such, ICT has been substituting unnecessary travel by enabling transactions over the Internet. Broadband Internet connectivity is affordable and high as is digital literacy, which all contribute to intensive use of opportunities offered by the Internet. Both government organisations and companies offer their employees opportunities for teleworking and government is also promoting teleworking by discouraging commuting trips through road pricing (mainly during peak hours). Government organisations have increasingly made their services available over the Internet and businesses have focussed on selling products and services over the Internet. The uptake of the e-economy in freight transport is not as fast as in the Intelligent City.

The three scenarios described possible futures of European cities. Although it is unlikely that any one of these futures will come true, the scenarios were useful as they helped us envisage how future developments, especially in the e-economy, may affect the functioning of the transport system. Specifically, we used these scenarios to design the Stated Preferences Experiments in the virtual case that studies the impacts of ICTs on re-location and teleworking decisions. In modelling the impacts of the e-economy on transport for specific urban areas (section 6) we focussed on an extreme scenario (called ‘High Adoption’) in which both passenger and freight transport witness a high uptake of the e-economy (IC for freight and NC for passengers), and on an scenario with an intermediate level for the uptake of the e-economy (called ‘Medium Adoption’: IC for passengers and NC for freight).

4. ACTUAL CASE STUDIES

The POET literature review (Polydoropoulou et al., 2004; POET D2, 2004) suggested that there is little evidence on the impact of ICT on passenger and freight transport. It was therefore decided to undertake several case studies to enhance our understanding of e-economy developments and their potential effect on transport. The selected case studies covered the impacts of developments in the e-economy on both passenger and freight transport.

The passenger case studies addressed the impact on travellers’ choices of those information technology tools, intelligent transportation systems, advanced telecommunication programs, etc. which have already been adopted and implemented. The case studies included studies dynamic route information and road charging, the use of ICT in business and office processes, tele-services, e-Government services, and new information and collaboration services provided via the Internet.

The freight case studies addressed the impact on the choices of firms and organisations of those information technology tools, intelligent transportation systems, advanced telecommunication programs, etc. which have already been adopted and implemented. The case studies included advanced (supply chain) planning, dematerialisation, home delivery and web shopping, and electronic auctioning.

4.1 Description of Case Studies

Each case will now be briefly introduced and its main findings discussed. Table 1 lists the case studies.

	Name/Description	Freight(F) or Passenger (P)
1	Woolworths case: use of Radio Frequency Identifications (RFIDs)	F
2	Danzas Chemicals: Integrated supply chain planning	F
3	KIALA: a new distribution concept for the home shopping market	F
4	Satellite newspapers: impact of printing on demand on transport in the media supply chain	F
5	DPT Digital distribution of parts: a new logistical service concept	F
6	Buying from a distance at Dutch Flower Auctions	F

7	Teleworking at Interpolis	P
8	Puget Sound: Impact of Intelligent Transportation Systems in the Seattle region	P
9	Trondheim: road pricing on the Trondheim Toll Ring	P
10	e-Government: the Case of IBG	P & F
11	ECS European Car Sharing	P

Table 1: Actual Case Studies

Woolworths: use of Radio Frequency Identifications (RFIDs). This case study explored the impact of RFIDs (in combination with other ICT) on asset management and efficiency, planning and visibility and delivery accuracy (Woolworths, 2002). It was based on a pilot study, conducted in the UK (<http://www.elogmag.com/magazine/20/woolworth.shtml>). The main barriers for the introduction of RFIDs described in this case are the costs and a lack of standards. The main findings from this case study are that there is an impact on asset management and efficiency (reduction of total trip time) and that there is increased capacity usage (utilisation increasing from 10% to 40%). However, this is only achievable as part of an integrated ICT and planning system solution, not simply as a result of RFID.

Integrated supply chain planning at Danzas Chemicals. This case study explored the impact of integrated planning and improved ICT on logistics and transport. ICT in combination with integrated planning (of truck and tank containers) is used to improve freight flow analyses, leading to a reduction of 1 million empty kilometres a year for Danzas. There is also a reduction of 3.7 million km (17% reduction) in vehicle km, due to modal shift and increased transport efficiency (Voegtli, 2002).

KIALA: a new distribution concept for the home shopping market. Kiala is a good example of a 4th Party Logistic Service Provider (LSP) (4th party LSPs advise on how to spatially and functionally reconfigure supply chains so as to save total supply chain costs and to improve customer service). Kiala has outsourced all asset-based activities and its core business is focused around the exchange of information, enabled by state-of-the-art ICT systems. For the Dutch home-shopping market the take-out store concept can lead to a reduction of 875,000 transport kilometres a year. There is also a better vehicle utilisation due to bundling. Finally there is also a trip type shift, from freight delivery to passenger pick-up, often in combination with other passenger related transport flows (<http://www.kiala.com/>).

