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# THE IMPACT OF TELECOMMUNICATION AND TRANSPORT ON SPATIAL BEHAVIOUR

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## Abstract

Telecommunication has not only for the sender but as well for the addressee both mobile and immobile elements. Regarding telecommunication in the interpersonal context with the related traffic behaviour, it becomes clear that telecommunication has so far an unknown influence on our spatial behaviour.

Based on these considerations a concept is being developed to demonstrate the influence, the use and the increasing penetration of communication and information media on spatial behaviour of humans. The question, which effects are to be considered from this for the future and in which way it affects planning of interventions in the traffic sector, follows directly.

On the basis of empirical results from Germany, Sweden and Korea it is shown that additional communication and information possibilities have no decreasing affect on the physical mobility of humans. Based on this result the advantages of novel communication and information services are being systematised to analyse the impacts on spatial behaviour in detail. For this it is possible to fall back on data-sets ranging from the mega-city Seoul over cities and rural regions in Germany to remote areas in Sweden.

So it is to be expected that certain time-consuming, standardise and according to their nature suitable activities/ trips (e. g. telebanking) might be substituted in the every day live. At the same time, however, it is to be expected that far distant destinations can be more easily investigated by better information and communication possibilities, in order to lead afterwards to additional physical mobility – thus an induction of physical transport appears this way. The increases are to be expected fewer in everyday life transport, since the financial and temporal budget restrictions are effective here due to capacity limitations of the traffic system. Rather increases in the weekend and holiday traffic are to be expected, where either by the generated interest via simplified information access or by the decrease of initial trave) thresholds (reduction of uncertainties concerning the selected destination by telecommunications) additional journeys can be performed. Within the leisure area and the global business and service area activities and appropriate journeys are thus generated, which would not have been possible without existence of the electronic media.

Finally, it is stated, which (feedback-) effects result on the structure of demand, if more spontaneous acts caused by information and communication technologies provoke critical and on a long-term basis not calculable effects.

*Keywords:* behavior, behavioral, complementarity, coordination, interdependencies, intrapersonal, labor, online, superposition, teleactivities, telecom, teleservice, telework.

## 1. The Extension of Spatial Action Fields

Telecommunication has not only for the sender but also for the addressee both mobile and immobile elements. The immobile element can be understood as the

fact not to be forced to move physically whereas the mobile element applies both to the sender and the addressee since the communicated information extends their spatial action field. Thus the only distinction between sender and addressee is the question whether the one or the other was active or passive.

When we try to translate this concept to physical transport we start to understand why the passive element of transport (to be visited) is much less important than the active element (to move), since the associated cost in terms of time, money, energy etc. is much higher for the active part. Nevertheless, we have to state that the passive part of transport contributes to the extension of the spatial action field of the visited person in the same way as telecommunication does.

These very basic definitions indicate a strong interrelation between transport and telecommunication both contributing in a more or less complementary manner to the (never-ending?) extension of spatial behaviour of humans [1, 2].

First quantitative but descriptive results concerning the interrelationship between physical and virtual transport (telecommunication) become possible by expanding our observation of spatial behaviour patterns by including the dimension of overcoming space on a virtual level [3].

The results of this empirical approach have clearly indicated that the interrelationship goes far beyond what is currently understood and incorporated in our general understanding. A basic phenomenon, however, has already emerged: there is a further increase to be expected in the field of telecommunication as well as in the field of transport giving the background of increasing spatial division of labour and further dispersion and specialization of private life. However, this will happen consistently, interrelated between transport and communication, probably with a stronger growth in the fields of telecommunication due to the lower cost in terms of personal time, cost, pollution etc.

And since it has been shown that evidently there is little hope for substitution theories and hopes for decreasing transport volumes it can be assumed that human positive curiosity is the driving factor for the demand to extend spatial action fields as much as possible – if not restricted by personal intellectual, time and cost budgets or social and environmental limitations (*Fig. 1*).

### *1.1. Some Coherent Spatial Elements of Transport and Telecommunication*

Having in mind that the penetration of the telephone was strongly correlated with the growth of the transport market [4], it is postulated that – among other causes – new telecommunication services can be understood as major driving factors to overcome spatial separation. Thus, the hypothesis is that new telecommunication services can cause more transport since they ease the investigation of new (distant) destinations.

