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Professional workers @ work: importance of work activities for electronic and face-to-face communications in the Netherlands

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Abstract We are living in a time of accelerating technological development, which affects us all in our professional and social lives. Using data obtained from a 2-day activity-travel-communication diary survey in the Utrecht–Amersfoort–Hilversum region in the Netherlands, we enhance insight into the use of Information and Communication Technologies by professionals of different types. The multivariate analyses show that one quarter of the sample has traditional work arrangements with continuous work at one location and shows a relatively low use of electronic communication modes. Half the professionals are telecommuters-car commuters and have short face-to-face and email contacts or are telecommuters-public transport commuters who in contrast rely on emails and face-to-face contacts. The final quarter of the sample shows a highly fragmented temporal work pattern with intensive face-to-face and electronic contacts.

Keywords Work activity · Professional workers · ICTs · Electronic and face-to-face communication · The Netherlands

Introduction

The importance of work as an activity for configuring daily activity-and-travel patterns is generally acknowledged (Cullen and Godson 1975; Dijst and Vidakovic 2000; Perrons et al. 2005). The meaning of the spatio-temporal organization of the work activities of various people, in terms of distance, fixity, and flexibility for travel, has received particular attention (Kwan 2000; Schwanen and De Jong 2008; Alexander et al. 2009). Considering

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this relevance of the organization of work activities, remarkably few studies have focused on developing an understanding of the importance of explaining occupations for work activities and related travel. One can expect occupations to differ markedly in the demand they put on work times and locations and on interactions with other people and artifacts. For example, a dentist is tied to a fully-equipped practice where patients are received while much of an airplane pilot's time is spent on the move and high in the sky. Through technological and educational developments and economic demands over the last 60 years the labor force in Western societies has become highly specialized, diversified, and intellectually qualified. The growth of the service economy and the professionalization of the labor force have become particularly dominant characteristics (Schön 1983; Kakihara and Sørensen 2004).

Through the supply and adoption of ubiquitous and pervasive fixed and mobile Information and Communication Technologies (ICTs) the spatio-temporal organization of work activities is expected to change. Observation of the implications of the use of these techniques tempted Helen Couclelis to formulate the statement (1998, p. 321): "*There is abundant evidence that human activity in post industrial societies is becoming increasingly person based as opposed to place based …* ". This statement actually means that the flexibility ICTs offer allows workers to choose the location and time of their work for themselves. This mobilization of activities stimulated the development of nomadic conceptualizations of work like the 'mobile worker' (Laurier 2002; Hurme 2005) who works at multiple locations, such as the office, home, public places or 'on the road' (Lyons and Urry 2005), and the 'mobile professional' or 'e-lancer' (Kakihara and Sørensen 2004), the freelancer who works as an expert independent of an organization on an ad hoc basis. However, the affordance of ICTs for professional work arrangements and its implications for travel is barely understood.

The aim of this study was to increase our understanding of professional workers' work arrangements and their relationship with electronic communications and face-to-face contacts. For that purpose, based on a large array of attributes of daily work practices, a typology of professionals was developed. The importance of this typology for the frequency and duration of electronic and face-to-face communications has been analysed. This research extends previous work in the arena of professional workers in a number of ways. First, unlike previous studies, we examine multiple aspects of work activities, namely temporal, spatial, planning, and commuting attributes. Second, we have adopted broad ranges of ICT-use variables to test how and to what extent the work of professional workers is associated with ICTs. In addition, we have included socio-demographic factors in the analysis to investigate the importance of professional work practices for communications in relation to these individual attributes. Finally, while previous studies have tended to be largely qualitative, we have used a dataset of 554 person-days of 427 professionals residing in the Netherlands who completed a unique 2-day activity-travel-communication diary survey. We have estimated multivariate models of communications based on this dataset.

The structure of this article is as follows. In "Theoretical background" section, we discuss what professional workers are and how their daily work practices are organized, together with the role of ICTs in their work activities. In "Research design and methodology" section we describe the research design and methodologies applied. The empirical results are presented in "Types of professional" and "Multivariate analysis" sections. In "Conclusions and discussion" section, we put forward our conclusions and suggest avenues for further research.

Theoretical background

In post-industrial society, increasing specialization in work activities fuelled by technological innovations is accompanied by an increase in the complexity of work and demands on specialized knowledge and skills (Kakihara and Sørensen 2004). In this service-based society specialized occupations like law, medicine, accountancy, engineering, management, and research are dominating various public and private organizations (Perkin 1996). The concept of professional workers has been extensively discussed (e.g. Hall 1968; Stanford and Econ 1975; Schön 1983; Perkin 1996). Based on a comprehensive literature review Kerr et al. (1977) have identified a set of attributes of the 'ideal professional'. According to these authors a professional (1) has an identifiable base of knowledge from which to practice, (2) has acquired a mastery of that knowledge through extended education, (3) has autonomy in making decisions regarding the application of that knowledge, (4) displays a strong commitment to the field, and (5) has a lifelong commitment to professional development. In particular, the specialized knowledge base a professional applies and the level of autonomy in work seem to be relevant to the spatio-temporal organization of work.