Satellite newspapers: impact of printing on demand on transport in the media supply chain. This case study describes how newspapers are digitised and printed on demand all around the world using file transfer via satellites (Runhaar, 2002). A large part of the physical transport of newspapers is replaced by an information transmission. Furthermore new markets can be targeted. Transport kilometres are reduced (in delivery and return flows) and inventory costs are minimised due to the printing on demand (<http://www.postinsight.pb.com/>)

Digital Parts Transfer (DPT) is a new logistical service concept. DPT transmits product descriptions and production specifications to production locations, which then are transformed into physical (spare) parts and products. The concept, which is still in a pilot phase, can lead to a reduction of transport kilometres (because products will be transported on much shorter distances) and a reduction of inventory

costs (given the production on-demand). However, the open marketplace concept might also lead to more transport, depending on the decision metrics of the final customer (being cost, delivery time and/or quality). Since the concept makes unused Computer Aided Manufacturing capacity transparent, the cheapest solution might still be to use the capacity from a facility which is located further away, but having total costs for production and transport lower than an alternative which might be closer by. The expected reduction in kilometres for the Netherlands approaches 15 million kilometres per year. The expected reduction of kilometres in an international perspective can of course be a lot higher. In an international perspective the distances will be harder to estimate on an average basis. The expected annual emission reduction of CO₂ and NO_x within The Netherlands is estimated at over 6 thousand tons and over 23 tons respectively. For non time critical production, many manufacturers will probably select production on the basis of quality and cost, rather than production location. In these cases the DPT concept might also lead to more transport kilometres. Therefore the exact effects on transport are not yet clear (<http://www.dptservices.net>).

Buying from a distance at Dutch Flower Auctions. The East African Flower (EAF) company set up a tele-flower Auction (TFA) in 1994, the first remote flower auction in the Netherlands (Cunden, 2004; Van Heck and Ribbers, 1997a, 1997b). Usage of this e-auction led to a reduction in person transport kilometres (traders no longer need to physically be present in the auction hall). The case discusses possible future directions for the impact of e-auctions on actual freight flows. There is an estimated reduction of 3,074,368 person kilometres per year for the TFA auction buyers (work related transport). However there are unclear / conflicting effects with regards to freight transport flows.

Teleworking at Interpolis. This case study, based on information supplied by Interpolis (<http://www.interpolis.com/>), shows the impact of telecommuting based on a new vision of working. This vision consists of three components: People & organization; working environment & building; and information management & ICT. Based on literature research and a simulation model effects were predicted on trip numbers and pollution levels. There is an estimated reduction in passenger commuting kilometres of 12,682 km per year for Interpolis. Furthermore, the possibility of flexible arrival time at work leads to possibilities of travelling during non-peak hours, thus to flexibility in departure time choices, reduction of daily commuting travel time and a potential re-distribution of travel demand.

Puget Sound: Impact of Intelligent Transportation Systems in the Seattle region. This case study describes the effects of Intelligent Transportation Systems, which provide travelers with information pre-trip and en-route (Goulias et al. 2003, 2004; Tsirimpa et al., 2005). This assists them in better decisions with regards to trip planning and so leads to a more efficient distribution of travellers' route and modes. Advanced Traveller Information Systems offer the promise of better informed travel decisions and more efficient use of transportation infrastructure. This information can help individuals readjust their travel decisions to account for rapidly changing travel conditions, make more informed travel decisions, reduce travel time and stress, and reduce congestion in transportation networks. From the data analysis it was found that respondents used some form of information system only for 4.1% of their total trips, while almost 36.3% of the respondents that used information systems on their trips actually made some changes in their usual travel pattern. The top three changes that respondents made are: (a) small changes in their regular route in order to avoid congested areas, (b) major route changes, and (c) departure time changes. The estimated models show that travel pattern characteristics, the time of information acquisition (pre-trip vs. en-route), the source and the content of provided information

significantly affect commuters' response to information. However, the effect on passenger kms saved is unclear.

Trondheim: road pricing on the Trondheim Toll Ring. Road pricing is a flexible and efficient way to charge road users for their actual road use. It can be differentiated by vehicle type or time of the day. Traditionally road pricing has been used as a demand management, congestion reduction tool, although in an increasing number of cases, toll schemes are implemented to finance infrastructure investment. Key findings from the Trondheim scheme (Cook, 1995) include: (1) a small decrease in total car traffic crossing the toll ring in the inbound direction; (2) inbound car traffic decreased by 10 percent during the charged periods, and increased by 8-9 percent during uncharged periods at evenings and at weekends, causing the volume of traffic to fall by an average of 4 percent overall; (3) the impact on shopping journeys has been greater than for other types of trips; (4) there is a slight increase in the use of public transport, cycling and motorcycle trips for work purposes; (5) it is estimated that the improvements introduced will reduce the volume of carbon dioxide emissions by 6500 tons per year; and (6) accidents have fallen by between 60 and 70 percent on the new sections of road, mainly because the mixed traffic pattern has been removed.

IBG (example of e-Government). Governments are increasingly implementing electronic services to increase service levels, work more efficient and effective and to offer a better product to individuals and households (consumers), and businesses (Dialogic, 2001; 2002). The nature of many e-Government efforts is such that it improves service through reducing physical transport or other efforts from the side of the user. This case study describes the potential impacts that e-Government might have on transport. In addition, it describes facilitators and barriers towards e-Government, on the basis of which an estimate of the impacts of e-Government on transport is made. With regards to *passenger travel*, over the past four years the number of visitors, e.g. number of trips to IBG's regional centres, has decreased by 7.5% per annum. If this trend continues, by 2020 a 75% reduction will have taken place over 20 years. With regards to *freight transport*, over the past three years the number of postal items has decreased by 12% per annum. If this trend continues, by 2020 an 80% reduction of postal items over 20 years may take place.

