Loss of labor time due to malfunctioning ICTs and ICT skill insufficiencies

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Abstract

Purpose – The purpose of this paper is to unexplore the area of information and communication technology (ICT) use in organizations related to the assumed productivity gains by the use of ICTs. On the one hand, the paper focus on the losses of labor time that are caused by malfunctioning hardware or non-functional software, and on the other hand, the paper focus on the labor time losses that are caused by a lack of skills to maximize ICT.

Design/methodology/approach – To estimate these losses, the paper conducted a large-scale survey among the Dutch workforce. The respondents were presented scenarios, and then they were asked to assess the loss of labor time.

Findings – When working with ICTs, malfunctioning ICT and ICT skill insufficiencies lead to a loss in labor time of 7.5 percent. The losses increase with decreasing educational attainment level. Age does not contribute to the total average losses. Workers highly underestimate the effects of ICT-related training. The role of co-workers is more significant than the formally organized means by the organization.

Originality/value – Due to ICT's significance among the labor force, investigating the reported losses is an important step to further improve the use of ICTs in the workplace.

Keywords New technology, Human resource management, Labour, Employee productivity, Productivity rate, Hours of work, Company performance

Paper type Research paper

1. Introduction

A vast body of literature considers the relationship between productivity acceleration and information and communication technology (ICT). ICT has become pervasive throughout the labor market with hardly any exempted jobs (Zhang and Aikman, 2007) and is currently believed to be one of the main drivers of productivity growth (e.g. Colecchia and Schreyer, 2002; Nordhaus, 2002; Oliner and Sichel, 2000; Timmer and van Ark, 2005). In this contribution, we empirically investigate an unexplored area that is directly related to the productivity gains that are assumed to be the effects of ICT use. We address both the losses of labor time that are caused by malfunctioning hardware or non-functional software, and losses of labor time caused by a lack of skills to maximize ICT.

Although both technical and human constraints are recognized, to our knowledge, no studies have attempted to make both facets explicit or have attempted to calculate the loss of labor time that is caused by both constraints. This might be the case because the relative losses due to both problems are deemed to be smaller than the overall gains in productivity, as accomplished with ICT. Therefore, investigating to what extent the use of ICTs in the workplace can be further improved remains interesting. Organizations rarely consider these aspects in their ICT expenditures, which in most cases will include costs such as purchase, maintenance and energy, and in some cases training. Failure to account for malfunctions or skills could potentially bias upwards the estimated effects of ICTs on productivity. Due to ICT's significance among the labor force, investigating the losses due

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to the technical and human constraints of malfunctioning ICTs and ICT skill insufficiencies is an important step to further improve the use of ICTs in the workplace.

This paper contributes to provide empirical evidence by using a sample of 1,741 workers among the Dutch labor force in all activity sectors. The sample considers firms of a great variety; our aim is to provide a broad picture that includes the total Dutch economy. Productivity losses are likely to vary among different organizations, as they do not all use the same technologies. Besides estimating the losses of labor time, our goal is to address differences among groups of workers and differences among firm sizes. For example, it is often assumed that older workers have lower levels of computer literacy which might result in higher losses. Also, in larger firms ICT support might be better organized than in smaller firms.

2. Literature review

2.1 Technological and human constraints of working with ICTs

Both hardware and software malfunctions and the misuse of ICT by human beings were considered by Forester and Morrison (1994) to be sources of the problems created for society by computers. Kling (2007) stressed that many organizations lose potential value after computerization because many organizations develop systems in ways that lead to a large number of implementation failures, few organizations design systems that effectively facilitate people's work, and it is underestimated how much skilled work is required to extract value from computerized systems. The distinction between technical issues and the issues caused by human skill insufficiencies is implicitly acknowledged in several domains. Regarding technical issues, Forester and Morrison (1994) provided several examples of computer malfunctions that are still applicable today. The authors stressed that unreliable hardware and software cost society an unknown number of billions every year in terms of downtime of ICTs, cost overruns and abandoned systems and that "unreliable computers are providing to be a major headache for modern society" (p. 8). The authors continued with "Computers tend to be unreliable because they are digital devices prone to total failure and because their complexity ensures that they cannot be tested thoroughly before use" (p. 8). Although these theories may be outdated, there are many well-known examples of computer crashes, networks that go down, unresponsive software or incompatibility problems. The first research question is:

RQ1. To what extent do malfunctioning ICTs affect labor time spent with ICTs in the workplace?

In addition to technical issues, the importance of ICT skills is stressed in several studies (e.g. Chapman *et al.*, 2000; de Koning and Gelderblom, 2006). However, there are few studies that address losses of productivity due to skill insufficiencies directly. Overall, there seems to be an agreement that changes and innovations are skill-biased, enhancing the need for investments in human capital and leading to a demand shift toward skilled labor (e.g. Bresnahan *et al.*, 2002; Caroli and van Reenen, 2001). Employers are upgrading their workforce because computerization enables firms to use high-skilled workers more effectively as a result of the diminishing importance of routine tasks (Borghans and ter Weel, 2004). Levy and Murnane (2003) observed demand shifts favoring educated labor during the computerization in the past three decades. The second research question is:

RQ2. To what extent do insufficient ICT skills affect labor time spent with ICTs in the workplace?

