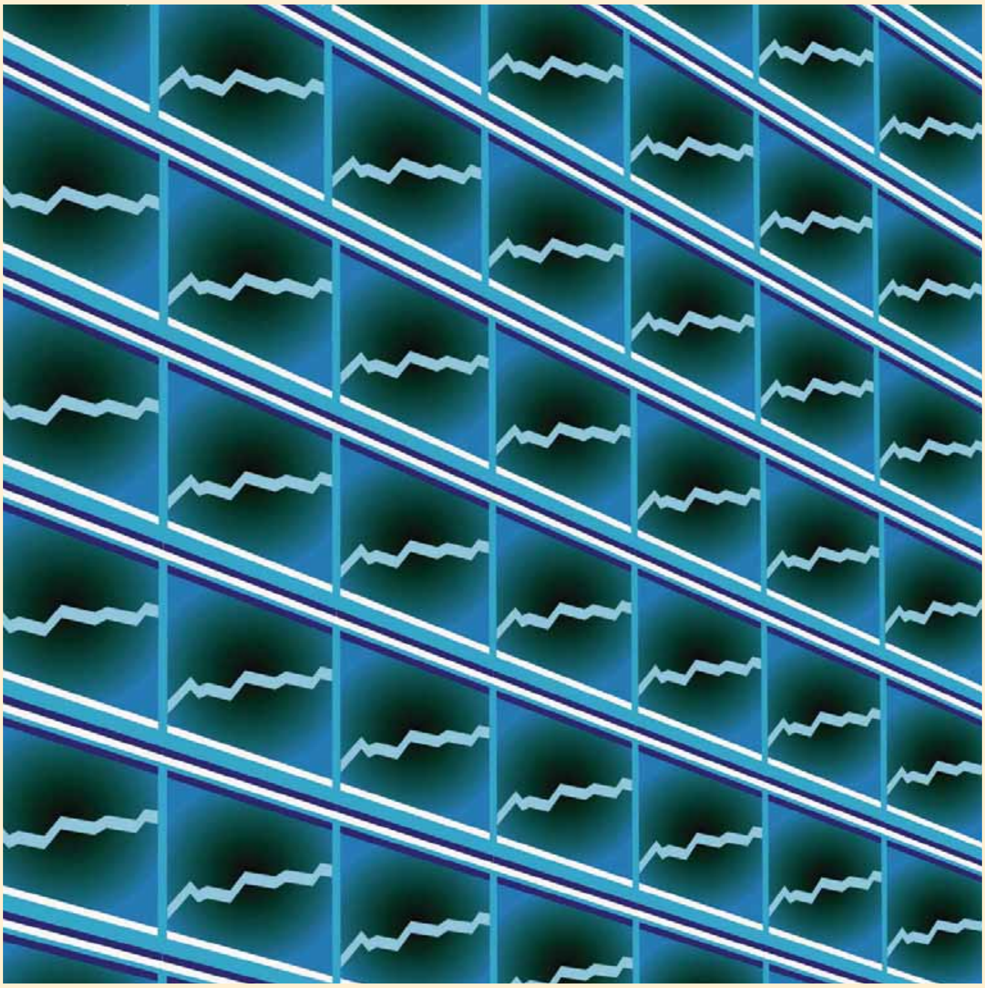
European Foundation for the Improvement of Living and Working Conditions

Use of technology and working conditions in the European Union



Use of technology and working conditions in the European Union

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European Foundation for the Improvement of Living and Working Conditions

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Foreword

Technology today plays a central role in European workplaces. It not only enables the direct production of goods and services, but it also facilitates communication and innovation. Given that innovation is one of the main pillars of the knowledge-based economy, and that Europe has committed itself to becoming the most competitive knowledge-based economy in the world as set out in the Lisbon Strategy, the use of technology and uptake of new technologies is becoming increasingly important.