ECS: European Car Sharing. In car sharing programs individuals gain the benefits of private car use without the costs and responsibilities of ownership (Enoch, 1999; Bonsall, 2002). Instead of owning one or more cars, a household or business accesses a fleet of shared-use vehicles on an as-needed basis. ICT is used for program management and customer service via improved vehicle access, reservations, and billing methods. Especially, ECS makes use of ICT-applications to manage their car park, keep track of car-kilometres, assign cars to members, and invoice car usage. The greater outcome of car sharing is the reduction in travel km by consumers and the increased capacity usage by sharing travel resources. It is claimed that travellers who join car-sharing organisations and reduce their household fleet by one vehicle end up reducing their overall vehicle travel by one-third to one-half. While early studies provide indications of positive shared-use vehicle impacts, there is inconsistency among methodological approaches and findings, confounding aggregate-level analyses. To evaluate program-wide effects, more systematic data collection and analysis approaches are needed (<http://www.carsharing.org>).

4.2 Analysis of case study results

As described above, all the case studies were analysed on the basis of expected impacts on passenger and freight Flows.

The passenger transport flows were divided into: work/commuting related travel; shopping related travel; and “other” travel (visit to schools, banks, government offices, hospitals, etc.). It is important to distinguish the impact of ICT-applications on these different types of passenger transport flows, as the characteristics of these trips are different (e.g. different times of the day, different modes) and, as a consequence, the overall impact on the functioning of the transport system may also differ.

For freight flows the expected impact was further analysed in the context of the conceptual diagram shown in Figure 3 which identifies 3 categories of flow: “type1” (upstream supply flows); “type 2” (downstream distribution flows); and “type 3” (return flows). With the Type 2 flows being further divided into “Trip I flows” (consolidated flows that usually occur between major sea ports or manufacturing sites at one end and distribution facilities at the other end) and “Trip II flows” (final distribution flows in metropolitan areas).

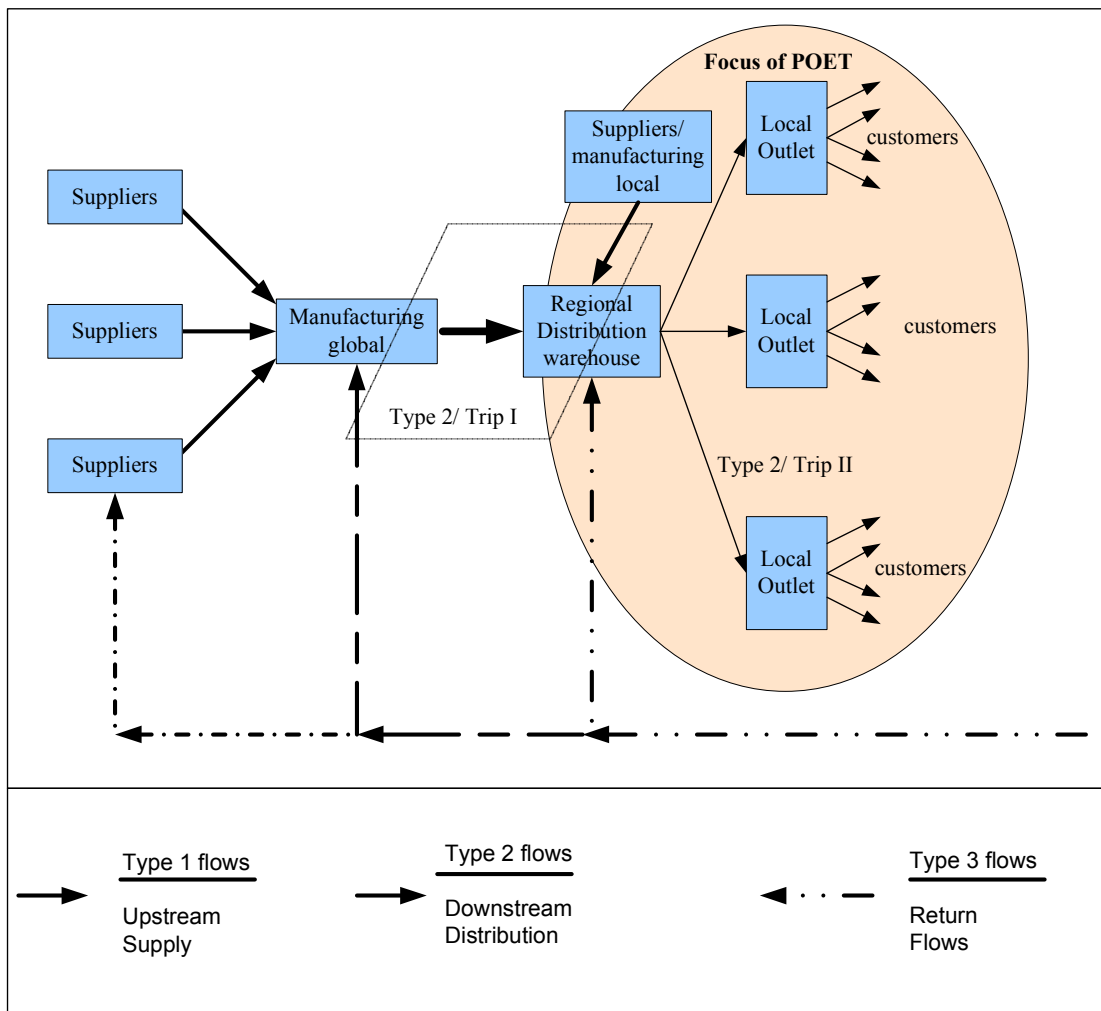


Figure 3: Conceptual Diagram for Freight Flows

The main focus of POET was on Type 2-Trip II freight flows and passenger transport flows in metropolitan areas. However, the analyses were been extended in some of the cases, depending on the scope of the expected impact. Table 2 contains a summary of the results of the 11 case studies using the this categorization.