The following empirical results (*Fig. 2 – 5*) which are derived from an integrated transport and telecommunication survey (see chapter 2.1) in the Baden-Württemberg region [5] shall illustrate the spatial and temporal co-ordination of

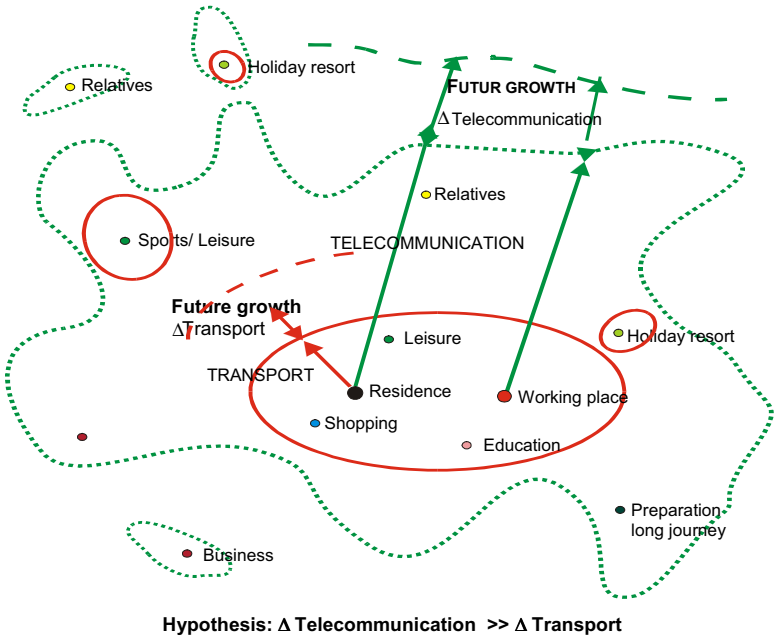


*Fig. 1.* Spatial action fields for traffic and communication

the interpersonal use of modes and media. Particularly, the differences in the use of media between certain person groups in a rural or urban context (*Fig. 4*) indicate the coverage of much more distant destinations by urban people – especially those being equipped on a high level. The same pattern appears when looking at all destinations of all trips and contacts originating from a small town (Weinberg), situated in a 50 km catchment area of Stuttgart (*Fig. 5*).

### *1.2. Availability, Competence and Acceptance of Modes and Media*

Availability of media and competence of their use vary with age. Particularly very young and old age groups develop rather different lifestyles resulting in an acceptance of media ranging from fashion to rejection [6]. *Figs. 6* and *7* clearly indicate this phenomenon at home and at work (affecting only one half of the population).

Obviously, this basic situation affects the acceptance of media and their accelerating change. In 1998, 15% of all Germans had access to the internet and online services; more than 9% used it regularly, 60% of them were between 20 and 39 years. Little fantasy is necessary to imagine that in 10 years this picture will change dramatically both in size and shape

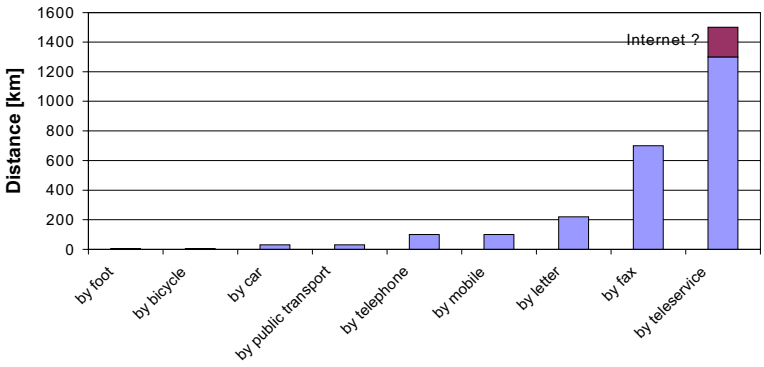


*Fig. 2.* Spatial elements of modes and media

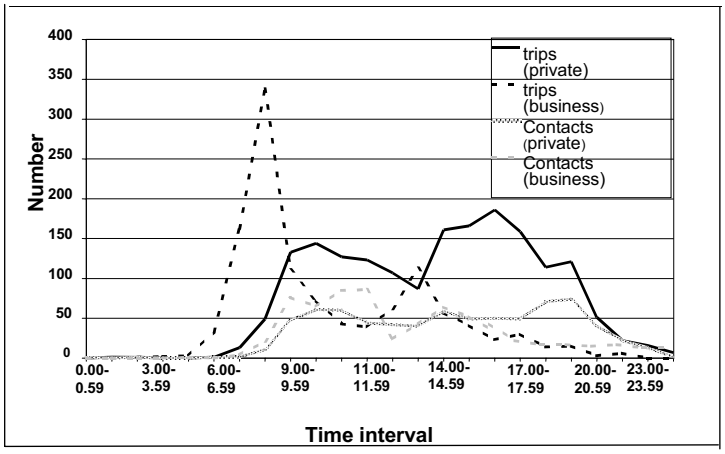


*Fig. 3.* Temporal distribution of traffic or telecommunications activities

## 2. Substitution versus Complementarity

The certainly interesting question of mutual interdependences between transport and telecommunication cannot be answered finally based on results of already completed surveys. The most eminent role of telecommunication as a tool to plan and perform physical transport became visible as well as the option to perform trips more efficiently. This can be associated with the substitution of more or less standardized trips. But, on the other hand, telecommunication opens the window to get in contact with far away destinations possibly resulting in a related long-distance travel. This view is consistent with the historical fact that transport and development of media were more or less correlated.