Against this background, the European Foundation for the Improvement of Living and Working Conditions (Eurofound) has, since 1990, been collecting data on developments pertaining to working conditions – a key area of life in Europe. The latest of these surveys, the fourth European Working Conditions Survey (EWCS), provides a comprehensive overview of working conditions across 31 countries in Europe. Among the central themes of this survey is the debate on the use of technology, its impact on working conditions and workers' health and well-being – topics that form the basis of this current report.

This study aims to analyse the ways in which technology use and work organisation are related to working conditions and to workers' health and well-being particularly in the 27 EU Member States. After establishing four categories of technology use at workplaces, the report provides an insight into the types of technology used by whom and where it is provided. It then goes on to examine the trends in the use of technology in different economic sectors and countries, while also considering the role of work organisation in this regard.

The findings of this research indicate that a machine–computer divide exists between the eastern and continental European countries in particular, and between the various sectors of activity. As technology use is shown to differ considerably between countries and sectors, this would seem to call for a country and sector-specific approach in following the EU's microeconomic and employment policy guidelines of the Lisbon Strategy.

As all European Member States strive to implement the Lisbon objectives, we trust that this report will contribute to a better understanding of what is required to foster the uptake of new technologies that will support the implementation of flexible forms of work organisation across Europe. This, in turn, should improve the working conditions of Europe's workforce and consequently their health and well-being.

Jorma Karppinen
Director

Contents

Abbreviations used in the report

EES	European Employment Strategy
EWCS	European Working Conditions Survey
ISCO	International Standard Classification of Occupations
LFS	Labour Force Survey (Eurostat)
NACE	Nomenclature générale des activités économiques dans les Communautés européennes (General industrial classification of economic activities within the European Communities)

Country codes

EU15	15 EU Member States prior to enlargement in 2004
NMS	10 New Member States that joined the EU in 2004
EU25	15 EU Member States, plus the 10 NMS
EU27	25 EU Member States, plus the AC2
AC2	Two countries that joined the EU in 2007: Bulgaria and Romania

EU27

AT	Austria
BE	Belgium
BG	Bulgaria
CY	Cyprus
CZ	Czech Republic
DK	Denmark
EE	Estonia
FI	Finland
FR	France
DE	Germany
EL	Greece
HU	Hungary
IE	Ireland
IT	Italy
LV	Latvia
LT	Lithuania
LU	Luxembourg
MT	Malta
NL	Netherlands
PL	Poland
PT	Portugal
RO	Romania
SK	Slovakia
SI	Slovenia
ES	Spain
SE	Sweden
UK	United Kingdom

EWCS – Survey methodology

Quality assurance

The quality control framework of the European Working Conditions Survey (EWCS) made sure that the highest possible standards were applied to the questionnaire design, data collection and editing processes in order to strengthen the robustness of the research and ensure the accuracy, reliability and comparability of the survey data. A wide range of information on the survey's methodology and quality control processes was published on the website of the European Working Conditions Observatory (EWCO). As part of the quality control procedures, Eurofound also conducted a qualitative post-test for the modules on training and job development in five countries (Austria, Czech Republic, Finland, Portugal and the UK) to understand better the survey's capacity to measure complex phenomena and to make improvements in the questionnaire for future surveys.

Geographic coverage

The evolution of the EWCS follows the changes in the EU itself over the last 15 years. In 1990/91 the survey covered the 12 EU Member States that made up the EU at that time; 15 countries were covered in 1995/96 and 16 in 2000 (including Norway for the first time). The 2001 EWCS was an extension of the 2000 survey to cover the then candidate countries (Bulgaria, Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia and Romania). The survey was subsequently extended to Turkey in 2002. The fourth major wave in 2005 had a larger geographic coverage encompassing 31 countries, including the 27 EU Member States, plus the candidate countries Croatia and Turkey, as well as the EFTA countries Switzerland and Norway.