4.3 Overall conclusions from the actual case studies

The eleven case studies illustrate different ways in which developments in the e-economy may affect the future demand for passenger and freight transport. Despite the differences in nature, it is possible to draw some overall conclusions. Below we briefly discuss the quality of the available evidence and identify areas for future research. In doing so, we explore whether ICT offers opportunities to address urban congestion and

Case nr/ Name/topic		Country/ geographic focus	Overall assessment of ICT impact on transport	Indication of areas of ICT impact on freight flows				Indication of areas of ICT impact on passenger flows			Indication of areas of ICT impact on transport flows and the expected size				
				Upstream supply	Downstream distribution		Return flows	Work related	Shopping related	Other	Ton Km	Vehicle Km	Load factor	Modal split	Trip type shift
					Trip I	Trip II									
1	RFID Woolworths	UK	Positive	Positive	Positive	Positive	Positive				reduction	reduction	Positive		
2	SCM planning Danzas	EU	Positive		Positive	Positive	Positive					reduction	Positive	Yes	
3	Take out store Kiala	EU	Positive but limited			Positive	Positive		Negative			Increase (pass.) reduction (freight)	Positive		Yes
4	e-Newspapers Satellite Newspaper	Internatio nal	Positive but Limited (in %of market)		Unclear	Positive	Positive		Positive		reduction	reduction	Negative		Yes
5	Digital parts Transfer DPT	Internatio nal	Unclear yet (high potential)	Positive	Positive	Unclear/ negative	Positive				reduction	Unclear	Unclear		Yes
6	e-Auction TFA	Netherlan ds / EU	Positive (passengers) Unclear yet (freight)		Unclear	Unclear		Positive				reduction (pass.) Increase (freight)			
7	Teleworking Interpolis	Netherlan ds	Unclear yet (positive)					Positive				reduction			
8	ITS Puget Sound	USA	Positive					Positive				reduction		Yes	Yes
9	Road pricing	Trondhei m	Positive					Positive				reduction	Positive	Yes	Yes
10	E-government	Netherlan ds	Positive							Positive		reduction			
11	European Car Sharing	EU	Positive but Limited (in %of market)					Positive				reduction	Positive	Yes	Yes

Table 2: Actual Case Studies Results

draw conclusions regarding the facilitators and barriers for the uptake of ICT applications that could affect to the demand for transport.

The availability of evidence on the impact of specific ICT-applications on transport is scanty, and more research needs to be done to fully understand this relationship. The case studies differ widely in the degree to which empirical data regarding the quantified impact of ICT on transport flows are available. Studying these impacts is difficult and time consuming. As a consequence, although some case studies (e.g. Danzas, Puget Sound, Trondheim Road Pricing, e-Government) include detailed data based on measurements over long periods of time, others only include limited data sets. Generally, assessments of the impact of ICT-applications on transport are only available in case studies where transport reduction was a major reason for implementation of that application. In many other case studies the main reasons for uptake of a specific technology were the prospect of increased service levels or reduced costs and, against this background, the impact on transport was seen as a side-effect and quantitative information regarding transport impacts was often not readily available. Where this is the case, the potential impact was estimated based on the expert judgement of the companies involved and/or the case study authors. Case studies in which such estimates are made include Kiala, Digital Parts Transfer, TFA Electronic Auctions, and Interpolis. Although these figures are probably not entirely correct, they provide a good indication of the expected impact. Finally, there were a few case studies in which the application was still in a pilot phase (RFID Woolworths) or the case was too complex and/or effects were too unclear to estimate the quantitative effects (Satellite Newspapers, European Car Sharing).

ICT is primarily an enabler and not a driver of changes in the transport system. The case studies show that e-economy developments, and particularly ICT, are more enablers than drivers of changes in transport flows. Therefore changes in transport are usually part of a larger complex of innovation or renewal. For example, the impact of RFID can only be achieved if it is integrated with other ICT and planning systems and combined with a redesign of the total supply chain. This makes it difficult to pinpoint the concrete change in transport due to ICT, let alone measure it.

The uptake of ICT-applications is often inhibited by barriers. Many of the case studies identified barriers that hinder or slow down the introduction of ICT applications that potentially have a substantial impact on transport. Taking away these barriers can facilitate the uptake of ICT-applications. Barriers mentioned in the case studies include:

- a lack of global standards (e.g. RFID)
- absence of integrated vision (e.g. regarding the introduction of e-government initiatives)
- difficulties in ensuring the safety and security of Internet-transactions
- lack of a central orchestrator (especially for inter-organisational implementations of ICT)
- process change and resistance to change, etc.