| Type of area | | Persons with mobile | | Persons with teleservice | | All Persons | |
|---|---|---|---|---|---|---|---|
| | | Number per person per day | average distance [km] | Number per person per day | average distance [km] | Number per person per day | average distance [km] |
| Rural area | Trips | 3.4 | 16.9 | 3.7 | 12.6 | 4.3 | 11.4 |
| | Contacts | 7.3 | 49.0 | 6.1 | 47.0 | 3.4 | 87.0 |
| Urban area | Trips | 5.6 | 9.7 | 4.5 | 11.1 | 4.0 | 9.0 |
| | Contacts | 6.0 | 172.0 | 3.6 | 211.0 | 2.9 | 162.0 |
| Total | Trips | 4.8 | 11.7 | 4.2 | 11.6 | 4.1 | 9.9 |
| | Contacts | 6.5 | 139.0 | 4.4 | 167.0 | 3.1 | 140.0 |

*Fig. 4*. Spatial separation overcoming behaviour as a function of the communication equipment of the households

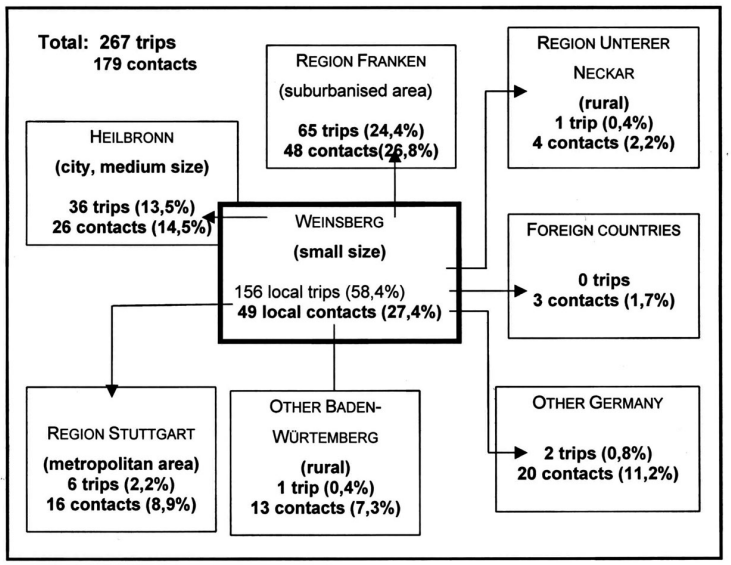


*Fig. 5*. Destination (trips/contacts) of interviewed persons in Weinsberg

Particularly a glance at lifestyle types shows that new telecommunication applications have a significantly higher use by young, male, highly qualified and mobile people. Thus we have to expect that only some decades later the picture may change totally. Is it not therefore necessary to observe our spatial behaviour in a new more comprehensive way?

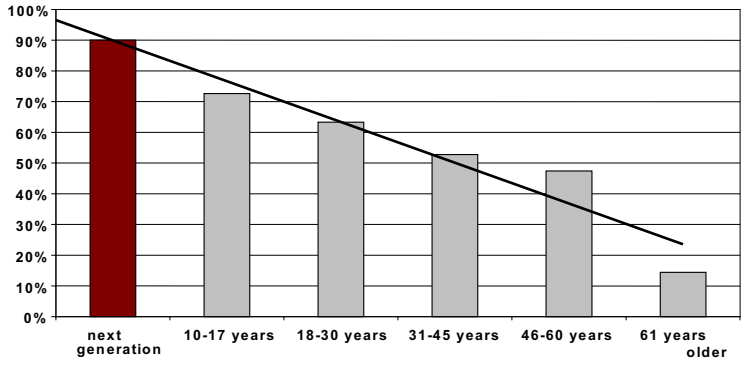


*Fig. 6.* PC-availability (at home) by age group (cohort effect)

| Telecommunication service | **(%)** |
|---|---|
| Telephone | 40.4 |
| Fax machine | 25.4 |
| Cellular phone | 5.8 |
| PC | 22.8 |
| PC (with Internet access) | 8.7 |
| None | 22.0 |
| Other | 1.0 |

*Fig. 7.* Telecommunication equipment at work

### *2.1. Observation of our Spatial Behaviour in a New Context*

The aggregate traffic flows as well as the amount of bits and bytes exchanging locally are always the result of the n of individual behavioural patterns. When defining a new context of our spatial behaviour, priority is given to the observation of individual behaviour. Consequently, the individual has to form the elementary sampling unit of the following surveys, observing the spatial behaviour of humans in an interpersonal context of all trips and contacts.