2.2 Socio-demographic differences and human constraints of working with ICTs

Many studies, often in the field of sociology, concern the use of ICTs among different social segments. These studies indicate that several demographics should be considered, the first being sex. There is a long history of ICT occupations and technical skills being stereotyped as masculine (Margolis and Fisher, 2003). Clayton *et al.* (2009) stressed that sex stereotypes might effect a women's choice over time, reducing their confidence and interest in ICT and turning them away from ICT as an occupation. Furthermore, as a consequence of the sex segmentation in the labor market, Cabrera and Malanowski (2009) assumed that women are less socialized to feel in command of using new technologies. Females are also less prepared to acquire competencies than men (Tijdens and Steijn, 2005). However, most studies do not find any difference between men and women with regard to hardware and software skills (e.g. Tijdens and Steijn, 2005; van Deursen and van Dijk, 2011). Furthermore, when present in ICT work, females tend to work in "softer" and "less technical" areas than males (Kelan, 2008). This might affect the losses due to malfunctioning ICTs or ICT skill insufficiencies.

Regarding age, older people are often considered laggards in the diffusion process of novel ICTs. In the labor market, older workers make less use of ICTs and find it more difficult to operate ICTs (de Koning and Gelderblom, 2006). de Koning and Gelderblom (2006) concluded that becoming older causes disadvantages in working with ICT, whereas (the level of) ICT use positively affects performance. Ilmakunnas and Maliranta (2007) revealed that in firms operating in the ICT industry sector, dismissals of older workers enhance productivity, whereas dismissals of prime-age workers hamper it. Older people may be less willing to continuously update their competences due to inferior mental agility, processing speed and learning capabilities than younger workers (Skirbekk, 2008). Furthermore, the introduction of ICT innovations can be daunting for older employees if it requires them to acquire new skills or change current practices (Beatty *et al.*, 2001). In addition, organizations might be reluctant to employ and train older workers given their shorter career horizon during which the training investments could be amortized (Cataldi *et al.*, 2011). For such reasons, the loss of labor time due to malfunctioning ICTs and ICT skill insufficiencies might be increasing with age. However, de Koning and Gelderblom (2006) also argue that although it is clear that older workers make less use of ICT in their work than younger workers, available literature does not say much about the level and the quality of the ICT-use by older workers who are actually using ICTs. There is, for example, evidence that older workers outperform their younger counterparts concerning informational and strategic internet use (van Deursen *et al.*, 2011).

Education has been proven to be a consistent global predictor of ICT use. Goldin and Katz (2008) argued that highly educated people are able to keep up with technological advancements. Furthermore, they make ICT investment and adoption easier because their higher educational level enhances the usage and impacts of ICT (Bayo-Morionesa and Lera-López, 2007). However, differences in education level do not necessarily result in the differences of problems encountered with ICTs. In labor organizations, using ICT applications that suit a particular educational level is expected. Usually, highly educated people make more use of advanced technologies, while individuals with minimal education use simpler ICT versions that are adjusted to their tasks. However, despite this general division of labor, the large differences in ICT-related skills and the use of ICTs among different educational levels often observed in the literature justify an investigation of the specific effects of education on the loss of labor time.

To conclude, some workers are better enabled than others in successfully using ICTs. The third research question is:

RQ3. Are there differences in the loss of labor time spent with ICTs due to both malfunctioning ICTs and ICT skill insufficiencies among sex, age and education level?

2.3 Organizational differences of working with ICTs

Firm size is an explanatory variable that is used in many studies of ICT adoption and is considered an important indicator for investments in ICT. Evidence from Australia, for example, showed that the earliest and most intensive users of ICTs and the internet tended to be large firms with skilled managers and workers (Gretton *et al.*, 2004). In large firms, skilled managers and employees often help in making technology work (Gretton *et al.*, 2004). Furthermore, there are differences in the uses of, for example, the internet; large firms may use it to redesign information and communication flows within the firm and to integrate these flows throughout the production process, while small firms only use the internet for marketing purposes (Pilat, 2004). Furthermore, firm size is connected to the availability of ICT-related skills (Morgan, Colebourne and Thomas, 2006). The fourth question is:

RQ4. Are there differences in the loss of labor time spent with ICTs due to both malfunctioning ICTs and ICT skill insufficiencies among different firm sizes?

2.4 Handling ICT-related problems

The workplace is the most frequently reported location for learning to use computers (Selwyn, 2005). Although the role of co-workers is often acknowledged, allowing workers to handle malfunctioning ICTs and the problems caused by skill insufficiencies require more formal support. Studies that aim to investigate the productivity contributions of ICTs indicate that complementary training for a successful organizational adoption of ICT is essential. The common wisdom seems to be that work-related training is associated with significantly higher productivity (e.g. Dearden *et al.*, 2006). Konings and Vanormelingen (2010) found that training boosts marginal productivity of an employee more than it increases its wage. Hempell (2003) stressed that training programs are not only directed toward new workers but are also designed to update the skills of current personnel to cope with special applications and changing tasks; often ICT applications are individually designed for the environment of companies. However, while a broad consensus that ICTs contribute to organizational productivity exists, actual empirical evidence is mixed (Hempell, 2003). An explanation might be that the decision to invest in training is likely to be endogenous with respect to a firm's performance (Hempell, 2003). The incentives to invest in ICT training are theoretically and empirically ambiguous and obviously depend on the specific types and aims of the training programs (Hempell, 2003). Hempell (2003) concluded that the benefits from ICT training are understated, while the productivity of ICT investments is overstated. The final goal of this study is to investigate how workers solve ICT problems and what the role of formally arranged solutions are:

RQ5. What sources of help do workers address when experiencing malfunctioning ICTs or ICT skill insufficiencies?