The uptake of ICT-applications has led to reductions in passenger kilometre and/or tonne kilometres. However, the role of ICT in transport reduction should not be overestimated as the case studies tend to reflect best-practice applications. In the majority of the case studies, the uptake of a specific ICT-application has led to some transport reduction. The potential of ICT to reduce tonne kilometres, especially those related to B2B transactions, was mainly illustrated by the cases on Woolworths (RFID) and Danzas Chemicals (SCM-planning). The potential of ICT to reduce passenger kilometers, especially work-related passenger kilometres, was illustrated by the cases on ITS Puget Sound and road pricing. However, it needs to be stressed that the case study selection was not a random process and that the selection was probably biased towards case studies with a positive impact on transport. This hypothesis is supported by the fact that the findings of the systematic literature review were somewhat less positive than the case studies about the potential of ICT.

E-economy developments may lead to replacement of passenger transport by freight transport. Several case studies show that the introduction of a specific ICT-application may have opposite effects on passenger and tonne kilometers; i.e. the reduction of passenger kilometres goes together with an increase in tonne kilometres. For example, in the case on TFA Electronic Auctions, work-related passenger transport flows are reduced, whereas freight transportflows probably increased. Another obvious illustration of this mechanism is e-shopping, which reduces passenger kilometres on the one hand, but increases freight kilometres on the other hand. This implies that different type of transport impacts always need to be considered, when measuring the impact of ICT on transport.

The potential impact of ICT on transport volume could be substantial if there was a wide uptake of ICT-applications. Most case studies have identified positive impacts of ICT on transport. However, the current impacts as identified in the case studies can generally be described as small. Some have some potential to develop but, seen individually, they are not substantial. The case studies do, however, only discuss 11 individual examples out of a wide variety of ICT-applications that may impact on transport. Looking at the broader context, one could speculate that especially the ICT-applications as described in the cases Woolworths (RFID), Danzas Chemicals (SCM-planning), and Digital Parts Transfer (exchanging CAD-CAM files), when developed further and used on a wider scale, could have a substantial impact in the coming ten to fifteen years.

5. VIRTUAL CASE STUDIES

The virtual case studies were designed to provide additional data to support our predictive models of the impacts of the e-economy on the demand for passenger and freight transport. They involved the use of interactive questionnaires and interviews to gather stakeholders' opinions on future levels of passenger trip making and freight haulage in an ICT-rich future.

The virtual case studies were intended to complement the information and knowledge gathered from the literature review and actual case studies and so were selected to cover sectors which were thought to be particularly important (e.g. teleworking) or for

which the existing evidence was sparse (e.g. business-related travel). Four virtual case studies were developed; dealing, respectively, with:

1. employers' expectations respecting commuting and business-related travel by road;
2. individuals' decisions respecting residential re-location and teleworking;
3. individual's use of e-shopping; and
4. freight industry expectations respecting transport to retailers and home deliveries

For the first three studies interactive on-line questionnaires, called Information Accelerators (see Urban et al. 1990; Urban et al. 1993; Koutsopoulos et al. 1995, Walker and Ben-Akiva, 1996), were used to collect information about current behaviours (levels of trip making, commuting patterns, shopping patterns etc) and about the respondents' expectation of how these might change in a series of future, ICT-rich, scenarios. The approach went beyond a more conventional stated preference questionnaire because, prior to asking our respondents to predict future behaviours, we exposed them to briefing texts designed to test the robustness of their opinions. Each briefing was presented as a collection of opinions from people with relevant experience or expertise but existed in two versions; one which was generally "positive" and one which was generally "negative" in its assessment of the impact of ICT. Subsequent analysis of the respondents' expectations of future behaviours would then allow us to gauge the extent to which they could be swayed by third party opinions.

For freight transport, given the complexity of logistics and transport chains, the multiplicity of actors, and the diffuse (and often unclear) nature of decision-making, it was decided to rely on more conventional interviews. Some of these were fixed format, customised computer-assisted telephone interviews, others were semi-structured face-to-face interviews designed to ensure that the opinions of major actors in the freight industry would be recorded and to allow an open discussion of important issues which had not been included in fixed format interviews.

5.1 Description of case studies

Each case study will now be briefly introduced and its main findings discussed.

Impact of ICTs on Commuting and Business –related Travel

This case investigated the use of ICT to substitute for business travel. Data was collected from senior management using a web-based questionnaire incorporating several innovative features; in addition to data on current and expected levels of home-working and business travel in a range of ICT scenarios, data was collected on the respondent's perception of the impact of different factors on future levels of these activities. Also, to test the robustness of respondents' opinions, the impact of alternative versions of a briefing text, one being very positive and one very negative about the role of ICT, on respondents' expectations was evaluated. Data was obtained from 233 companies in 4 different countries. Analysis revealed that employers expect the continued growth in ICT to result in more home-working and less business-related travel. It became clear that a number of factors which are often ignored or taken as constant would actually be very influential in the future levels of home-working and

business travel. Generally, issues of cost appeared much less influential than the speed and security of communications. Assumptions about future travel conditions were seen to have considerable influence on expected levels of home-working and business travel. Respondents' opinions about home-working were found to be more robust than those relating to business travel. Models were specified and calibrated on respondents' expectations. Predictions by these models appear reasonable and in line with recently published trends. A more detailed description of this case study can be found in Bonsall and Shires (2005, 2006).