Questionnaire

The survey questionnaire was developed with the support of a questionnaire development group involving members of Eurofound's Governing Board, representatives of the European social partners, other EU bodies (European Commission, Eurostat, the European Agency for Safety and Health at Work), international organisations (OECD, ILO) and national statistical institutes, as well as leading European experts in the field. The questionnaire was translated into 27 languages and 15 language variants.

The fourth EWCS questionnaire consists of more than 100 questions and sub-questions covering a wide range of work-related aspects, such as job characteristics and employment conditions, occupational health and safety, work organisation, learning and development opportunities, and work–life balance. Although the total number of questions has been steadily increasing since the first survey in 1990/91, the core variables of the questionnaire have been maintained, so that trends and changes in working conditions in the EU over the last 15 years can be examined.

Sample

The survey sample is representative of persons in employment (employees and self-employed), aged 15 years and over, resident in each of the surveyed countries. In the 2005 edition of the survey, around 1,000 workers were interviewed in each country, with the exception of Cyprus, Estonia, Luxembourg, Malta and Slovenia, where the number of persons interviewed totalled 600. The survey sample followed a multi-stage, stratified and clustered design with a 'random walk' procedure for the selection of the respondents.

Fieldwork

In total, 29,680 workers were interviewed face-to-face in their homes from 17 September to 30 November 2005, within different timespans in each country and an average of seven weeks. The fieldwork was coordinated by Gallup Europe and a network of national contractors carried out the data collection in each country.

Weighting

Data is weighted against the European Labour Force Survey figures. Variables used for the weighting are: sex, age, region (NUTS-2), occupation (ISCO) and sector (NACE).

Access to the survey datasets

The complete set of survey datasets is accessible via the UK Data Archive (UKDA) of the University of Essex at www.esds.ac.uk. To access data files, users are required to register with the UKDA. Information on the registration procedure is available at **www.esds.ac.uk/aandp/access/login.asp**. The archive also provides access to survey documentation and guidance for data users. Users are recommended to read supplementary supporting documentation on the methodology provided on this website before working with the data.

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Executive summary

Introduction

The fourth European Working Conditions Survey (EWCS) conducted in 2005 by the European Foundation for the Improvement of Living and Working Conditions (Eurofound) addresses topics that figure high on the European Union's employment policy agenda. The overall aim of the EWCS is to provide an overview of the state of working conditions throughout Europe, and an indication of the extent and type of changes affecting the workforce and the quality of work. Following the 2005 survey, Eurofound carried out further in-depth analyses of its findings on key themes relating to working conditions in the EU. The relationship between the use of technology, working conditions and the health and well-being of workers in Europe was one of the themes explored.

The research looked at four different categories of technology used in workplaces – machinery, computer, machinery and computer, and no technology – in order to gauge their influence on working conditions and health outcomes. It then examined the trends in technology use in different economic sectors and countries over the period 1995–2005, while also considering the role of work organisation in this regard.

Policy context

Technology plays a significant role in workplaces. It not only enables the direct production of goods and services, but it also facilitates communication and innovation processes. Innovation is one of the main pillars of the knowledge-based economy, and Europe has committed to becoming 'the most competitive knowledge-based economy in the world' as set out in the Lisbon Strategy. Thus, the use of technology and uptake of new technologies – such as information and communication technologies (ICT) – is increasingly important. Economies with a skilled labour force are better able to create and make an effective use of new technologies. In its microeconomic and employment policy guidelines, the European Commission encourages investments in human capital through better education and skills in order to increase the adaptability of workers and companies, as well as the flexibility of labour markets.

However, some concerns have emerged that the benefits and costs of technology use are unevenly distributed between different parts of the EU and also among its citizens. Equality concerns relate to whether the complexity and the cost of new technologies will widen the gaps between industrialised and less developed areas, between young and older people, and between those having enough knowledge and skills and those who have not.

Key findings

With the ongoing changes in technology use, the nature of work is changing and so are the demands and requirements placed on workers. The study findings reveal that it is not so much the technology itself but rather the working conditions associated with the technology used at work that cause higher risks to workers' health and well-being.