RQ6. What are the roles of helpdesks and ICT training in overcoming malfunctioning ICTs and ICT skill insufficiencies?

3. Method

3.1 Survey sample

To explore the losses due to malfunctioning ICTs and ICT skill insufficiencies, we conducted a survey in November 2011 among a large sample of Dutch workers aged between 16 and 67. We used a Dutch business panel including 108,000 workers which is believed to be a largely representative sample of the Dutch working population, although migrants are slightly underrepresented. Members of the panel receive a small incentive of a few cents for every survey question. We set two requirements for participating in this study:

- the total working time had to be at least 12 hours per week (this was true for 93.7 percent of the respondents); and
- the total computer use for work had to be at least two hours on an average working day (this was true for 70.7 percent of the respondents).

Both requirements were imposed due to the nature of this survey. The sample is stratified by sex, age and education. Because our goal was to include a large variety of job types to represent the whole labor force that uses ICTs, we included workers from 18 different labor sectors (both public and private), covering all of the Dutch economy. In total, we randomly invited 10,136 respondents via e-mail to reach a sample of at least 1,200 workers. Of the 10,136 invitations, 2,805 people started the survey (27.7 percent). After excluding those who did not meet the two requirements, in total 1,741 workers filled in the survey entirely (75 surveys were not fully completed and removed from the data set). Table I shows the distribution of the sample. There are no official statistics available of the Dutch working population with a working time of over 12 hours a week and at least two hours ICT use a day. However, as shown in Table I, the distribution of

	n	%	Average work week (hr:min)	Average daily use of ICT for work (hr:min)	Distribution of Dutch labor force (%)
Total	1.741	100	36:01 (SD = 7:22)	5:59 (SD = 1:55)	100
Sex					
Male	922	53	38:43 (SD = 6:03)	5:51 (SD = 1:58)	55
Female	819	47	32:58 (SD = 7:31)	6:07 (SD = 1:48)	45
Age					
16-34	497	29	36:15 (SD = 7:04)	6:17 (SD = 1:58)	32
35-49	732	42	35:52 (SD = 7:18)	6:07 (SD = 1:50)	40
50-67	512	29	36:00 (SD = 7:46)	5:31 (SD = 1:51)	28
Education					
Low	398	24	35:32 (SD = 7:40)	5:50 (SD = 1:52)	23
Medium	728	45	35:29 (SD = 7:43)	6:03 (SD = 1:53)	43
High	615	31	36:57 (SD = 7:15)	5:59 (SD = 1:57)	35
Firm size					
< 10	245	14	38:26 (SD = 10:53)	5:50 (SD = 1:57)	27
10-49	296	17	35:41 (SD = 7:49)	5:54 (SD = 1:56)	26
50-99	187	11	35:38 (SD = 7:06)	5:55 (SD = 1:58)	10
100-249	240	14	35:54 (SD = 6:43)	5:57 (SD = 1:49)	10
> 250	773	44	35:30 (SD = 5:45)	6:05 (SD = 1:53)	27

Table I. Overview of the research population our sample resembles the distribution of the total Dutch workforce. However, larger firm sizes are overrepresented in our sample.

The respondents averaged a working week of 36 hours and one minute. This average is slightly higher than the average working week for the entire Dutch labor force, which is 34 hours and 18 minutes (second quarter of 2011) (CBS Statline, 2012). This difference is caused by the fact that we only included people who worked for at least 12 hours per week. The respondents in this study use a computer for their occupational tasks for an average of five hours and 59 minutes each day.

3.2 Measurements

To assess the loss of labor time among the Dutch labor force, we conducted a large-scale survey in which respondents were presented scenarios of real-life ICT problems. After having read the scenarios, the respondents were asked to assess the loss of labor time due to malfunctioning ICTs or ICT skill insufficiencies. Wason and Cox (1996) defined scenarios as stories which present hypothetical situations which require action or judgment from the respondents. Our main objective of using scenarios was to provide respondents with the type of problems under consideration. The scenarios described a hypothetical situation in which someone experiences problems with ICT at work. The problems described in the hypothetical scenario presented to all participants were chosen to possess mundane realism (Weber, 1992). The scenarios were pre-tested among six workers who use computers at work. These workers were interviewed using prospective verbal probing techniques (Willis, 2005). Questions to establish the subject's capability to understand the scenario and to determine whether the subject is confident enough to judge the meaning of the questions were incorporated.

The first scenario presented a malfunctioning ICT:

> Imagine [...] After arriving at work, it is not possible to login to your computer. The network appears to be down. When the outage is over, you start working. Unfortunately, the software application you are using may not be everything you could want. To make matters worse, halfway through, the application fails to respond at all. You are forced to restart your computer. When you are finally finished, the printer fails [...]. What a day!
>
> The next questions are about computer problems at work. Think for example of login failures, network failures, applications that are unavailable, computers that freeze or become annoyingly slow, applications that are incompatible with each other, printers or scanners that are not working as they should, portable media that are rejected (e.g. a USB drive or CDROM), etc.