Over the years, the use in work practices of ICTs like the landline phone, mobile phone, laptop, and personal computer and the accompanying electronic services has become integrated. These ICTs offer the potential to free workers from their traditional fixed and formal workplace and working times. Work can be carried out in a car, on public transport, at a client's place, in a public place, at home, and so forth and at times chosen by the employee (Churchill and Munro 2001; Kakihara and Sørensen 2004; Vilhelmson and Thulin 2001). Professionals with highly specialized knowledge and skills in particular can apply these more efficiently and effectively with the support of these electronic means. According to Kakihara and Sørensen (2004) ICTs increase a professional's temporal, spatial, and organizational autonomy. This relationship between ICTs and work activities is reciprocal: ICTs offer the opportunity for restructuring work activities, but at the same time also make work more dependent on ICT devices and networks (Laurier and Philo 2003). In spite of the prevalence of ICTs in the spatio-temporal organization of professionals' work, the physical copresence of people, objects, and buildings is still important for them (Kakihara and Sørensen 2004). This importance might be related to the addition of face-to-face contacts. Boden and Molotoch (1994, p. 277) see corporeal copresent interaction as the fundamental mode of human interaction and socialization: '*Through the trust, commitment and detailed understandings made possible in situations of copresence the essential space–time distantiation of modern society is achieved*'. (See also Dijst 2009).

Developments in the field of ICTs and efficiency demands from contemporary businesses and organizations affect the ways in which work will be restructured. One consequence is the fragmentation of activities in both time and space (Couclelis 2000; Hubers et al. 2008). The fragmentation-of-activity hypothesis states that ICTs have weakened the associations between activity, place, and time, thereby facilitating the disintegration of activities into smaller sets of acts that can then be performed at different times and/or different locations. Temporal fragmentation is expressed by, for example, working outside office hours and is often accompanied by flexible work-hour arrangements (Vana et al. 2008; Alexander et al. 2009). Spatial fragmentation can take the form of working at home (Ory and Mokhtarian 2006; Hadded et al. 2009), during business trips (Laurier 2002) or commuting (Lyons and Urry 2005). Other studies have shown that an increase in the flexibility of the timing and location of work activities offered by ICTs has made the combination of family and work activities easier for employees (Toffler 1980; Chesley

2005; Hubers et al. 2011). For example, using the phone at work offers the opportunity to coordinate domestic responsibilities at-a-distance, which can improve the work-life balance, particularly of women and time-pressed households.

Following Kakihara and Sørensen (2004), Hubers et al. (2008), and Alexander et al. (2011) we distinguish three types of flexibility associated with the work activities of professionals that are related to the use of ICTs: temporal, spatial, and interactional flexibility (Table 1). *Temporal flexibility* refers to the level of temporal fragmentation whereby a certain activity is divided into several smaller pieces that are performed at different times. This fragmentation might be expressed in the number of episodes in which an activity occurs, the distribution of the size of these episodes, and the level of their clustering (Hubers et al. 2008). *Spatial flexibility* can be defined as the level of performance of work activities at different spatial locations and associated travel. This fragmentation of work activities can also be described in terms of the number, distribution, and clustering of work episodes. *Interactional flexibility* refers to the intensity and occurrence of interactions with a wide range of people (Kakihara and Sørensen 2004).

As Table 1 shows, we expect interactional flexibility to be very high for all professionals, but less so for those working in natural, technical, and cultural professions (e.g. actors and authors). Although variations might exist within categories of professions, we hypothesise that the professional groups mentioned largely differ in the opportunities they have to substitute face-to-face contacts by electronic means. Although observation, collecting information, and even surgery by electronic means at a distance is now possible, such activity takes place at the margins of daily medical practice and does not replace face-to-face contacts. The same might be said for educational professionals whose work is largely situated in classrooms supplied with presentation materials and where teachers and students meet in person. These types of professionals are also those who will show relatively low temporal and spatial fragmentation of their work. This situation will be in sharp contrast with business professionals like accountants, consultants, lawyers, (travelling) salesmen and other finance and sales-associated occupations.

Table 1 Hypothetical flexibilities of types of professional

	Temporal flexibility	Spatial flexibility	Interactional flexibility	Use of ICTs
Managers: e.g. production, operation, and specialist managers	–	–	++	+
Natural and technical: e.g. engineers, chemists, programmers	+	+	+	++
Health: e.g. medical doctors, dentists, nurses, pharmacists	±	–	++	–
Educational: e.g. teachers at primary, secondary and higher educational level	±	–	++	–
Business: e.g. accountants, lawyers, financers, sales representatives	++	++	++	++
Social: e.g. sociologists, psychologists, social work professionals	–	+	++	+
Cultural: e.g. artists, authors, entertainers, models	+	+	+	–

– Implies a low degree, + implies a moderate degree, ++ implies a high degree

Research design and methodology

Data employed

We conducted a survey among professional workers residing in the Utrecht–Amersfoort–Hilversum region in the central part of the Netherlands in 2007. The survey was conducted among single and dual-income households. The collection of data took place in several stages. First, neighborhoods were selected on the basis of a combined income, density, and accessibility matrix (Fig. 1). Selection questionnaires were sent at random to about 13,500 respondents living in these neighborhoods. People were asked about their general household characteristics (e.g., gender, age, employment status), possession of ICT devices, and in addition whether they would like to participate in the main survey. This feedback provided more detailed information about socio-demographics and ICT availability and usage and included a 2-day activity-travel-communication diary. In total, the main questionnaire was completed by $\sim$740 respondents, either online or in a mail-out/mail-back paper-and-pencil format; the activity and travel diary was completed by 662 respondents (paper-and-pencil format only). The original dataset was further screened for empirical analysis of the use of ICTs by different types of professional. Individuals who did not engage in working activities during the survey days were excluded from the sample. After the screening process, 427 individuals provided useful information for the analysis and 554 person-days were made available for the empirical analysis.