Users of machinery, who account for almost a quarter of all workers in the EU, have less favourable working conditions than workers who use computers and those who do not use technology at the workplace. People working with machines run a higher risk of developing musculoskeletal disorders and work-related stress symptoms, and therefore report relatively low job satisfaction. Such symptoms, in turn, can be attributed to the high work intensity, few learning opportunities in the job and significant ergonomic risks that machine users face.

Computer users, on the other hand, enjoy better working conditions and show higher levels of job satisfaction. Therefore, they have greater chances of being in better health than workers using machines. However, two work organisational characteristics – working in autonomous teams and high task autonomy – appeared to ease the negative effects of machine use at work, increasing the level of learning opportunities and lowering the risk of developing stress symptoms.

In all age groups, women report greater use of computers at work than men. This gender difference in computer use is not related to differences in education or in the distribution of men and women across the sectors of activity. Women's greater use of computers at work can rather be explained by the fact that men and women have different occupations and/or work at different occupational levels.

There is considerable evidence of a machine–computer divide between the eastern and continental European countries in particular, and between the various sectors of activity. In general, machine use is most common in the agriculture and fishing, manufacturing, mining and construction sectors, and among workers with low educational qualifications. Conversely, computer use is more common for highly educated people and in sectors such as financial intermediation, real estate, and public administration and defence. The use of machines at work is particularly widespread in eastern and southern European countries, while the Scandinavian and continental European countries show the highest proportion of workers using computer technologies, such as e-mail and the Internet.

Trends in technology use in the EU27 between 1995 and 2005 show an increase in computer use and a decrease in technology-free work situations and machine use. This trend is found for both men and women in all age groups, but not for all countries within the EU27 – the eastern European countries, as well as the latest accession countries of Bulgaria and Romania, are found at an earlier stage of technological development than the continental European countries, particularly the Netherlands and the Scandinavian countries.

Overall, in terms of trends related to the skills that are used in jobs, the proportion of unskilled work – that is, monotonous, short repetitive work – is highest and continues to increase in the southern European countries, while the share of skilled work – that is, non-monotonous, non-repetitive work – remains low and is declining in these countries. The Scandinavian countries and the Netherlands, on the other hand, have a relatively high and increasing proportion of skilled work, while the share of unskilled work is relatively low and decreasing. Eastern European countries show a decrease in both 'skilled' and 'unskilled' work.

Policy recommendations

- An increase in the uptake of new technologies and of computer technologies in less computerised regions could promote better working conditions across Europe. As the observed trends in technology use are different between countries and sectors, the microeconomic and employment policy guidelines of the Lisbon Strategy should be implemented at the national level, regional level, and at the sectoral level.

- Because the use of computers is associated with higher skill levels, technological change could favour high skilled workers to the detriment of lower skilled workers who may be 'left behind' in a widening knowledge gap. To avoid such a polarisation of the labour market, it is crucial to implement the Lisbon Strategy's policy guidelines regarding new occupational needs, key competencies and future skills requirements by improving the definition and transparency of qualifications, their effective recognition and the validation of non-formal and informal learning.
- The increased use of technology must be accompanied by policy changes that allow for a corresponding adaptation of work organisation. Greater attention should be paid to working conditions and work organisation in general, and to machine users in particular. Policies fostering interventions in terms of work organisation such as the promotion of autonomous team practices could be beneficial and positively impact on workers' health and well-being. Improving autonomy at work is considered an important 'job resource' that can compensate for the negative effects of job demands on workers' health and well-being.
- Fostering the uptake of new technology may impact positively on work organisation, thus also promoting flexible forms of work organisation.

Introduction

Every five years, since 1990, the European Foundation for the Improvement of Living and Working Conditions (hereafter Eurofound) has conducted a survey analysing working conditions across Europe. These surveys provide a comprehensive overview of the extent and type of changes affecting the workforce and the quality of work. Topics covered in the surveys include the use of technology, work organisation, pay, work-related health risks and health outcomes, and access to training.