Impact of ICTs on Re-Location and Teleworking Decisions

This case study investigated the incremental impacts of ICT on employees' preference for residential location and the effect this decision might have on their commuting patterns and travel behavior. A total of 512 respondents completed questionnaires. A stated preferences experiment was developed representing different types of residential locations reflecting the scenarios identified in Section 3 (a stagnant city; an intelligent city and a networked suburb). Individuals were asked if they would move in such areas and if yes what their travel patterns might be. A discrete choice model was developed for the re-location decision. Results show that city residents are more likely to move to an intelligent city than to a networked suburb with high ICTs, and least likely to move to a stagnant city. It also seemed that individuals who currently telework are less likely to relocate than non-teleworkers. A regression model predicting the number of teleworking days was also developed. Results show that individuals living in the United Kingdom and the Netherlands are likely to telework more days than individuals living in Greece, Italy and Israel. Also, employees living in households with young children (younger than six) are more likely to telework than those living in households without children, or older children. Finally, women are more likely to telework than men. A more detailed description of this case study can be found in Polydoropoulou et al. (2006).

Impact of e-shopping on Travel Demand

This case study investigated individuals' e-shopping behaviour and its effects on transport demand. The data collection and modelling methodology sought to explore how e-shopping affects the individuals' travel behavior. Since e-shopping may lead to a reduction of shopping trips, the study focused on identifying whether the saved time is used for performing activities other than travel or for modifying the travelers' daily travel pattern. 319 completed surveys were collected over the Internet from 5 different countries. The results show that the highest percentage increases in e-shopping were stated for the purchase of electronic goods and computer software product categories respectively, while the smallest increase found corresponds to leisure products. Substitution of conventional shopping trips by e-shopping was prominent for several categories of goods (especially grocery products) while there was little evidence of additional trips for other purposes as a result of the reduction in conventional shopping trips. The stated preferences data was used to estimate a model to forecast the difference in the number of daily trips for shopping as a function of both scenario variables (e.g. problems with credit cards solved, internet connection free or faster, etc.) and individual-specific variables. The results suggest that some types of people (e.g. young individuals, workers familiar with the internet), are more likely to perform e-shopping and that the technological improvements having the

greatest effects on the increase of e-shopping (and on the consequent decrease of shopping trips) are those related to overcoming delivery and security problems. A more detailed description of this case study can be found in Papola and Polydoropoulou (2006).

Freight Case study

A questionnaire was designed to address what we had deemed to be the key issues: changes in responsiveness to consumer demand; transport and inventory planning; the effect of increased information on transport; and the potential effect of increased e-shopping. The questionnaire was developed using the WinMINT (Hague Consulting Group, 1990) stated preference interviewing software and focused on transport to retail outlets and on home deliveries. Questions were asked about the current situation and for three scenarios for the e-economy in 2010. Interviews were carried out with 77 firms in six countries, with an emphasis on retailers and logistic service providers. Data on transport to retail outlets were used to estimate regression models. A significant influence of e-economy developments was found for the vehicle load, the probability of a return load, the load factor for the return trip, the number of retail deliveries, the number of additional stops and the share of cars and small vans.

5.2 Overall Conclusions from the Virtual Case Studies

Analysis of the results from the virtual case studies revealed some interesting findings about the respondents' expectations. Key results from the passenger studies include the following:

- employers expect that, by 2010, the proportion of their workforce working from home on a typical day will have increased from about 9.1% in 2004 to about 9.9% as a result of general trends in Society. They did not expect this figure to be significantly increased by accelerated reductions in the costs of ICT but did think that it would grow more rapidly if the speed and security of ICT links were enhanced or if journey times deteriorated markedly;
- employers expect that, between 2004 and 2010, the number of business-related trips by road would have gone down by 5% due to general trends, by about 9% if the costs of ICT fall significantly and most bullish forecasts of increased ICT capability come to fruition, by about 8% in journey times increase by 20%, and by almost 18% if all these eventualities come to pass.
- employers expect the average length of business-related trips by road to fall by about 5% if the most bullish ICT forecasts come to fruition and if journey times increase by 20%;
- individuals believe that the opportunity of teleworking would affect their relocation decisions;
- individuals believe that teleworkers are more likely to make more trips for other trip purposes;
- household characteristics (such as number of cars, kids of different age categories) play an important role on the decision to relocate;
- individual characteristics (such as gender, ICT familiarity) affect the decision to telework;
- there is an interrelationship between the decision to relocate and to telework;

- individuals expect to reduce the number of shopping trips for groceries by 2 to 3 trips per month.

For freight transport, the virtual case studies indicate that the e-economy will lead to an increase in the average load factor, less empty driving, more use of smaller vehicles and more delivery trips.

Further analysis of the data from the first virtual case study and comparison with additional data collected using a hard-copy questionnaire (Bonsall and Shires, 2005) showed differences in the robustness of different opinions. For example it appears that employers were more certain about the future levels of working from home than about the impact of an ICT-rich future on the number and length of business-related trips. The further analysis also revealed the extent to which the profile of respondents, and the opinions they expressed, were influenced by the data collection medium used.

6. IMPACT OF THE E-ECONOMY ON TRANSPORT IN FIVE URBAN AREAS

In the modelling of the impacts of the e-economy on transport in a number of selected urban areas in Europe, several pieces of information within POET come together. The modelling for the urban areas used existing transport models (passengers and freight) for Paris, Stockholm, Naples, Hamburg and The Randstad (The Netherlands). It also uses scenarios for the year 2010, based on the scenario work for the period up to 2020 carried out earlier in POET (de Jong et al. 2006).

The transport models produced mode and destination choice and assignment to the networks, with feedback effects of congestion on these choices. The outcomes in terms of vehicle kilometres were also used to calculate impacts of the e-economy on energy use, emissions and traffic accidents. Also for some areas, we calculated impacts on congestion and accessibility.