Defining professional workers

The main questionnaire contains questions about a respondent's occupation, sector of the job market, and weekly working hours. With regards to the occupation, we used International Standard Classification of Occupations-88 (ISCO) classification to record the job

Fig. 1 The selected neighborhoods in the region Utrecht–Amersfoort–Hilversum in the Netherlands

information in the survey (International Labour Office 2001). In this study, we focus on higher-level professional workers. The following types are distinguished (% in sample): managers (9.6 %), natural and technical (16.8 %), health (16.8 %), education (13.7 %), business services 24.4 %), social (11.0 %), and cultural (7.6 %).

Operationalization of variables

The daily work practices of professional workers are characterized in this study by 26 descriptors grouped (listed in Table 2) into five sets. *Temporal aspect of work activities* includes: the time spent on work activities on a given day, temporal fragmentation measures, home-working, and employment time autonomy and work schedule flexibility. Temporal fragmentation refers to: the total number of episodes, the temporal distribution of work episodes (*T-index*), the average inter-episode duration, and an inter-episode duration index. Note: an episode is defined as an uninterrupted stretch of time devoted to paid work. The *T-index* is based on the number of minutes allocated to a certain episode. A value of 0 indicates that the work activities of an individual on a given day are not fragmented. A detailed description of these fragmentation measures can be found in Alexander et al. (2011). In addition to these temporal variables, the respondents in our sample were asked to answer the following questions: "How often do you work away from home each week?", "To what extent are you able to choose your own start and end times for work?" and "Do you work at irregular times or shift hours?".

The second set of variables concerns the *spatial aspects of work activities*. For professional workers we know the number of work locations, work time spent in the office, at home or elsewhere. The following variables represent the spatial fragmentation of work activity: the temporal distribution across locations (*S-index*) and the dispersion of work locations. The *S-index* describes how the time spent on the episodes is distributed across different locations. A value of 0 indicates that the work activities of an individual on a given day are not fragmented (see Alexander et al. 2011 for details).

In addition, the respondents were also asked to provide information of the *planning of work activities*. This information indicates the number of work activities that are routine-based, planned or impulsive. Finally, three variables reflect the *commute characteristics* of professional workers: distance, car or public transport use.

The communication behavior of the professionals is covered by questions in the diary concerning the nature of the contact—face-to-face or by electronic means (landline, mobile phone, email, SMS, MSN and other)—and the purpose of the contact (making appointments, updating, exchange of ideas, discussion of problems, and other). On the basis of this information the frequency and duration of these contacts were calculated.

Methodology

The daily work pattern of each professional worker on each day is characterized by 26 descriptors. However, using several dozen variables directly to analyse the work patterns of professional workers would probably lead to biased results through the high correlations between variables. We therefore chose first the principal component analysis (PCA) to identify the key measures of work activity of professional workers. These key measures provide useful information and can be related to socio-demographic (listed in Table 3) and communication characteristics (listed in Table 4). Next, we applied k-means clustering to capture a number of classes of professional workers with strong internal similarities in their work and ICT-use characteristics. We estimated the linear regression models for the

Table 2 Rotated component matrix (only loading ≥|0.500| is displayed

	Temporally fragmented routine work	Spatially fragmented	Telecommuting	Public transport-mobile work	Meeting	Long working hours	Shift working
Component							
Total number of work episodes on a given day	0.925						
T-index-temporal dispersion of work episodes	0.859						
Number of episodes for other task	0.824						
Number of routine work activities	0.784						
Mainly work in primary office	0.707						
Number of episodes for emailing	0.703						
S-index-spatial dispersion of work episodes		0.877					
Total number of work locations on a given day		0.802					
Number of other work locations		0.766					
Spatial dispersion of work locations		0.657					
Employment time autonomy			0.755				
Working from home at least 1 day per week			0.754				
Commute distance			0.629				
Public transport use				0.689			
Number of episodes for on the way working				0.611			
Car use				−0.587			
Number of work episodes at home on a given day					−0.708		
Number of episodes for meeting					0.605		
Total time spent on work activities on a given day						0.694	
Number of planned work activities						0.534	
Work scheduling shift							0.872