The fourth wave of the European Working Conditions Survey (EWCS) in 2005 collected data on working conditions in 31 countries in total: the present 27 Member States of the European Union (EU27), the two candidate countries, Croatia and Turkey, and two of the European Free Trade Association (EFTA) countries, Norway and Switzerland. This particular report on the use of technology and workers' health and well-being will concentrate on the analysis of the situation in the current EU27.

Technology refers to the use of tools and techniques for the application of scientific or other knowledge to practical tasks. Although many people would consider technology as being hardware like cars and machines, technology also refers to the body of knowledge about the means and methods of producing goods and services (Steijn, 2001). After all, a car is useless if one does not know how to drive it and a machine is useless if one cannot operate it. Technology today plays an important role in workplaces. It not only enables the direct production of goods and services, but it also facilitates communication and innovation processes. Information and communication technologies (ICT), for example, support innovations by facilitating the flow of information between companies and between workers (Hempell and Zwick, 2005; Zijlstra, 2007). Computers enable more efficient and effective use of information, they help to control complex systems and processes, and facilitate electronic communication (Zijlstra, 2007). As innovation is one of the main pillars of the knowledge-based economy, and as Europe has committed itself to becoming the most competitive knowledge-based economy in the world as set out in the Lisbon Strategy, the use of technology and uptake of new technologies is becoming increasingly important.

Technology allows people to be more effective and efficient in their work and thus more productive. It may be used to replace manpower (substitution) or to enhance human possibilities (extension) (Zijlstra, 2007).

The present study describes the state of and trends in technology use in European worksites and relates these to workers' working conditions and their health and well-being.

Policy relevance

Technological developments take place within the context of the knowledge-based economy. The knowledge-based economy is an umbrella concept which refers to several characteristics of the new economy, including a high level of investment in innovation, intensive use of acquired technology and a highly educated workforce (Godin, 2006). The concept of such an economy first appeared in the 1960s, supported by new trends in the economy and new data. In 1996, the Organisation for Economic Co-operation and Development (OECD) defined knowledge-based economies as 'economies which are directly based on the production, distribution and use of knowledge and information'. At national and European levels, a large set of statistics is collected under the umbrella of the knowledge-based economy. Some of these indicators are related to the use of technology; for example, computer use is one of the 32 indicators of the knowledge-based economy (Godin, 2006).

Since the 1980s, technology has been increasingly incorporated into the way of how markets function. Economists have developed models on the assumption that, unlike physical objects, knowledge and technology are characterised by increasing returns, which in turn drive the process of growth. This constitutes the basis of the new growth theory (Cortright, 2001), according to which technological progress is considered a product of economic activity.

Within the framework of the knowledge-based economy, in addition to knowledge investments, knowledge distribution through formal and informal networks is essential for economic performance (OECD, 1996). Knowledge is increasingly being codified and transmitted through computer and communications networks in the emerging information society. Technological change raises the relative marginal productivity of capital through education and training of the labour force, investments in research and development, and the creation of new managerial structures and work organisation.

Relevant policy guidelines

The Lisbon Strategy explicitly refers to technological progress, innovation and the use of ICT, such as in the Microeconomic Guideline No. 13. As economies with a skilled labour force show a greater ability to innovate and effectively use new technologies, the European Commission encourages investments in human capital through better education and skills (Employment Guidelines Nos. 22 and 23). The Commission also promotes an increased adaptability of workers and enterprises, as well as greater labour market flexibility (Employment Guideline No. 20).