For assessing the loss due to ICT skill insufficiencies, three short scenarios were presented regarding ICT applications other than internet and e-mail (from now on referred to as ICT applications), the use of the internet at work and the use of e-mail at work. We have chosen to incorporate the internet and e-mail into separate scenarios because overall, these applications appeared to be used for the longest periods of daily working with all ICT applications. The following scenario concerned ICT applications:

> Imagine [...] You are attempting to open a file that you saved before. However, you seem to be unable to retrieve the file. Frustrated, you start to work in an older version of the file, meaning that some of the prior work has to be done all over again. While working on the file, suddenly a co-worker tells you that the edits you've done could have been done in a much easier way. If only you would have known!
>
> The next questions are about working inefficiently with ICT at work. Think for example of lacking general ICT skills and the skills for specific actions, forgetting to save files, being unable to retrieve files, performing actions that could have done much easier, etc.

The respondents who use the internet at work for work purposes were presented with the following scenario:

> Imagine […] While working on the Internet, it appears you are unable to find a website you visited before. Furthermore, you struggle to find required information when using a search engine. The result is that while using the Internet, you were unable to accomplish your goal.
>
> The next questions are about inefficient use of the Internet at work. Think for example of problems with retrieving visited websites, failing to store or share documents over the Internet, being unable to find required information, having problems with defining proper search queries, not knowing on how to do something on the Internet, etc.

The respondents who use e-mail at work for work purposes were presented with the following scenario:

> Imagine […] While sending a co-worker an e-mail, you forget to add an attachment. Also, you suddenly note that the e-mail was sent to too many receivers. Annoying, because when answering, you did not remove the prior private conversation which is now available for all receivers.
>
> The next questions are about inefficient use of e-mail at work. Think for example of forgetting to add attachments, sending e-mail to the wrong recipients, not knowing how to use the address book, not knowing how to conduct a specific action in your mail program, working inefficiently because of irregularly checking your e-mail, etc.

After all scenarios, respondents were asked to indicate how often they experienced similar problems (number of times per day, week, month or year). Subsequently, they were asked to assess how much time they lose on average when such a problem occurs (minutes). Respondents were also asked whether they provide help to their co-workers that experience problems, and if so, to estimate how often they provided help and how much time this required on average (minutes).

To answer *RQ5*, respondents were asked how they solved experienced ICT problems: by using a helpdesk, asking co-workers for aid, seeking help outside work (e.g. friends or family) or by individually addressing the problem (e.g. by using the computer's help functions). In answering *RQ6*, we asked the respondents whether they had performed any ICT-related training in the past three years. Respondents who attended ICT training were asked how much time they saved each day as a result of the training. Respondents who did not attend ICT training in the past three years were asked how much time they think they might save after attending training. Additionally, we asked them the reasons for not attending ICT training (i.e. no need, lack of time, not being allowed, inability to find training that suits their needs, cost of the training, excessive entry requirements and poor accessibility).

3.3 Data analyses

The responses to the scenarios were treated as separate observations. The unit of analysis was the loss of labor time due to the problems described in the scenarios. Because the respondents that were included in this study do not fully represent the Dutch labor force (due to the participation requirements), the average time loss rates are shown as percentages. The overall labor time losses when working with ICTs were calculated and linear ordinary least square regression analysis was used to predict which factors (age, sex, education and firm size) contribute to the labor time losses. The distribution of the losses of labor time were positively skewed with long right tails and were log-transformed. Two dependent variables, namely internet and e-mail skill shortage losses contained zero values, 11.9 and 10.9 percent, respectively; therefore a small positive constant (1) was added to the responses. The categorical independent variables of sex, age and firm size were coded as dummy variables. The data regarding education were collected by degree. These data were subsequently divided into three overall groups of low, medium and high educational attainment (primary school equivalent, high school equivalent, college and university equivalent), and coded as dummy variables. Solving the experienced ICT problems was analyzed in multiple ways. Logit regression analyses were conducted to analyze what help sources were used by men and women of different ages, at education levels and in different firm sizes. A similar analysis was conducted for the sources people indicated that they learned the most when using ICTs at work, and to find sex, age, education level and firm size differences in attending ICT training.

4 Results

4.1 Loss of labor time

The respondents on average lost 12 minutes and five seconds of labor time each day due to malfunctioning ICTs (SD = 19.19; median = 03.00). Of the total working time with ICTs (05:59.00), this loss equals 3.4 percent. Furthermore, 55.9 percent of the respondents include helping co-workers that experienced malfunctioning ICTs in their daily working time with ICT. This took an average of four minutes and six seconds each day (SD = 05.54; median = 03.00), resulting in a loss of 1.1 percent for the people who offer help, or an average of 0.6 percent for all respondents. The total loss of labor time due to malfunctioning ICTs then is set at 4.0 percent of the time working with ICTs.