Table 3 Socio-demographics of the classes of professional

Variables	Professional workers								Total
	Class 1 traditional workers		Class 2 temporally fragmented workers		Class 3 telecommuters-car commuters		Class 4 telecommuters-public transport commuters		
Professions	*N**	*%*	*N**	*%*	*N**	*%*	*N**	*%*	*N**
Managers	9	7.3	11	10.1	17	12.6	9	15	46
Natural/technical	19	15.4	14	12.8	28	20.7	11	18.3	72
Health	43	35	23	21.1	17	12.6	5	8.3	88
Education	18	14.6	24	22	19	14.1	6	10	67
Business services	22	17.9	28	25.7	40	29.6	25	41.7	115
Social	8	6.5	5	4.6	5	3.7	1	1.7	19
Cultural	4	3.3	4	3.7	9	6.7	3	5	20
Total	123	100	109	100	135	100	60	100	427
Gender									
Women	75	62.5	60	55.5	64	47.8	30	50.8	229
Men	45	37.5	48	44.5	70	52.2	29	49.2	192
Total	120	100	108	100	134	100	59	100	421
Household type									
Single	29	24.6	21	19.3	24	18	16	27.1	90
Living with a partner only	53	44.9	48	44	62	47	24	40.1	187
Living with a partner and children	36	30.5	40	36.7	46	35	19	32.2	141
Total	118	100	109	100	132	100	59	100	418
Net household income (in Euro per month)									
1,000 or less	5	4.8	2	2.1	0	0	0	0	7
1,001–2,000	26	25	19	19.8	11	8.3	10	17.2	66
2,001–3,000	23	22.2	20	20.8	36	27.1	15	25.9	94
3,001–4,000	26	25	32	33.3	47	35.3	15	25.9	120
4,001 or more	24	23.1	23	24	39	29.3	18	31	104
Total	104	100	96	100	133	100	58	100	391
Presence of small children <12 years old	36	29.3	40	36.7	46	34.1	19	31.6	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Age (continuous)	47	11.3	44.5	10.6	45	10.4	45.1	11.2	
Number of car per household									
No car	37	31.4	36	33	7	5.1	12	20	92
1 car	53	44.9	48	44	59	43.4	32	53.3	192
2 cars	26	22	24	22.1	64	47.1	12	20	126
More than 2 cars	2	1.7	1	0.9	6	4.4	4	6.7	13
Total	118	100	109	100	136	100	60	100	423

Table 3 continued

	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Urbanization degree (addresses/km^2)									
<500	32	26.7	30	31.9	26	19.5	14	23.7	102
500–1,000	20	16.7	20	21.3	20	15.0	14	23.7	74
1,001–1,500	25	20.8	14	14.9	35	26.3	19	32.2	93
1,501–2,500	18	15	13	13.8	35	26.3	8	16.6	74
≥2,501	25	20.8	17	18.1	17	12.8	4	6.8	63
Total	120	100	94	100	133	100	59	100	406
Work location									
Inside of Randstad	108	97.3	105	97.2	126	94.7	48	84.2	387
Outside of Randstad	3	2.7	3	2.8	7	5.3	9	15.8	22
Total	111	100	108	100	133	100	57	100	409

* Number of professional workers in each class (smaller sample size for some variables are due to missing values)

frequency and duration of the use of ICTs to determine the relative importance of the different types of professional worker in explaining various communication modes.

Types of professional

Key components of work activity

We applied the PCA with 26 input variables to determine the key descriptors of the work activity of professional workers. First, we estimated the communalities (squared multiple correlation) for each variable. The communality measures the percent of variance in a given variable explained by all the factors jointly and may be interpreted as the *reliability of the variable*. When a variable has a low communality, the factor model is not working well for that variable and it should possibly be removed from the model (Bryant and Yarnold 1995). We therefore excluded the variables that had low communality of <0.500: these were average inter-episode duration; inter-episode duration index; number of episodes for web browsing; weekly working hours; number of impulsive work activities.

We then extracted factors from the remaining 21 variables. A total of seven factor components were significant and each of them had an eigenvalue greater than one. Our choice was based on the Kaiser criterion (1960) and Cattell's test (1966). The resultant seven factor components collectively account for 69.4 % of the total variance. Table 2 shows the rotated component matrix and only loadings ≥|0.500| are displayed. The seven components can be described as follows:

The first component is *Temporally fragmented-routine work:* the "total number of work episodes on a given day"; "T-index", and "number of episodes for other tasks" have high positive loadings. This component is also highly associated with "the number of routine work activities" (refers to habitual activities), "mainly work in primary office", and "number of episodes for emailing". The second component was labeled *Spatially fragmented work*: it is highly associated with "S-index", "total number of work locations on a given day", "number of other work locations" and "spatial dispersion of work locations". Component three is expressed as *Telecommuting* with positive loading for "employment time autonomy", "working from home at least 1 day per week" and "commute distance".