Therefore an empirical investigation of the daily context of telecommunication and trips was carried out on a microscopic level, aiming at a deeper insight into the interpersonal frequency of using different modes and media (including cars, public transport, walking, cycling, telephone, fax, letters, mobile phones, e-mail, internet etc.) and their interrelationships [7].

Based on this empirical approach, meanwhile the following samples have been realized:

| | | | |
|---|---|---|---|
| Bavaria | 1994 | 2000 households | (5) |
| Baden-Württemberg | 1997 | 750 households | (5) |
| Seoul (Korea) | 1998 | 750 households | (8) |
| Sweden | since 1998 | 1000 households/ year | (9) |

The results given in this paper are based on these surveys.

### *2.2. Transport and Telecommunication Activity Patterns*

The integrated interpersonal observation of our spatial behaviour includes both physical transport and telecommunication forms of the empirical platform for potential model developments. Since the aim of such modeling approach is the estimation of impacts of new telecommunication services, the key issue of modeling is considered to be the combined pattern of physical and virtual off-home activities which are based on the following definitions:

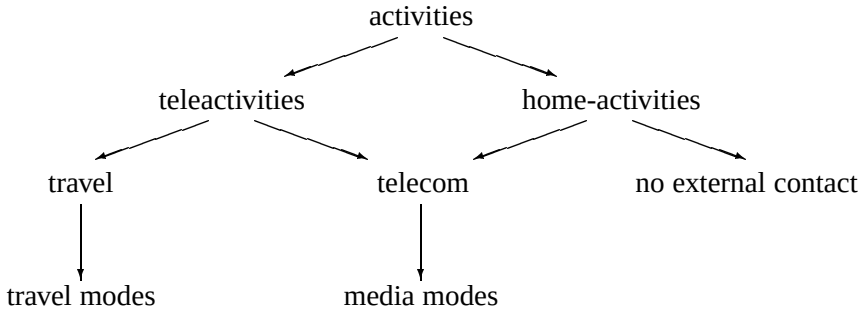


*Fig. 8.* Physical and virtual activities

Thus, an activity is described by the purpose and the spatial element, which could be constituted by one, two or more spatial elements (traffic zones etc.). The resulting activity pattern then forms a sequence of activities containing the information per activity already mentioned (*Fig. 9*).

| **activity pattern** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **purpose** | home | | work | | private contact | home | |
| **spatial element** | residence | | working place | | person in zone *x* | residence | |
| **potential travel/communication choices** | | | | | | | |
| **choice A no travel** | home | | Telework | | phone | | home |
| **choice B car travel** | home | car | work | car | visit | car | home |
| **choice C bus travel** | home | bus | work | bus | phone | | home |

*Fig. 9.* Examples for combined travel/telecommunication activity patterns

For further simplification all activities are defined by the codes given in *Table 1*.

*Table 1*. Codes of activities

| Code/ activity | Code/ activity |
|---|---|
| 1 work | 6 missing value |
| 2 business | 7 contact |
| 3 education | 8 leisure |
| 4 shopping | 9 private affairs |
| 5 home | |

Thus it follows that the inclusion of a combined trip/communication generation process is a necessary prerequisite for modeling interactions between modes and media. The basic characteristic of this module should be among others that

- either trips can be omitted due to contacts (substitution)
- or trips can be generated due to contacts (complementarity).

For further investigation the following form is selected in support of SCHULMEYERS work [9] for the representation of a trip-/contact sequence:

$$X - H - Y - 5 - Z$$

$H$: terminal characters for the main activity with $H \in \{1 \cap 2, 3, 4, 8 \cap 9\}$
5: terminal characters for the way home
$X, Y, Z$: nonterminal characters for sequence sections which stand

- before main activity ($X$)
- on the way to main activity and way home ($Y$)
- after the way home from main activity ($Z$)

| Trips-/contact patterns | 4 | 7 | 1 | 2 | 7 | 5 | 8 | 5 |
|---|---|---|---|---|---|---|---|---|
| Formal representation | X | | H | Y | | 5 | Z | |

In the example, the observed person goes shopping before going to work and executing a contact. Before she drives home from work, the person undertakes a business trip and executes a contact. After coming home from work she undertakes a leisure activity outside and subsequently drives home afterwards.