The policy guidelines contained in the Lisbon Strategy and the European Employment Strategy (EES) set out the following objectives:

- Guideline No. 13 on facilitating innovation and the uptake of ICT stipulates that Member States (…) should facilitate the uptake of ICT and related changes in work organisation in the economy. This statement is based on the assumption that the 'uptake of ICT particularly depends on an adaptable organisation of work'.
- Guideline No. 20 on promoting flexibility combined with employment security – namely, 'flexicurity'– and reducing labour market segmentation encourages the:
  - promotion of innovative and adaptable forms of work organisation to improve quality and productivity at work with due regard for health and safety;
  - adaptation to new technology in the workplace (*see also p. 7*).
- Guideline No. 22 on investment in human capital suggests enhancing the participation of workers in continuous workplace training throughout the lifecycle.
- Guideline No. 23 on adapting education and training systems outlines the need to respond to new occupational needs, key competencies and future skills requirements, by improving the definition and transparency of qualifications, their effective recognition and the validation of non-formal and informal learning.

Guideline No. 20 on improving workers' and companies' adaptability

'In today's increasingly global economy with market opening and the continual introduction of new technologies, both enterprises and workers are confronted with the need, and indeed the opportunity, to adapt. While this process of structural changes is overall beneficial to growth and employment, it also brings about transformations which are disruptive to some workers and enterprises. Enterprises must become more flexible to respond to sudden changes in demand for their goods and services, adapt to new technologies and be in a position to innovate constantly in order to remain competitive. They must also respond to the increasing demand for job quality which is related to workers' personal preferences and family changes, and they will have to cope with an ageing workforce and fewer young recruits. For workers, working life is becoming more complex as working patterns become more diverse and irregular and an increasing number of transitions need to be managed successfully throughout the lifecycle. With rapidly changing economies and attendant restructuring, they must cope with new ways of working, including enhanced exploitation of Information and Communication Technologies (ICT) and changes in their working status, and be prepared for lifelong learning. Geographical mobility is also needed to access job opportunities more widely and in the EU at large.'

Guideline No. 20 is formulated as follows:

'Promote flexibility combined with employment security and reduce labour market segmentation through:

- the adaptation of employment legislation, reviewing where necessary the level of flexibility provided by permanent and non-permanent contracts;
- better anticipation and positive management of change, including economic restructuring, notably changes linked to trade opening, so as to minimise their social costs and facilitate adaptation;
- support for transitions in occupational status, including training, self-employment, business creation and geographic mobility;
- the promotion and dissemination of innovative and adaptable forms of work organisation, including better health and safety and diversity of contractual and working time arrangements, with a view to improving quality and productivity at work;
- adaptation to new technologies in the workplace;
- determined action to transform undeclared work into regular employment.'

Source: European Commission, *Integrated guidelines for growth and jobs (2005–2008),* 2005.

Concerns about technology use

Since the 1990s at least, concerns about the impact of the uptake of technology have occupied policymakers. The pace at which new technologies are introduced varies between countries, regions, economic sectors, industries and companies (European Commission, 1996). The European Commission has observed that the benefits – in the form of prosperity – and the costs – in the form of burden of change – are unevenly distributed between different parts of the EU and also among its citizens. Equality concerns relate to whether the complexity and the cost of the new technologies will widen the gaps between industrialised and less developed areas, between young and older people, and between those having enough knowledge and skills and those who have not (European Commission, 1996, p. 3).

In general, workplace innovation can have a positive outcome for workers in terms of increased quality of work and well-being. However, evidence of a downside is also emerging, including the potential for increased stress and job insecurity (Totterdill et al, 2002). Furthermore, at a policy level, the relationship between the introduction of new technologies and required skills of the labour force has caused concern. An earlier study on the use of technology commissioned by Eurofound suggested that the introduction of new technologies may lead to a 'polarisation of the workforce into those enjoying relatively stable and skilled work, and a group of low-skilled, temporary workers in atypical forms of employment' (Weiler, 2006, p. 19). In the literature, explanations for the observed upskilling of the labour force are partly sought in the 'skill-biased technological change' hypothesis. This hypothesis assumes that the reason for the upskilling of the labour force is related to the non-neutrality of technological change, which benefits skilled labour more than other production factors (Piva et al, 2005; Chenells and Reenen, 1999). In other words, as highly skilled workers benefit more from technological change, an acceleration in the rate of technological change increases the demand for skilled labour (Piva et al, 2005). According to Chenells and Reenen (1999), evidence exists to support this hypothesis.