Table 4 Communication characteristics of the classes of professionals

Sample size = 554	Classes of professional workers								
	Traditional workers		Temporally fragmented workers		Telecommuters-car commuters		Telecommuters-public transport commuters		Statistical test
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Frequency of electronic communication									
Appointment	3.01	3.66	5.64	5.64	4.49	4.34	4.72	4.09	$F = 8.595$ $p = 0.000$
Catching up	1.1	1.42	1.66	2.5	1.56	1.96	1.81	2.11	$F = 3.044$ $p = 0.028$
Exchange idea	0.53	1.25	0.76	1.21	0.8	1.4	1.31	1.75	$F = 3.500$ $p = 0.015$
Discuss problem	1.03	2.45	2.17	3.18	1.63	2.36	1.59	2.5	$F = 4.502$ $p = 0.004$
Other	1	1.76	0.99	1.55	1.08	2.36	0.98	2.9	$F = 0.070$ $p = 0.976$
Frequency of electronic communication mode									
Landline	2.56	3.22	4.18	4.94	2.82	3.21	2.53	2.3	$F = 6.256$ $p = 0.000$
Mobile	1.49	2.37	1.6	2.32	2.49	3.32	2.11	2.76	$F = 2.724$ $p = 0.044$
Email	1.57	2.9	4.49	4.92	3.69	4.85	4.8	4.95	$F = 14.62$ $p = 0.000$
SMS	0.67	1.49	0.49	1.12	0.41	1.02	0.57	1.26	$F = 1.368$ $p = 0.252$
MSN	0.09	0.58	0.1	0.33	0.15	1.11	0.14	0.54	$F = 0.216$ $p = 0.885$
Other	0.29	1.07	0.28	0.95	0.18	0.72	0.12	0.45	$F = 1.116$ $p = 0.342$
Electronic communication duration									
Total time spent on electronic communication	40.3	39.4	57.7	45.7	56.9	49.1	57.1	49.9	$F = 4.565$ $p = 0.004$
Appointment	9.94	12.1	21.6	29.5	15.7	20.9	14.4	17.4	$F = 7.572$ $p = 0.000$
Catching up	11.5	17.06	14.5	19.1	16.6	24.01	20.5	32	$F = 3.178$ $p = 0.024$
Exchange idea	2.59	6.94	5.31	11.8	5.58	10.5	8.5	16.2	$F = 5.425$ $p = 0.001$
Discuss problem	5.8	12.2	11.9	17.3	10.4	20.4	10.3	16.9	$F = 3.579$ $p = 0.014$
Other	6.07	22.1	4.87	10.4	6.36	14.8	4.31	12.6	$F = 0.454$ $p = 0.714$
Electronic communication duration by mode									
Landline	15.5	19.8	20.9	22.2	17.4	21.1	17.4	24.3	$F = 1.620$ $p = 0.184$

Table 4 continued

Sample size = 554	Classes of professional workers									
	Traditional workers		Temporally fragmented workers		Telecommuters-car commuters		Telecommuters-public transport commuters		Statistical test	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
Mobile	7.08	13.1	8.07	15.7	12.9	23.1	9.7	16.1	*F = 3.408*	*p = 0.017*
Email	6.22	10.9	19.5	24	17.7	30.2	21.7	29.7	*F = 10.94*	*p = 0.000*
SMS	0.95	2.12	0.99	2.59	0.63	1.73	1.31	3.93	*F = 1.677*	*p = 0.171*
MSN	0.88	5.29	1.21	4.7	1.74	12.1	3.29	14.9	*F = 1.227*	*p = 0.299*
Other										
Frequency of F2F communication	1.02	1.43	2.28	2.28	1.33	2.9	2.04	1.88	*F = 31.27*	*p = 0.000*
Time spent on F2F communication	150.9	199.2	192.5	162.3	114.9	155.1	191.7	175.9	*F = 6.572*	*p = 0.000*

*Italic values are significant at 0.05 level

Factor four captures the *Public transport-mobile work* component, yielding positive loadings for "public transport use", "number of episodes for on-the-way working" and negative loading for "car use" (−0.587). Component five has been labeled *Meeting* and is negatively associated with the "number of episodes at home on a given day" and positively with "number of meeting episodes". Factor six comprises a *Long working hours* component with positive loading for the variables "total time spent on working" and "number of planned work activities". Finally, factor seven is highly and positively correlated with "work scheduling shift" and represents a *Shift working* component.

Analysis of the mean factor scores by type of professional shows that the social professionals have relatively high scores for the component *Temporally fragmented-routine work* they are followed by cultural, education, and business professionals. For the component *Spatially fragmented work*, managers have the highest score, as one would expect. As Table 1 shows, education professionals also have a positive score on the second component—an unexpected result. Their organizations probably allow them to manage their work relatively independently, which allows them to work from alternative work locations, at home for instance. The positive score for the component *Telecommuting* indicates that the business, natural/technical, cultural professionals, and managers have more employment-time autonomy and frequently work from home. All these results are in line with our expectations.

Business professionals have a positive score on the component *Public transport-mobile work*, indicating that the business professionals frequently use public transport and work while travelling. Although not showed, we have calculated the mean factor scores by type of professionals. These calculations show that the component *Meeting* includes a large fraction of social professionals and, to a lesser extent, health professionals. For example, the social professionals often visit people to provide social care that will meet their clients' psychosocial needs, as do health workers. Managers, education, and social professional workers have a positive score for the component *Long working hours*. This is an expected finding, because the work activities of these groups of professional workers seem to be less strictly bound to specific times and to the work place. These workers can be assumed to use ICT in their daily work and to manage their work relatively independently, which allows them to work from places other than the office and outside office. Consequently their working hours could increase. As far as the component *Shift working* is concerned, the cultural professionals have quite a high score, followed by health professionals, indicating that cultural and health professionals work in shifts or irregular working schedules.

Homogenous groups of professional workers

The purpose of this section is to identify a number of classes of professional workers with strong internal similarities in their work characteristics and to describe whether aspects such as socio-demographic and communication characteristics are associated with particular classes of professional worker. Before starting the cluster analysis we calculated the factor score for each individual case for each component. Values of factor scores range from approximately −3.0 to +3.0 and those have a value greater than that range considered as outliers. After eliminating these, the dataset was reduced from 586 to 554. K-means cluster analysis was based on seven components from the PCA. We opted for a four-class solution, because we felt that this preserved the most essential and readily interpretable differences in the work patterns of professional workers.