This form of illustration shall make it possible to examine trip-/contact patterns systematically, with the purpose to get pictures on structures of the combined trip/contact patterns [11]. These are classified by their main activities (education/ training, work, shopping, leisure). In the following, for the main activity ‘education/ training’ the frequence distributions of the individual sequence sections will

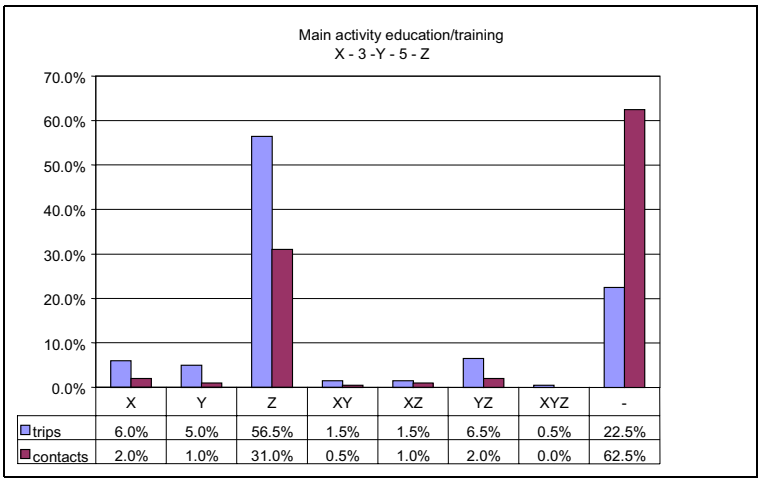


*Fig. 10.* Structure of trip-/contact patterns with the main activity education/training

be represented and commented, and they are distinguished by sequence sections containing trips or contacts.

In 56.5% of all investigated cases additional trips were made after returning home from a training or educational facility. 6.5% of all patterns included additional trips between these two locations. 22.5% of all patterns consisted of a direct trip to the educational/training facility plus a corresponding way home only. Additionally, contacts were transacted mostly after returning home. However, in 62.5% of all cases no contacts were transacted at all. Therefore, the typical structure of a trip/contact pattern with the main activity education/training is as follows: $3 – 5 – Z$. Subsequently, the structure of the sequence section $Z$ is to be examined more detailed. Thus, the following table contains selected sequence sections, occurring together with the main activity education/training.

This table illustrates that a leisure activity, combined with a way home is the most frequent basis sequence[1]. Furthermore, this basis sequence is part of most sequence sections. In addition, after the main activity the leisure activity is dominant for the individual behaviour of a person in the formation. 6% of all sequence sections contain another education trip. That means, the observed person drives home for lunch and returns to training facility afterwards.

Additionally, it has to be stated that still 48 different sequence sections can be determined despite the high aggregation level.

The table also shows that trips are often combined with contacts and 10.6% of all sequence sections consist of contacts only. As mentioned before it is useful to localize the individual contacts in a combined sequence section for an evaluation of

[1]Basics sequences are defined to consist of one activity and a trip back home only.

*Table 2.* Selected sequence sections (3-5-*Z*)

| Sequence section *Z* | Absolute frequency | Relative frequency | Explanation |
|---|---|---|---|
| 8 – 5 | 28 | 21.2% | Leisure time, home |
| 7 – 8 – 5 | 18 | 13.6% | Contact, leisure time, home |
| 7 | 14 | 10.6% | Contact |
| 3 – 5 | 8 | 6.0% | Education/training, home |
| 8 – 5 – 8 – 5 | 5 | 3.8% | Leisure time, home, leisure time |
| 9 – 5 | 3 | 2.3% | Private transactions, home |
| 8 – 5 – 7 | 3 | 2.3% | Leisure time, home, contact |
| 7 – 3 – 5 | 3 | 2.3% | Contact, education/training, home |
| 4 – 5 – 8 – 5 | 3 | 2.3% | Shopping, home, leisure time, home |
| 7 – 8 – 5 – 7 | 3 | 2.3% | Contact, leisure time, home, contact |
| | 12 | 9.1% | Twice occurring sequence sections |
| | 32 | 24.2% | Once occurring sequence sections |

the effect of telecommunication on the individual traffic behaviour. *Table 3* shows the position of contacts in sequence section *Z*.