Several developments in the e-economy might influence the tour generation. This will especially be true for telecommuting, teleshopping and other teleservices. The existing urban transport models cannot properly accommodate such changes. Therefore new front-end models were estimated on stated preference data from POET's virtual case studies. For passenger transport, these front-end models give the impact of some development in the e-economy on the full daily tour pattern, in terms of percentage changes (up or down) by travel purpose.

After having changed the inputs of the existing transport models in term of tours or trips, these models have been run as they are, to give mode, destination and assignment results. Other changes in transport model inputs from the front-end models are changes in average trip length. For freight transport, the front-end models explain changes to the load factors (the share of vehicle capacity that is in use), the number of delivery trips and vehicle size.

We investigated five urban areas with this combination of scenarios, transport models, front-end models and exogenous rates. One of the scenarios studied is the High

Adoption scenario, where ICT develops very favourably (also increasing effective road capacity), and people and firms react very positively to it (in terms of teleworking, telebusiness, teleshopping and changes in the load factor and vehicle mix in freight). However, residential locations are kept the same as in the Reference 2010 (the Stagnant City Scenario). The High Adoption Scenario is a combination of the Intelligent City scenario for freight transport and the Networked City for passenger transport (see section 3). For this scenario we found:

- Substantial reductions in passenger kilometres in Naples (-9%), the Randstad (-8%), Paris (-7%), Stockholm (-3%) and Hamburg (-3%).
- For freight transport, the number of lorry kilometres increases by a few percent. This is the net result of two forces working in opposite directions:
 - Developments in the e-economy that increase the efficiency of freight transport: more optimal planning of delivery tours, information and e-markets for return loads.
 - Developments in the e-economy (smaller inventories, just-in-time management, smaller and more frequent deliveries, effective and fast consumer response systems) that decrease the efficiency of freight transport.In the areas studied (as well as in the literature and the interviews with industry experts) we see clear indications that the latter effect will be stronger than the former.

In the Medium Adoption scenario, ICT develops very favourably, but we take a more conservative view on how people and firms react to it. The Medium Adoption Scenario is a combination of the Intelligent City scenario for passenger transport and the Networked City for freight transport.

For this scenario we find that the reductions in passenger kilometrage in the Randstad (-7%), Paris (-6%), Naples (-6%), Stockholm (-3%) and Hamburg (-1%) are the same or smaller. The impacts on freight transport are similar to those of the High Adoption scenario.

In Figure 4 are the results for passenger kilometres by scenario for the Paris region. Without the e-economy developments there will be an eight percent increase between 2004 and 2010. The High Adoption scenario for 2010 brings this down to below the 2004 level, and the Medium Adoption scenario almost. Especially the number of shopping trips will be reduced considerably.

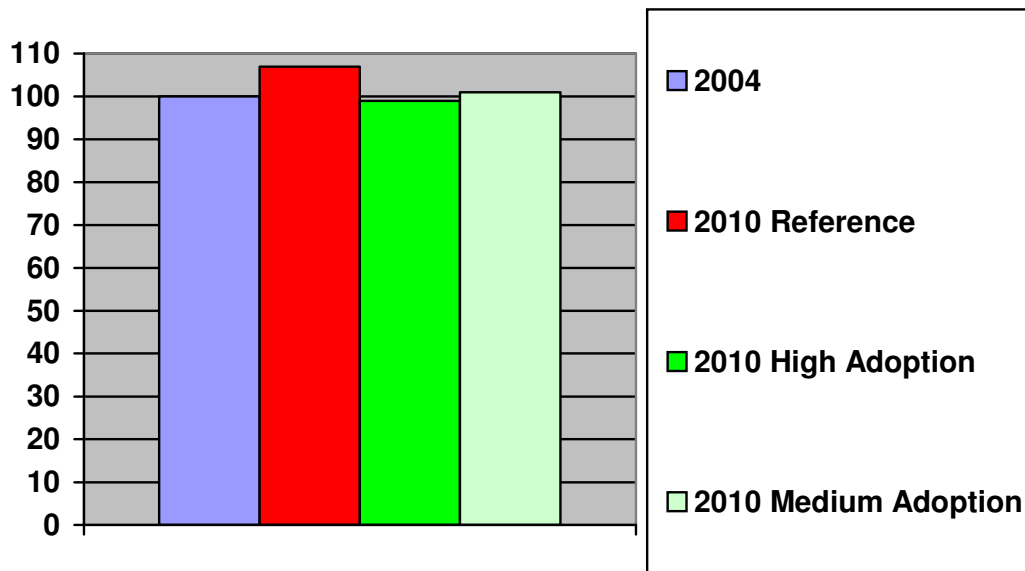


Figure 4 Total number of passenger kilometres for the Paris region by scenario (2004=100)

The net effect for most combinations of passenger and freight scenarios is a (small) decrease in total passenger and freight vehicle kilometres: the reductions in passenger car kilometres will outweigh the increases in lorry kilometrage.

The expected reductions in vehicle kilometres lead to less energy use and emissions of greenhouse gases and local pollutants compared to the reference for 2010. Congestion decreases because of the e-economy (Stockholm, Randstad) and in Stockholm accessibility increases in spite of the decrease in the number of tours made.