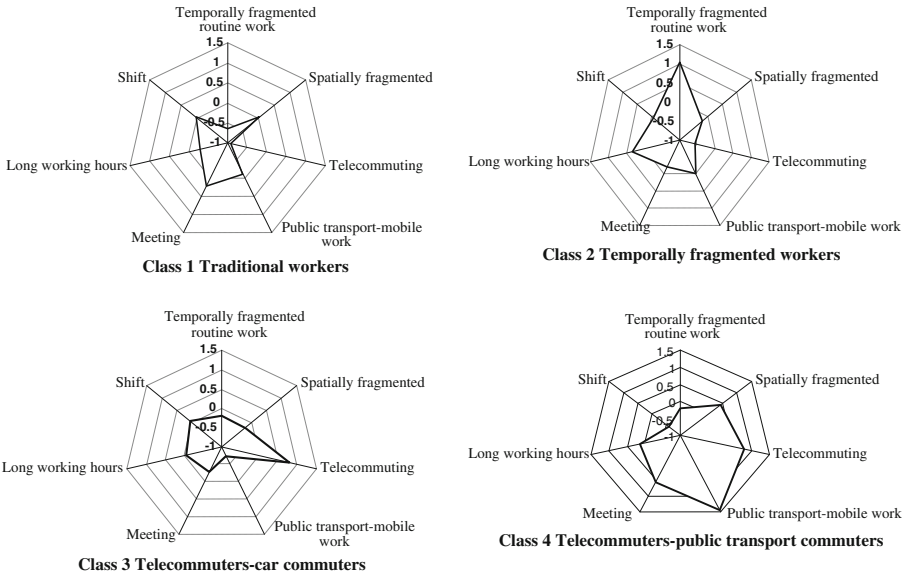

Fig. 2 Mean factor scores of each class of professional

The mean factor scores of each class of professionals are shown in Fig. 2. This figure indicates that Traditional workers (class 1) have relatively strong negative scores for the component *Temporally fragmented routine work* and the component *Telecommuting*. These findings suggest that professionals in class 1 have fewer temporally-fragmented work patterns and are less likely to work from home than others are. The work patterns of Temporally fragmented workers (class 2) are clearly different from those in the other classes. This group has a relatively high and positive score on the component *Temporally fragmented routine work* and the component *Long working hours*. This result presumably comes about because long working duration increases the propensity of having more temporally-fragmented paid work: if people work long hours they are more likely to distribute work across different episodes and across the day. Telecommuters-car commuters (class 3) are characterized by the highest positive factor score on the component *Telecommuting* and a negative score on the component *Public transport mobile work*. Professionals belonging to class 3 are evidently more likely to work from home and less likely to commute by public transport and usually take their private cars. The final class was labeled Telecommuters-public transport commuters. The mean factor score for class 4-professionals suggests that they also have a high frequency of telecommuting, but unlike class 3, they frequently commute by public transport when not working at home.

Socio-demographics of professional classes

The socioeconomic characteristics of the professional classes are presented in Table 3. Professionals belonging to *Traditional workers* (class 1) are largely *health* professionals, women, senior, living only with a partner and residing in less urbanized areas. In addition, this class is characterized by a relatively high fraction of professionals who live in households with one car. It might be hypothesised that some of these professionals commute for short distances by bicycle (or on foot) or public transport (see also Fig. 2).

Temporally fragmented workers (class 2) are *education*, *health*, and *business* professional workers, predominantly female, who live in less urbanized areas, with a partner alone or also with children, in households that own one car. These findings make sense, since more women tend to work in education and health sectors. Female professionals in this class face more space–time constraints resulting from housework and childcare responsibilities so they tend to work part time. The fragmentation of paid labor seems to provide an option for them to have a better work-life balance. A similar result was found by Hubers et al. (2008) who reported that women with young children are likely to have more domestic responsibilities with more rigid space–time constraints and therefore might display different work practices than would those without young children.

The *Telecommuters-car commuters* (class 3) group contains a greater proportion of *business* and *natural/technical* workers, who predominantly live in more urbanized areas, are men, living in a household with a partner alone or with children, with a high net income. This result seems to be consistent with other studies (Reskin and Padavic 1996) reporting that men continue to spend more time in paid work than women do and that women continue to spend more time on household chores and caring for children than men do, even when both spouses work. *Telecommuters-public transport commuters* (class 4) is dominated by business and natural/technical professionals, who live in less urbanized areas with their partners alone or with children. Relatively often, their work location is outside the Randstad. This finding could indicate that they have a relatively-long commute distance and more spatially-fragmented work patterns.

Communication characteristics of professional classes

The descriptive statistics of the communication characteristics of each professional class are presented in Table 4. Professional classes can be seen to differ in terms of electronic and face-to-face communications. The differences are statistically significant. *Traditional workers* (class 1) are characterized by the lowest frequency of electronic communication, higher frequency of use of SMS and other modes (e.g. fax and pager) for electronic communication. This finding is to be expected (Table 1), because compared with the other professional workers the health professionals have relatively low ICT-dependent work tasks. The *Temporally fragmented workers* (class 2) group is associated with the highest frequency of electronic communication for making an appointment and discussing a problem, the highest frequency of landline phone calls, and the longest duration for electronic and face-to-face communications. This finding reflects the complementary relationship between ICT use and electronic and face-to-face communication. At the same time, high frequency of ICT use is associated with more temporally-fragmented work patterns. This result is consistent with the findings of other studies (Lenz and Nobis 2007; Hubers et al. 2008).