*Table 3.* Position of contacts in the sequence section Z (3-5-*Z*)

| Position of contacts | Absolute frequency | Relative frequency |
|---|---|---|
| 'only contacts' | 14 | 19.7% |
| before a trip | 41 | 57.8% |
| between two trips | 1 | 1.4% |
| before a way home | 2 | 2.8% |
| at the end of the sequence | 13 | 18.3% |

19.7% of the sequence sections contain contacts only. 57.8% of contacts in sequence section *Z* are performed before a trip. To do predictions on the physical relevance of these contacts one has to know why these contacts are examined (*Table 4*). But strengthened predicates cannot be found, because the specification of the contact purpose often becomes unimportant and specifications like 'chat' or 'private' do not permit conclusions concerning the relevance. Nevertheless, here shall be assumed that contacts can be useful for following activities and therefore could represent the preparation of physical traffic, too.

The following *Fig. 11* gives a first glance at the main activity 'work' to show the existing differences (for further main activities see [11]).

*Table 4.* Contact purposes

| Contact purpose | Proportion [%] |
|---|---|
| private (without specification) | 12.6 |
| make appointment | 12.2 |
| chat | 12.4 |
| pass on or receive an information | 12.1 |
| advertisement/shopping/order | 3.4 |
| telebanking | 2.4 |
| other | 9.4 |
| no specification | 35.5 |

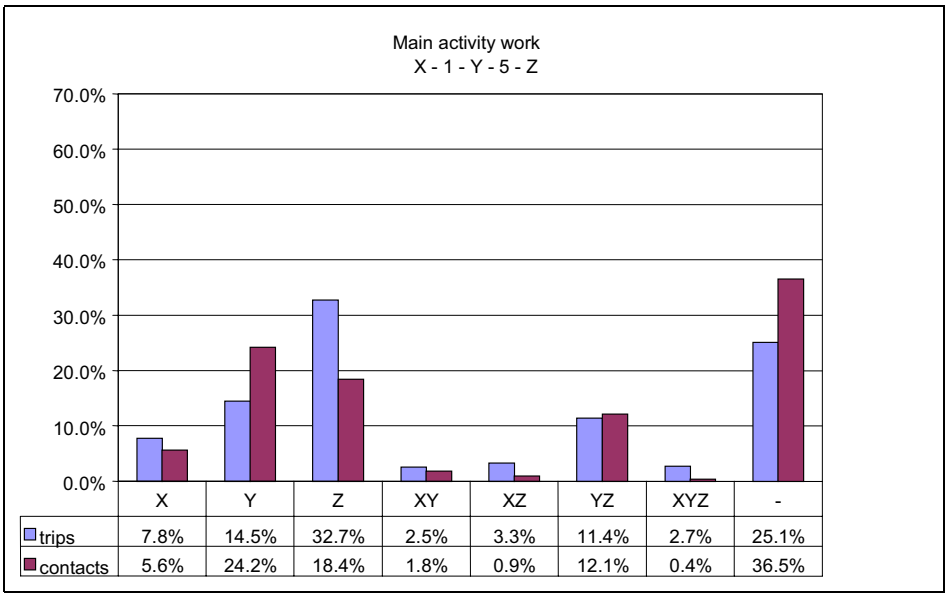


*Fig. 11.* Structure of trip-/contact patterns with the main activity work

In connection with the main activity ‘education/training’ additional trips occur mainly after returning home. This simplicity does not exist regarding the main activity ‘work’. 32.7% of all trips occur after returning home from work. Further 11.4% contain additional trips between job and way home. 14.5% of all trip-/contact patterns include further trips in sequence section *Y* only. In 24.2% of all cases contacts are executed on the way to work and the way home. Again, most contacts occur in sequence section *Z*.

Due to the distribution of sequence sections the following structures for trip-/contact patterns are possible:

$$1 - 5 - Z$$
$$1 - Y - 5$$
$$1 - Y - 5 - Z$$

(For further details see also [10]).

### *2.3. Potential Model Developments*

The detailed analysis of combined travel and telecommunication patterns indicates that a strict distinction between the substitution process (see chapter 3) and the induction process (see chapter 4: complementarity) should be made since both processes seem to be independent.

So it is to be expected that certain time-consuming, standardizable and – according to their nature – suitable activities/trips (e.g. telebanking) might be substituted in the every day life. At the same time, however, it is to be expected that an induction of physical transport is driven by new telecommunication services. The increases are to be expected fewer in normal transport processes, since the financial and time related budget restrictions are effective here due to capacity limitations of the traffic system. Increases during the weekend and holiday traffic are rather to be expected, since additional journeys can be performed neither by the generated interest via simplified information access nor by the decrease of initial travel thresholds (reduction of uncertainties concerning the selected destination by telecommunications). Within the leisure domain and the field of global business and service activities, appropriate journeys are thus generated, which would not have been possible without existence of the electronic media. And since the substitution part seems to be solvable by the introduction of transition probabilities (see chapter 3) the complementarity part needs further empirical work (see chapter 4).