7. POLICY-RELEVANT CONCLUSIONS

7.1 Policy-relevant findings from the POET project

Our findings suggest that some of the impacts of ICTs on passenger and freight travel could have a significant effect on traffic volumes and hence on traffic-related outcomes. It appears that, by facilitating these ICTs governments may obtain substantial benefits for Society in addition to those accruing to individual and firms.

The net effect of the e-economy on passenger and freight transport taken together in an urban area is likely to be a reduction in the number of vehicle kilometres. This is not an aim in itself. What matters for society is whether this will increase welfare. This is quite likely to happen. The reduction in passenger travel is for a large part reached by substituting electronic communication for physical communication, so for the relevant travel purposes, there is not really a reduction in activities that used to take place at out-of-home destinations.

Most of the utility gains from these activities will be retained (indeed, for some activities, the ability to conduct them at home might bring increased utility). For trips that are not substituted, the travel time will decrease (or increase less rapidly) due to there being less congestion than would otherwise be the case. Furthermore, the external effects (notably congestion, energy use, emissions, and accidents) from travel are reduced. Any reduction, or reduced increase, in the congestion would be beneficial for accessibility and so might enhance regional competitiveness and, perhaps promote increased commercial and industrial activity.

Given the expected positive welfare gains from e-economy changes on and through transport, policies to promote these e-economy developments (e.g. standardisation, awareness campaigns, fiscal incentives, subsidies) would be beneficial. Our work has suggested that interventions designed to improve the speed and security of electronic data transfer would be particularly helpful in encouraging greater uptake of e-alternatives to travel. Security of communications is clearly seen to be an important issue. Many people are dissuaded from paying for goods and services via the Internet because they perceive there to be a security problem. It may be that publicity aimed at overcoming this perception would be a relatively cost-effective means of encouraging e-shopping in particular. Although policy interventions such as these fall outside the normal realm of transport policy, we suggest that they could well have more influence on the performance of the transport system than traditional transport policies.

Slowing down the adoption of ICT by firms, as a means to avoid the likely increases in freight vehicle kilometers, is probably not a good course of action. This might harm the competitive position of firms affected by this policy relative to those not affected. If e-economy developments should lead to more vehicle kilometers in freight transport and more emissions, these effects should be countered by transport and environmental policy measures, not by promoting a slower adoption of ICT by firms (even if that were possible).

If the e-economy would increase freight traffic but reduce passenger traffic, then this would also have consequences for infrastructure planning, since passenger and freight transport have different origin-destination patterns, concentrated in different time periods, etc.

7.2 General observations on policy making in the area of ICT and Transport

Policy makers are usually interested the interaction between ICT and transport because they assume that ICT can substitute for physical travel and thus reduce transport-related externalities. The substitution hypothesis assumes that people are 'cost minimizers'. However, there is increasing evidence that, even when an ICT alternative exists, many people prefer to travel rather than rely on virtual travel (Mokhtarian et al. 1997; Mokhtarian et al. 2001) and, in doing so, they are acting as 'utility maximizers' rather than cost minimizers. Notwithstanding the general preference for physical travel, there are clearly some circumstances where people may benefit from being able to carry out tasks and activities without having to engage in physical travel. In some cases the activity may bring more utility if carried out via ICT than by physical travel. For some people, "virtual mobility" offers attractive advantages in the context of much of their administrative personal business (administrative chores, financial transactions, comparison shopping etc), some of their

retail trips and perhaps their daily commute. Policymakers should focus their attention on identifying the circumstances in which virtual mobility is attractive, and on investigating ways to promote it, rather than on a general effort to promote ICT as an “substitute” for travel.

The results we have presented in this paper make it very clear that developments in the e-Economy will not replace all, or even the bulk of, the physical transport of goods and people. However, the e-Economy does offer policy makers some new opportunities for addressing the increase in passenger and freight transport and the accompanying problems.

What can policymakers do to exploit the full potential of the e-Economy in dealing with the problems of transport? How, for example, could they use the e-economy to help reduce dependence on fossil fuels or the emission of greenhouse gasses? Our case studies have clearly established that these new technologies are *enablers* of change but not necessarily *drivers* of change. The adoption of new technologies is limited by the lack of standards, an overall framework, concerns about information security, and the lack of an independent and non-partisan player who can facilitate inter-organisational transactions (for example, an organisation like SABRE that provides a reservation system for airlines).

Policy makers, but not necessarily *transport* policy makers, have a clear role in setting standards and creating frameworks to facilitate the adoption of new developments in the e-Economy. Transport policy may not be the right vehicle for bringing about changes to mitigate the problems resulting from transport of passengers and goods. The virtual case studies point out that employees’ perceptions about the importance of being in the workplace to advance their careers may play a bigger role than previously thought in limiting the growth of tele-working. This highlights the need to consider the role of factors outside the traditional realm of transport policy in the making of policy to deal with the problems of transport.

Developments in the e-Economy work their way into the demand and supply of transport in complex ways and it would be naïve to think that a policy measure that stimulates, for example, the number of employees working from home, will by itself result in fewer trips, or alleviation of all congestion problems in cities. Policy makers need to think in terms of policy packages comprising a variety of measures targeting different problems or facets of the demand and supply of transport.

In closing, we must emphasise that our understanding of the effects of the e-Economy on the demand and supply of transport is still limited; we still do not really understand the *mechanisms* by which new developments change people’s behaviour and produce structurally different patterns of demand. More work is needed to produce the improved understanding that will help policy makers to make better policy.

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