As far as *Telecommuters-car commuters* (class 3) are concerned, as expected (Table 1) professionals like business representatives and natural/technical people, have the highest frequency of mobile calls and the longest communication duration via mobile phones. Compared with the former class, *Telecommuters-public transport commuters* (class 4) have high frequency and duration of mobile phone use and use these devices for updating and exchanging ideas. They also use emails frequently with a large time investment. These professionals are also highly involved in face-to-face contacts. These results are not surprising, considering the presence of a large fraction of business professionals in class 4 (see also Table 1). Overall, the results of the descriptive statistics of the communication characteristics show that the ICT variables are associated with the work arrangements of

professional workers. As hypothesized in Table 1, the usage of ICT differs considerably among the professional classes.

Multivariate analysis

In this section we report our estimations for frequency and duration of use for three electronic communication modes—landline phone, mobile phone, and email— and the relative importance of face-to-face communications for the various classes of professional.

Frequency of communications

We applied the negative binomial regression (NBR) model to our data and Table 5 contains the estimation results for the NBR of the frequency of use of landline, mobile, email, and F2F communication. Although many variables were tested, only those that were significant (at $p \leq 0.05$ and 0.10 levels) have presented here. The signs of all the coefficients generated in the NBR models were convincing and consistent with our expectations. The estimated dispersion parameter (α) from the NBR is positive and it is significantly different from zero. This finding suggests a case of over-dispersion.

The estimation results of the models indicate that the factors associated with frequency of ICT use differ for the kind of ICT. *Traditional workers* are less likely to use mobile phone and emailing frequently and less likely to have many face-to-face meetings. In line with Table 4, *Temporally fragmented workers* appear to have frequent use of landline phone and a high frequency for face-to-face contacts. However, for emailing significant results were not found. As expected (Table 4), *Telecommuters-car commuters* are less likely to have frequent face-to-face contacts. The estimated coefficients indicate that *Telecommuters-public transport commuters* have frequent emailing activities.

We also found that the frequency of mobile phone, email, and face-to-face communication are strongly associated with the socio-demographics of professional workers. For example, senior professionals are more likely to have a high frequency of use landline phones but less likely to use mobile phones and emailing. This contrast might be a consequence of the greater familiarity and better skills of young professional workers who have grown up in a digital culture. Male professional workers use mobile phones more often, probably as a result of their early adoption of new ICT devices and services. Moreover, they have a high frequency of face-to-face contacts than female professional workers. Household income proved to be a significant stimulating factor influencing the frequency of electronic communication modes. Professionals who live in a household with a higher net household income tend to have more frequent mobile phone calls and emailing. This is to be expected, because individuals with higher household incomes can afford advanced ICT devices and services more easily than individuals with lower household incomes. Finally, Table 5 shows that single professional workers more often use emails. No statistically significant effects of spatial variables on frequency of communication were found.

Duration of communications

The duration model shows that a professional worker's characteristics are highly associated with the duration of use of electronic and face-to-face communications (Table 6). In line

Table 5 Frequency of use landline, mobile, email and F2F communication

	Land line		Mobile		Emailing		F2F	
	Coef	*p* Value	Coef	*p* Value	Coef	*p* Value	Coef	*p* Value
Class of professional workers								
Traditional workers			−0.373	0.084	−0.813	0	−0.678	0
Temporally fragmented workers	0.44	0.007					0.346	0.014
Telecommuting-car commuters							−0.425	0.003
Telecommuters-public transport commuters					0.298	0.087		
Age	0.008	0.097	−0.023	0	−0.12	0.043		
Male	−0.236	0.023	0.471	0.001			0.282	0.005
Household type								
Single					0.495	0.004		
Living with a partner only								
Living with a partner and have children								
Presence of small children								
Net household Income (in Euro per month)								
1,000 or less								
1,001–2,000								
2,001–3,000					1.022	0.039		
3,001–4,000			1.102	0.068	0.971	0.053		
4,001 or more			1.464	0.016	1.2	0.017		
Number of cars in household					−0.225	0.017		
Urbanization degree (Address/km^2)								
<500								
500–1,000								
1,001–1,500								
1,501–2,500								
≥2,501								
Randstad								
N	555		555		555		555	
α	0.853		1.44		1.22		0.53	
Log likelihood	−1094.76		−861.54		−1143.53		−865.92	
Pearson χ^2	529.39		503.78		568.29		494.72	

with the frequency results, *Traditional workers* also have a low duration for email communication. In line with Table 4, *Telecommuters-car commuters* have intensive mobile phone use and extensive face-to-face contacts. *Temporally fragmented workers*, like professionals in education and health, spend more time on landline phone calls which can be easily made at their relatively fixed work locations.