## 3. Modelling Substitution – the Seoul Case

As part of a comprehensive research a modeling approach [8] was implemented in Seoul, for which results can be reported here. This approach was based on integrated transport/telecommunication surveys (see chapter 2.1) and interactive interviews performed in banks (telebanking) and storehouses (teleshopping). The resulting transition probabilities (reduced by the share of interviewers having had already experience, *Fig. 12*) were applied to the Transport and Telecommunication Activity Pattern by a Monte-Carlo-Simulation process. Thus, it was possible to define certain rules for the impacts of the substitution of an activity on the subsequent activities. After aggregation, the potentials to substitute trip could be quantified for the metropolitan area of Seoul (*Fig. 13*) as well as on the level of the infrastructure.

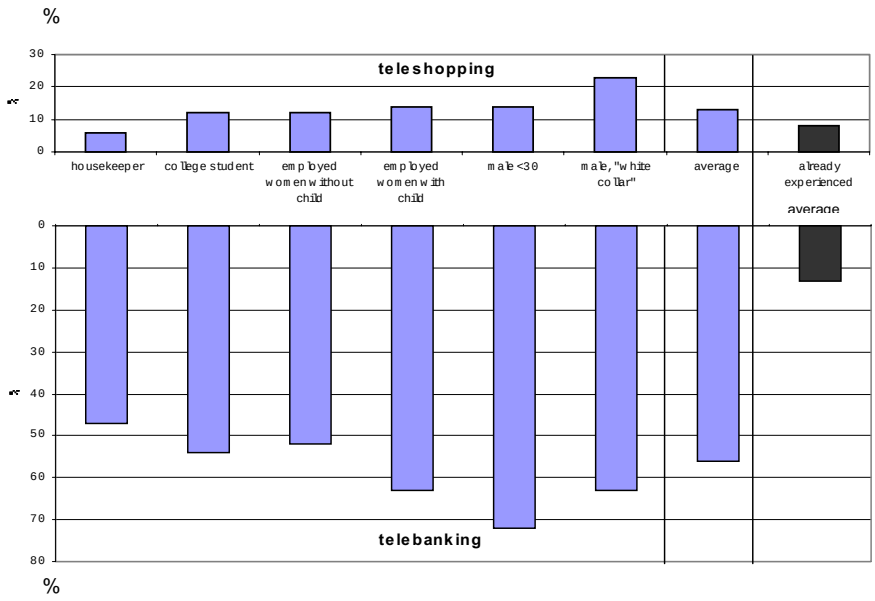


*Fig. 12.* Transition probabilities and experience by person groups

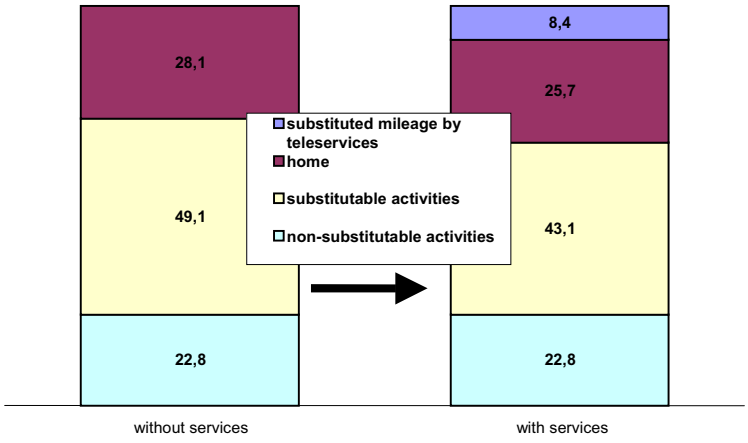


*Fig. 13.* Potential for substitution of mileage in Seoul

The major advantage of these simulation runs include

- the ability to run sensitivity tests related to potential measurement errors,
- the expectation to produce spatially differentiated results (infrastructure, regional development)

- the potential to include biographic factors in forecasts to reflect the different lifestyles and adaptation processes between generations (*Fig. 11*).