Table II summarizes the loss of time due to ICT, internet and e-mail skill insufficiencies. All of the respondents use ICT applications at work. Here, approximately five minutes and four seconds are lost due to skill insufficiencies, or 2.3 percent of the time working with ICT (other than internet and e-mail). Of the respondents, 87.0 percent indicated the use of internet for work purposes. On average, these respondents lost four minutes and 17 seconds due to internet skill insufficiencies, a loss of 5.0 percent of the total time working on the internet. Regarding e-mail use at work, the average loss is 1.6 percent. Of the total five hours and 59 seconds of computer use each day, the total assessed loss of labor time caused by ICT skill insufficiencies is then set at 2.7 percent. On top of this, the loss of ICT labor time caused by helping co-workers that experience problems caused by ICT skill insufficiencies should be added. As such, 63.6 percent of the respondents report to include offering help to co-workers in their daily ICT use for an average of four minutes and 46 seconds (SD = 06.37; median = 03.00). This percentage results in a total additional labor time

Table II.
Daily loss of labor time when working with ICTs due to insufficient skills

	% of respondents	Daily working time (hr:min.sec)	Average daily loss time M (min.sec)	SD (min.sec)	Median (min.sec)	%	Total loss of time over all respondents (%)
ICT applications	100.0	3:44.18	05.04	09.55	01.50	2.3	1.4
Internet	87.0	1:25.14	04.17	08.43	00.75	5.0	1.0
E-mail	92.4	1:05.18	01.01	02.50	00.25	1.6	0.3
Total							2.7

loss of 0.8 percent over all respondents. Altogether, the total assessed loss of labor time caused by ICT skill insufficiencies is 3.5 percent.

In Table III, OLS estimates are shown in which average daily loss of labor time due to malfunctioning ICTs and due to skill insufficiencies is predicted from sex, age, education and firm size. The effect size for low education is equal to exp(0.504)−1 (Halvorsen and Palmquist, 1980); low-educated workers have a 0.7 percent higher loss of working time due to ICT skill shortages than high-educated workers. Furthermore, in small firms with one to nine workers employed, individual daily losses of labor time are 0.3 percent lower than in firms with over 250 workers. A lack of significant difference due to sex and age remain. Table III also reveals that males have a 0.2 percent higher loss of working time due to ICT skill shortages. Low-educated workers have a 0.3 percent higher amount of working time loss caused by ICT skill insufficiencies, and a 0.2 percent higher amount of working time loss caused by internet skill insufficiencies as compared to high-educated workers. Concerning helping co-workers with skill-related problems, medium-educated workers lose a 0.2 percent more time by offering help than higher educated workers.

4.2 Means to overcome malfunctioning ICTs or ICT skill insufficiencies

Respondents were asked how they solved problems that were caused by malfunctioning ICTs. Most of the respondents (48.7 percent) sought aid from a helpdesk. Solving experienced problems alone was preferred by 29.4 percent of the respondents, and asking a co-worker for help was favored by 18.2 percent. Finally, 3.0 percent of the respondents attempted to obtain help outside of the work environment. Table IV reveals that men are significantly more likely to attempt solving a problem alone (odds ratio 1.648), and significantly less likely by the addressing the helpdesk (odds ratio 0.803) or asking

	B (SE)				
Explanatory variables	Malfunctioning ICT losses	ICT skill shortage losses	Internet skill shortage losses	E-mail skill shortage losses	Loss with providing help
Constant	1.642 (0.080)***	1.027 (0.067)***	0.651 (0.076)***	0.435 (0.041)***	2.582 (0.078)***
Sex					
Male	0.075 (0.057)	0.186 (0.047)***	0.097 (0.054)	0.061 (0.029)	0.106 (0.056)
Age (reference: ⩾50)					
<35	0.089 (0.076)	−0.079 (0.063)	0.134 (0.072)	−0.042 (0.039)	0.072 (0.077)
35-49	0.067 (0.067)	−0.112 (0.056)	0.055 (0.064)	−0.065 (0.034)	0.054 (0.066)
Educational level (reference: high-educational level)					
Low-educational level	0.504 (0.075)***	0.247 (0.063)***	0.189 (0.073)**	−0.021 (0.039)	0.075 (0.075)
Medium-educational level	0.117 (0.064)	0.121 (0.054)*	0.223 (0.060)***	0.048 (0.032)	0.138 (0.062)*
Firm size (reference: ⩾250)					
1-9	−0.378(0.085)***	−0.017 (0.071)	0.140 (0.079)	−0.070 (0.043)	−0.054 (0.095)
10-49	−0.095 (0.080)	−0.045 (0.067)	0.035 (0.076)	−0.034 (0.041)	−0.138(0.080)
50-99	0.015 (0.095)	0.081 (0.079)	0.045 (0.089)	0.023 (0.048)	−0.012 (0.090)
100-249	−0.058 (0.086)	0.062 (0.072)	0.194 (0.083)	0.004 (0.044)	0.086 (0.084)
n	1,741	1,741	1,514	1,609	1,107
R, R^2, adj R^2	0.198, 0.039, 0.034	0.153, 0.024, 0.018	0.132, 0.017, 0.012	0.101, 0.010, 0.005	0.119, 0.014, 0.008

Notes: [a]Log-transformed. *,**,***Significant at the 5, 1 and 0.1 percent level, respectively

Table III. OLS analyses with average daily loss of labor time due to malfunctioning ICTs[a] (column 2) and average daily loss of labor time due to skill shortages[a] (columns 3-6) as dependent variables