Table 6 Duration of use landline, mobile, email and F2F communication

	Duration of							
	Land line		Mobile		Email		F2F	
	Coef	*t*	Coef	*t*	Coef	*t*	Coef	*t*
Class of professional worker								
Traditional workers					−0.199**	−4.365		
Temporally fragmented workers	0.078**	1.787						
Telecommuters-car commuters			0.133**	2.878			−0.188**	−3.793
Telecommuters-public transport commuters								
Age	0.088**	2.009	−0.104*	−2.231	0.093**	1.999		
Male	−0.091**	−2.066	0.097**	2.075	0.115*	2.457		
Household type								
Single								
Living with a partner only								
Living with a partner and have children								
Presence of small children								
Net household income (in Euro per month)								
1,000 or less							0.097**	2.105
1,001–2,000					−0.090*	−1.872	0.143**	2.984
2,001–3,000								
3,001–4,000					−0.110**	−2.233		
4,001 or more			0.099**	2.878				
Number of cars in household							0.108**	2.098
Urbanization degree (address/km^2)								
<500					0.135**	2.653		
500–1,000			−0.105**	−2.214				

Table 6 continued

	Duration of							
	Land line		Mobile		Email		F2F	
	Coef	*t*	Coef	*t*	Coef	*t*	Coef	*t*
1,001–1,500			−0.122*	−2.550			0.096**	2.041
1,501–2,500								
≥2,501								
Randstad	0.073*	1.678						
N								
	553		539		547		554	
R^2								
	0.026		0.068		0.088		0.068	
Adjusted R^2								
	0.019		0.055		0.076		0.058	
F stat								
	3.493		5.437		7.255		6.594	
Significance								
	0.011		0.000		0.000		0.000	

** Significant at the 0.05 level

* Significant at the 0.10 level

With respect to the household characteristics of professional workers, we found that household net income, age, and gender were the most highly significant factors influencing the duration of ICT use and face-to-face communication. No statistically significant effects were found for household composition or the presence of small children. Consistent with our expectations, professional workers who live in high-income households have longer mobile phone contacts than others do. The results also suggest that professional workers with low household incomes spend less time on electronic communications and more time on face-to-face contacts. While men spend more time on mobile phone calls and emailing and less on fixed-lines, young professionals have shorter mobile phone calls, but spend more time on land line phone calls and their emails.

Additionally, a positive effect was found of the number of vehicles in a household on the duration of face-to-face contacts. Several significant effects were found for urbanization degree: professionals living in less urbanized areas spend more time on emailing while those in medium-density neighborhoods have longer face-to-face contacts and fewer long mobile phone calls. This contrast is intuitively understandable: more urbanized areas have more events and opportunities for face-to-face contacts than less urbanized areas do.

Conclusions and discussion

This study was directed towards developing a better understanding of professional workers' work arrangements and their relationship with electronic communications and face-to-face contacts. We have noticed that in previous studies knowledge of the importance of professional work for ICT use has been limited. We have analysed this importance using data obtained from a 2-day activity-travel-communication diary survey in the Netherlands. The following conclusions can be drawn. Based on the temporal, spatial, and planning attributes of work activities as well as commuting features, the work arrangements of professionals differ markedly. Just over a quarter of the respondents show traditional work arrangements, which means that they largely work continuously at one work location. Examples are professionals in health, in education, and some professionals in business services (e.g. in banks and law offices). However, most professionals deviate from this model. Almost half of them are labeled 'telecommuters', a large share in comparison with previous studies. This difference might result from the definition of teleworkers who, in our study, are people working from home at least 1 day per week. The car users amongst them, dominated by people working in *business* and *natural/technical* professions, show little temporal or spatial fragmentation of their work activities. This finding means that they largely work from 9 to 6, but predominantly at two locations (e.g. in their office and at home). In contrast, the telecommuters who also use public transport, highly dominated by business professionals, are the ones who work at a few more than two locations. This result seems counter-intuitive since one would expect that those who need to go to lots of locations would want to use a car in order to get to them more easily. This situation might be true for a car-based society as in the USA, but in the Netherlands public transport provision is of a relatively high quality. A quarter of the professionals show large temporal fragmentation of their work activities. They are working in the *education*, *health*, and *business* sectors.

As expected, these different work arrangements are reflected in the use of communication modes. Traditional workers in *health*, *education*, and some *business* professions make hardly any use of electronic communication means such as mobile phones but especially emails. The nature of the work of employees in these professions demands face-to-face contacts with colleagues, patients, clients, and students. As they largely participate

in work activities at two fixed locations (work and home) where internet connections are available, telecommuters who also use the car (*business* and *natural/technical* professionals) make relatively short face-to-face communications but spend more time one their mobile phone. Telecommuters who use public transport for their personal meetings are more inclined to have face-to-face than electronic contacts. Telecommuters also have relatively frequent face-to-face contacts. Finally, the professionals (in *business* and *health*) characterized by fragmented temporal working patterns have frequent face-to-face contacts as well as frequent and long electronic contacts by landline phone. The findings for professionals with a fragmented temporal work pattern as well as for telecommuters who also use public transport show that different communication channels act as complements rather than substitutes.

The professionalization of the work force as well as the adoption and intensive use of ICTs is expected to increase. Even the traditional professions that demand the personal presence of doctors, nurses and patients or teachers and students might experience some changes in the spatial organization of their work. E-health could for example substitute for some physical consultations or might save a trip to the pharmacy for medication. Students can start their study at a distance as with the Open University in the UK and other European countries. The study of the meaning of these transformation processes for transport would be worthwhile. In any case the continuous integration of ICTs in the arrangement of work encourages activities to take place at any time, in any place. Consequently more professionals will work at non-traditional locations such as at home, on the road or in the offices of others.

In this study we have considered a wide range of professionals in order to obtain a more comprehensive understanding of the importance of professionals' work arrangements and their relationship with electronic and face-to-face communications. However, the results also show that, within the same types of profession, work arrangements and communications differ widely. In order to develop more in-depth understandings we advise setting up case studies on professionals of different types and their work activities and communications and use these studies to refine quantitative analyses of professionals' communications.

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