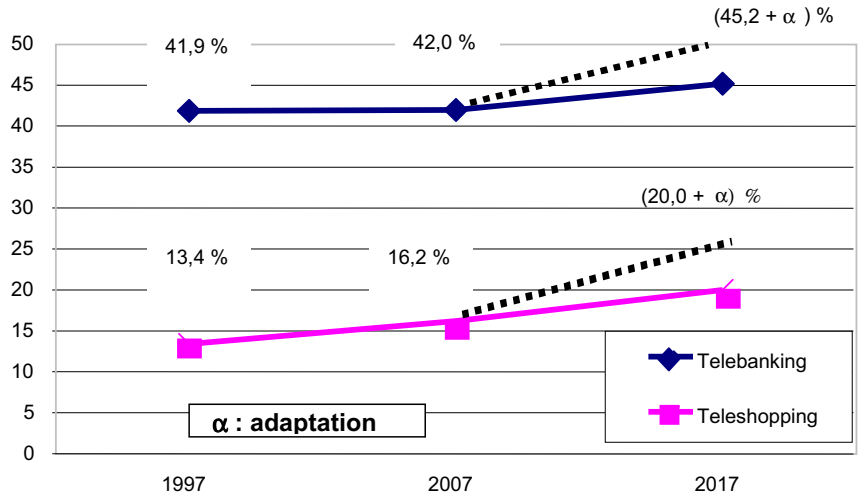


*Fig. 14.* The development of transition probabilities over time in Seoul

## 4. The Problem of Modeling Complementarity

Since decades transport researchers have worked in the field of induced demand [12], which can be seen as an analogous problem to the complementarity issue [13]. It can be described as follows: On a cross-sectional or infrastructural basis the problem seems to be solvable by the introduction of highly aggregated budgets. But on the time-axis (longitudinal view) and on an individual (biographic) basis nearly all basic questions remain without answer.

### *4.1. General Insight*

The same situation applies to the complementarity issue. Telecommunication affects transport demands to a quite high extent, which can be quantified roughly [14]. Following our results, it can be assumed that about 40% of all contacts deal with the question of future transport – but would these trips occur without or with better means of communication to a different extent? We do not know; but we know that more empirical work may be helpful and it has to be focussed on the links which exist in combined travel and telecommunication activity patterns (see chapter 2.2) between contacts and trips. The following project shall contribute to this issue.

### *4.2. The EU-Spirit Project*

The EU-Spirit Project intends to develop and demonstrate a customer-friendly information system for integrated travel services in Europe. Thanks to this system it will be possible, by the use of Internet as well as conventional sales and information channels, to plan and prepare a door-to-door travel between distant European regions, using all means of public transport such as main railway lines, regional trains, buses etc. The same environment offers a direct access to all other information and services which justify (e.g. event notes, tourist information) or are necessary (e.g. information on accommodations) for an attractive travel plus complete ticketing and reservation options.

Quintessential point of evaluation is an Internet-based multi-level questioning on long-distance travel behaviour before and after availability of such a Europe-wide information service. The contacting of probands takes place both 'on-trip', i.e. for example at airports, at platforms directly before a train arrives, at motorway restaurants in direct border proximity (e.g. between Germany and France), and also via Internet.

To measure the acceptance of the new information system on the basis of an interactive demonstrator in the 'sociological laboratory', the vision of the 'European information system' is obtained in form of a presentation tool (cinematic demonstration), which points out different scenarios for the future organization and the progress of long-distance travels chosen as examples, both for business travelers and for tourists. Following this demonstration a final questioning occurs on whether and to what extent this service would have affected either the specific long-distance travel via railway, plane or passenger car (depending on the location where the probands were contacted), or a trip performed recently by test persons not contacted on-trip. Additionally, those probands, specifying that such an information system would not influence their trip planning and transaction, are asked for their personal reasons for refusal. This is to permit predictions whether disuse of such a service depends either on the mode how information is provided or on a negative attitude to principle with regard to information systems, considering the previous habits.

Basic objective of the survey is the production of a quantitatively substantial database for the estimation of the long-distance travel behaviour influenced by the introduction of the information system EU-Spirit. Furthermore, to obtain insights in the process how and to which extent (novel) information contributes to the generation of transport.

## 5. Outlook

The outlook is completely virtual. If you would like to have a deeper insight into the structure of the interactive interviews aiming at a better understanding of the complementary contribution of telecommunication towards transport visit the

internet home page http://www.euspirit.de.

If possible, do not hesitate to participate in our latest survey on long-distance travel behaviour. And if you like to perceive whether the internet is a platform for a virtual social laboratory to support the understanding of novel teleservices, concentrate on the cinematic demonstration presented within this survey.

If you get in contact with this paper when the internet survey has already finished, ask the author (zumkeller@ifv.uni-karlsruhe.de), Dr. Stephan SCHNITTGER (sg@ifv.uni-karlsruhe.de) or Mr. Olaf EBERHARD (oe@ifv.uni-karlsruhe.de).

And please remember: Future as well as virtual reality are constituent elements of reality.

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