Table IV.
Logistic regression analyses for help sources when confronted with malfunctioning ICTs as dependent variables

	Odds ratio			
Explanatory variables	Helpdesk	Individually	Co-worker	Outside
Constant	2.785***	0.228***	0.078***	0.007***
Sex				
Male	0.803*	1.648***	0.761*	0.624
Age (reference: ⩾50)				
<35	0.712*	1.289	1.255	0.726
35-49	0.840	1.188	1.145	0.495
Educational level (reference: high-educational level)				
Low-educational level	1.067	0.647**	1.494*	1.623
Medium-educational level	1.044	0.784*	1.259	1.586
Firm size (reference: ⩾250)				
1-9	0.111***	3.353***	2.497***	26.441***
10-49	0.244***	1.616**	4.984***	3.895*
50-99	0.350***	1.168	4.839***	1.001
100-249	0.490***	1.372	2.446***	1.609
Nagelkerke R^2	0.177	0.072	0.112	0.227
χ^2	245.973***	90.051***	123.469***	83.750***

Notes: *,***Significant at the 5, 0.1 percent level, respectively

a co-worker for help (odds ratio 0.761) than women. Workers aged under 35 are significantly less likely to turn to a helpdesk than workers aged over 50 (odds ratio 0.712). Furthermore, the results show that low-educated workers are significantly less likely to addressing malfunctioning ICTs oneself (odds ratio 0.647) than high-educated workers. They are, however, significantly more likely to asking a co-worker for help (odds ratio 1.494). Finally, workers in firms sized over 250 workers are significantly more likely to address a helpdesk and significantly less likely to attempt solving a problem alone, ask a co-worker or find help outside the organization.

The source that respondents learned most from concerning the use of ICT at work are co-workers (38.1 percent), followed by the internet and books (19.4 percent) and people outside work (15.2 percent). ICT help functions were mentioned by 5.2 percent. Finally, 11.2 and 11.1 percent claimed to have learned from ICT training and the helpdesk, respectively. Of the people that actually had training, 34.9 percent indicated to have learned most from training. Still, co-workers remain an important source for learning (33.5 percent). Table V reveals that men are significantly more likely to learn from the internet or books (odds ratio 2.018) and significantly less likely to address the helpdesk (odds ratio 0.608) compared to women. Workers aged younger than 35 are significantly more likely to have learned most from the internet or books than older workers (odds ratio 1.472). However, they are significantly less likely to have learned most from training (odds ratio 0.531). Workers with a low level of education are significantly more likely to address co-workers than workers with high levels of education (odds ratio 1.390). Finally, workers in small firms (one to nine) are significantly more likely to have learned most from internet or books (odds ratio 1.797) and people outside work (odds ratio 2.597) than workers in the largest firms (over 250). They are significantly less likely to have learned most from co-workers (odds ratio 0.515), training (odds ratio 0.580) and helpdesk (odds ratio 0.552).

A significant formal organizational means to improve working with ICTs is training. Of all respondents, 20.2 percent had ICT training at work in the past three years. The second column in Table VI shows that workers aged under 35 are less likely

Explanatory variables	Co-workers	Internet/books	Odds ratio People outside work	Training	Helpdesk
Constant	0.525***	0.123***	0.174***	0.206***	0.215***
Sex					
Male	0.872	2.018***	0.776	0.950	0.608**
Age (reference: ⩾50)					
<35	1.203	1.472*	0.847	0.531**	0.998
35-49	1.238	1.267	0.827	0.739	0.889
Educational level (reference: high-educational level)					
Low-educational level	1.390*	0.716	1.165	0.914	0.892
Medium-educational level	1.124	1.075	1.131	0.986	0.752
Firm size (reference: ⩾250)					
1-9	0.515***	1.797**	2.597***	0.580*	0.552*
10-49	1.267	0.979	1.125	0.599*	0.602*
50-99	1.079	0.970	1.279	0.734	0.781
100-249	0.994	1.040	0.790	0.802	1.389
Nagelkerke R^2	0.028	0.046	0.039	0.021	0.032
χ^2	36.193***	51.005***	39.550***	18.514*	28.155***

Notes: *,**,***Significant at the 5, 1 and 0.1 percent level, respectively

Table V. Logistic regression analyses for sources that people learned most from concerning the use of ICT at work as dependent variables

Explanatory variables	Attending ICT training	Odds ratio No need	No time	Not allowed
Constant	0.485***	0.550***	0.111***	0.078***
Sex				
Male	1.001	0.964	1.539**	0.785
Age (reference: ⩾50)				
<35	0.434***	2.581***	0.648*	1.324
35-49	0.796	1.630***	0.852	1.051
Educational level (reference: high-educational level)				
Low-educational level	0.632**	0.854	0.819	1.610*
Medium-educational level	1.005	0.769*	0.879	1.497*
Firm size (reference: ⩾250)				
1-9	0.306***	1.870***	2.479***	0.667
10-49	0.579**	1.600**	1.638*	1.020
50-99	0.828	1.178	1.026	1.542
100-249	0.877	0.972	1.439	1.277
Nagelkerke R^2	0.062	0.070	0.038	0.021
χ^2	70.021***	94.213***	35.311***	17.328*

Notes: *,**,***Significant at the 5, 1 and 0.1 percent level, respectively

Table VI. Logistic regression analyses for attending ICT training (column 2) and barriers of attending ICT training (columns 3-5) as dependent variables

to have received training than workers aged over 50 (odds ratio 0.434). Lower educated workers are significantly less likely to have attended ICT training than higher educated (odds ratio 0.632). Finally, people in firms with one to nine workers are significantly less likely to attend training than people in firms with more than 250 workers (odds ratio 0.306). The same goes for people in firms with ten to 49 workers (odds ratio 0.579).