Some authors also believe in 'skill-biased organisational change', which implies a greater impact on work organisation. They state that the increasing diffusion of new organisational practices in companies plays a role in the growing demand for skilled workers. Their reasoning is that organisational practices such as teamwork and multitasking require workers to perform a greater variety of tasks and to rotate between different jobs, which in turn requires higher skills (Piva et al, 2005).

Both hypotheses seem, however, complementary: technological and organisational change often occur simultaneously and generate mutually reinforcing effects in terms of productivity (Piva et al, 2005). Therefore, it can be concluded that skills remain an important concern when it comes to benefiting from technological change.

Developments in technology use

According to Zijlstra (2007), the developments in technology use can be classified into three phases:

1. mechanisation;
2. automation;
3. computerisation.

In each phase, more human activities are substituted by machines. While in the mechanisation phase human muscle power is substituted by machines in simple and repetitive operations, in the automation phase, machines also take over the gearing of several simple operations to each other. In the automation process, human operators controlling industrial machinery and processes are replaced by control systems, for example, by computers. Whereas mechanisation provided human operators with machinery to assist them with the physical requirements of work, automation greatly reduces the need for human sensory and mental requirements. When the personal computer (PC) was introduced in the 1970s and 1980s, the automation of office practices began, followed by computerisation in the 1990s. The introduction of algorithms enabled simple decisions to be taken by machines. The development of microchips led to the creation of more high-speed computers that were able to communicate through networks and the microchips, in turn, enabled faster data processing and data transport, resulting in major efficiency improvements.

In light of these changes in technology use, the nature of work is changing and so are the demands that are put on workers. People are no longer at the centre of the production process. Work is becoming more abstract: it requires a mental representation of the production process and an assessment of work processes by means of information (Zijlstra, 2007). Consequently, a computerised information society has become the most important objective of work. This is a major reason for the increasingly cognitive character of work and the increasing cognitive demands that are put on workers.

Research in the field

Technology has a great impact on workers' task characteristics and thus on their health and well-being. This section will explore the research literature analysing the relationship between technology use, work content, work organisation and health outcomes.

Pace of work

Strategies to divide and simplify work – building on the ideas of Adam Smith (*The wealth of nations*, 1776), Frederic Taylor (1865–1915) and Henry Ford (1863–1947) – led to simple and monotonous work with a highly repetitive character in both manufacturing industries and office work. Machines increasingly dictated the work pace. A paced task is one in which a time limit has been imposed, while schemes of pacing deal more with the degree of control one has over the task (Garrett et al, 2000). Work tasks can be machine-paced, self-paced or not paced at all.

A machine-paced task is defined by a fixed time in which a task is to be performed. The same amount of time is allocated to a task, regardless of whether the task is successfully completed or not. Machine-paced work in industry offers certain economic advantages, such as the minimisation of work in progress, maximisation of floor space usage and simplification of the organisation of supplying components to the right place at the right time (Garrett et al, 2000). The concept of pacing is widely used in industry, since it reduces the variability of the production line – that is, work in progress – and limits the number of items stored in a queue or stockpile. Many industries incorporate some form of pacing into their manufacturing lines. However, under this type of paced working condition, operators are required to complete each task within a rigidly fixed time such that certain principles related to the quality of work are lacking. An important principle that is lacking in such a case is job control, which is known to be related to a worker's well-being (Jonge et al, 2007).

Moreover, in the case of machine-paced work such as assembly line work, time pressure and a high work pace lead to high psychological job demands. According to Karasek's 'job demand–job control' model, working situations with high job demands and low job control lead to high levels of strain among workers (Karasek, 1985). Many empirical studies have confirmed this hypothesis (Jonge et al, 2007). Several studies have shown that machine-paced tasks have negative consequences for the mental health of workers. Research in this regard generally reported more depressive feelings, negative self-perception, apathy, reduced self-confidence, alienation and higher levels of dissatisfaction among workers (Zijlstra, 2007).