Table VI reveals that men are more likely to mention time constraints than women (odds ratio 1.539) as a barrier of attending ICT training. People aged below 35 and aged between 35 and 49 are significantly more likely to mention not needing training (odds ratio 2.581 and 1.630, respectively) than people aged over 50. Furthermore, people aged below 35 are significantly less likely to mention time constraints (odds ratio 0.648) than workers over 50. People with low and medium levels of education are significantly more likely to not being allowed to follow a training (odds ratio 1.610 and 1.497, respectively) than high-educated workers. Finally, the results suggest that workers in smaller firms have significantly less need and less time to attend training compared to workers in firms with over 250 employers.

Respondents who had not attended ICT training in the past three years assess that they will gain an average of 16 minutes each day after attending such training. Respondents who actually attended ICT training confirm to have gained an average of 33 minutes each day (keep in consideration that both groups have different sample characteristics). Table VII reveals that lower and medium educated workers lower assessed the expected profit of attending ICT training than higher educated workers for people who did not have such training. The most significant reason for not attending training is not needing it (59.5 percent), followed by a lack of time (15.9 percent), not being allowed (12.2 percent) and not being able to find a suited training (6.0 percent). Costs, excessive entry requirements and poor accessibility (e.g. location) are rarely mentioned as barriers.

5. Discussion

5.1 Main findings

This contribution focusses on the losses of labor time in the workplace due to malfunctioning ICTs and ICT skill insufficiencies. To our knowledge, such figures have not explicitly been investigated in surveys. The first research question concerns the loss of labor time that is caused by malfunctioning ICTs. Our results suggest that 4.0

	B (SE)	
Explanatory variables	Perceived profit of people who actually followed an ICT training	Assessed profit when following an ICT training of people who did not
Constant	2.004 (0.112)***	2.687 (0.199)***
Sex		
Male	0.094 (0.076)	0.208 (0.156)
Age (reference: ⩾50)		
<35	−0.117 (0.101)	−0.304 (0.230)
35-49	−0.002 (0.092)	−0.247 (0.172)
Educational level (reference: high-educational level)		
Low-educational level	0.195 (0.100)	−0.069 (0.219)
Medium-educational level	0.150 (0.087)	0.408 (0.173)*
Firm size (reference: ⩾250)		
1-9	−0.234 (0.110)*	−0.044 (0.333)
10-49	−0.052 (0.106)	−0.128 (0.241)
50-99	−0.137 (0.129)	0.219 (0.253)
100-249	0.142 (0.117)	−0.533 (0.223)*
n	351	1,387
R, R^2, adj R^2	0.119, 0.014, 0.008	0.248, 0.061, 0.037

Notes: [a]Log-transformed. *,**,***Significant at the 5, 1 and 0.1 percent level, respectively

Table VII. OLS analyses with perceived and assessed daily profit due to ICT training[a] as dependent variables percent of the time worked with ICTs on average is lost due to ICT malfunctions in Dutch labor organizations. When this would lead to the actual loss of 4.0 percent of labor productivity, often one of the largest expenditures for organizations, this figure is quite notable. In fact, according to the European Sick Leave Index, in the Netherlands losses of productivity due to sickness is 4.5 percent, causing a 10.8 billion euros loss each year. Therefore, we suggest that organizations have to account for malfunctioning ICTs when they assess the total organizational ICT expenditures. It might be very useful to carefully examine all systems or applications to identify which cause the highest labor time losses.

Concerning the second research question, on average, our results suggest that 3.5 percent of the time working with ICTs is lost due to skill insufficiencies. Again, this might lead to a notable decrease of labor productivity. The relatively high loss of labor time when using the internet caused by internet skill insufficiencies is also remarkable. A possible cause might be that internet use is less structured than the use of most PC applications; there is a relatively large freedom in choices and variety in internet applications.

In light of *RQ3*, the results do not reveal sex differences concerning losses because of malfunctioning ICTs. However, male workers lose more time than female workers due to ICT skill insufficiencies. One explanation is already suggested: females tend to work in "softer" and "less technical" ICT areas than males, requiring less advanced skills. However, how the nature of the ICT tasks at work affects such figures should be further investigated. Aging does not appear to contribute to malfunctioning ICTs or skill insufficiencies. In Section 2, it was mentioned that there is little evidence that the level and the quality of the ICT use by older workers who are actually using ICTs is lower than their younger counterparts. Workers aged over 50 on average use ICT for five and a half hours on a working day. It should be further investigated whether older workers that make less use of ICT at work would experience higher losses. The results suggest that employers should not expect that hiring younger employees automatically results in the occurrence of less problems regarding skill efficiency. We suggest to assess the skill levels for all employees at the time of hiring and to monitor them throughout their employment. The loss of labor time increases when the level of educational attainment decreases. Low-educated workers have a higher amount of working time loss caused by malfunctioning ICT's, a higher amount of working time loss caused by ICT skill insufficiencies and a higher amount of working time loss caused by internet skill insufficiencies as compared to high-educated workers. It might be beneficial to identify the exact problems that lower-educated workers meet. Organizations should investigate whether these problems are caused by unnecessarily complicated technology, insufficient skills or the complexity of tasks and associated applications. This group of workers clearly needs more support.

Concerning *RQ4*, workers employed in small firms with one to nine workers have a higher amount of working time loss caused by malfunctioning ICT's as compared to workers in very large firms (over 250 workers). This can be explained by the discussed differences in ICT investments, which are greater in larger firms. Furthermore, firm size is said to be positively related to the availability of ICT-related skills. The prior recommendation to identify which of the systems or programs cause the highest labor time losses seems even more relevant for smaller firms.

Regarding *RQ5*, a notable additional loss of labor time is caused by helping co-workers that experience problems. However, we do not know how effective this help actually is. Because the help that co-workers offer occurs spontaneously and naturally, it is hard to influence for organizations. However, because co-workers often help one another, it might be useful to partly institutionalize this type of help by designating the most obvious person and provide this person with a more formal additional task. These so-called "ICT-buddies" may then create a network that might serve as an extension of the helpdesk. Providing experienced employees with the "space" to help co-workers is beneficial. So far, co-workers who are able to show others how to use the computer effectively or to correct mistakes are unlikely to receive a higher wage because of this superior effectiveness (Borghans and ter Weel, 2006). For the lower-educated groups, ICT-buddies might provide large improvements of productivity. Workers with a lower level of education ask their co-workers more often for help and rely heavily on learning to work with ICTs.

The results further suggest that the role of co-workers is more important than formally organized means to reduce labor time losses in using ICTs. Only approximately 22 percent of the respondents indicated that they learned the most from formal training and the helpdesk. The management of many organizations has no formal policy in reducing labor time losses on account of malfunctioning ICTs or skill inefficiencies. Workers are left to themselves and try to find all kind of informal solutions in solving problems. Organizations do not seem to actively monitor and stimulate the development of necessary skills. This observation is also supported by the results regarding ICT training. It appears that only 20 percent of the respondents attended such training in the previous three years. It is also remarkable that although lower-educated workers are confronted with the highest levels of labor time loss when working with ICTs, they attend less ICT training. The lower a worker's level of education, the less he or she is allowed to attend ICT training. In addition, the potential gains of training do not seem to be recognized by employees who do not attend training. Although some study results suggest that the effectiveness of most computer use is a matter of learning by doing (e.g. Borghans and ter Weel, 2006), we believe training is a necessary investment. Our results highlight that releasing staff from work to be trained in the use of ICTs is beneficial. When this training results in time saving, the cost of providing such training will be returned in a very short period of time.

5.2 Shortcomings and future research

Losses in labor time would ideally be investigated by actually timing unused labor time (although this would also have validity problems due to obtrusive measurement). However, such an attempt would be nearly impossible for such a large sample. Our study relied on self-assessments. Respondents may have given their best guess, but in addition to errors of judgment, they might also have provided distorted estimates due to social desirability concerns (e.g. individuals might want to overestimate time losses when they are unhappy at work, or underestimate time losses because they love their Apple). Concerning these assessments, it is not fully clear how the imposed scenarios affected the respondent estimations of their time losses. We attempted to provide scenarios that clearly revealed what type of problems were at hand. In future studies, it might be useful to compare the actual loss of labor time by direct observations of behavior with the reported time in self-assessments.

The results of our study may suffer from a potential omitted variable and causality bias. Furthermore, the determination coefficients of most regression analyses are low. However, even though not a large amount of variation in the response is explained, the significant relationships between predictors and the response are important. The low value reflects the high level of variation in the scores, but regardless of the higher variation, the results indicate that in some cases losses will be higher than in other.

In future research it is recommended to add additional explanatory variables such as ICT expenditures and labor sector.

At the very least, we demonstrated the necessity of future research regarding malfunctioning ICTs and ICT skill insufficiencies, which have a substantial impact on the way people work with ICTs. We suggest to investigate the specific groups that are most in need of improvement. The results indicate that lower-educated workers are the most obvious category for future study. Furthermore, differences over sex and age should be further investigated. The existence of potential selection biases, i.e. older workers that have less ability with ICT may not appear in the sample as they do not use ICT a significant amount of time in their work, cannot be ruled out.

6. Concluding remarks

This study reveals that the gain in productivity attributed to the use of ICTs over the last few decades can be further increased. When working with ICTs, both malfunctioning ICTs and ICT skill insufficiencies lead to a labor time loss of 7.5 percent according to the estimations reported in this study. We conclude that organizations do not seem to realize that higher productivity gains are within reach. Managers might be very interested in metrics that center on profitability, returns on capital investment, earnings per share and share price, but they should not overlook the possible gains reported in this study. Talking about ICT expenditures they add the costs of hardware, software, energy and IT-support and tend to forget the human factors in working with ICTs. We acknowledge that the loss of labor time due to malfunctioning ICTs and ICT skill insufficiencies cannot be reduced to zero. One has to spend learning time with every new technology or innovation. However, small improvements might transform into large profits (or less losses).

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