Repetitive work

Repetitive work is characterised by repeating a single work task over and over while performing repetitive movements of the upper limbs (Bonde et al, 2005). This type of work represents an important risk factor for developing musculoskeletal disorders (MSDs) (Melchior et al, 2006; Dhondt et al, 2001). Among manual workers who traditionally use machines, like assemblers and machine operators, the prevalence of MSDs and levels of exposure to physical risk factors in the workplace are particularly high (Melchior et al, 2006).

Furthermore, although repetitive work is defined by physical work characteristics – that is, upper limb movements – it is correlated with psychosocial factors (Bonde et al, 2005). For example, a measure of repetitiveness is cycle time, which may be related to time pressure and perceived job demands. Moreover, repetitive work is most often associated with low job control, skill discretion and decision latitude. Repetitive work may increase the psychosocial load at work and cause psychological strain among workers in the form of stress symptoms. This, in turn, may lead to musculoskeletal tenderness and pain due to increased muscle tone, modified pain perception and reduced capacity to cope with the biomechanical workload (Bonde et al, 2005; Huang et al, 2002). Many studies have shown strong relationships between job-related stress symptoms and the reporting of musculoskeletal pain (Andersen et al, 2002; Huang et al, 2002).

Work intensity

It is frequently suggested that computerisation – namely, the introduction of new technical systems – has led to an intensification of work and higher psychological job demands (Zijlstra, 2007). A report on the previous wave of the EWCS in 2000 found that a strong link exists between the degree of work intensity and the reporting of health problems (Paoli and Merllié, 2001, p. 13). It has been shown that effects of the introduction of new technical systems on work intensity depend on the occupational level of the workers (Zijlstra, 2007). For instance, workers with a low occupational level may experience an increase in work intensity because their work content grows at a lower rate: they have more monotonous and routine work to accomplish, requiring their attention continuously to perform the work tasks. This leads to increased psychological demands and lower levels of well-being. However, such effects are not found among workers at high occupational levels (Zijlstra, 2007). Explanations for this finding are sought in the fact that workers at high occupational levels were more frequently involved in making decisions regarding the introduction and implementation of new technical systems. In other words, they had more power and influence in the workplace and could ensure that the introduction of new technical systems contributed to making their work both more interesting and varied.

Blatter and Bongers (1999) performed risk analyses of the intensity of computer use and the risk of repetitive strain injuries (RSI). The research found that more than six hours of computer use a day is associated with an increased risk of RSI. A recent systematic review of the effects of extended computer use found moderate evidence of an association between the duration of mouse use and the incidence of hand or arm complaints among office workers (Ijmker et al, 2007). A study by Houtman et al (2006) among over 21,000 European workers showed that working with computers contributes to a high psychological workload; the data for this study came from the 2005 EWCS.

Learning opportunities and use of skills

Automation is found to be associated with poorer work content and reduced learning opportunities. Operators of highly automated systems frequently do not feel that they are in control of the system and thus cannot prove their ability to perform well in their job. They experience low levels of job demands – that is, their work is boring – and of subjective health and job satisfaction (Zijlstra, 2007).

It has been debated whether ICT leads to a poorer work content and fewer learning opportunities or, on the contrary, whether it leads to an upgrading of qualifications and more learning opportunities. A study by Kraan et al (2000) including more than 11,000 Dutch workers shows that, in most cases, the introduction of new ICT is associated with greater learning opportunities. Nonetheless, whether the impact of ICT on learning opportunities is positive or negative depends on the occupation. For example, in the case of administrative and logistic professions, the introduction of specialised software is associated with poorer work content and fewer learning opportunities. Kraan et al show that this effect could be offset by certain organisational practices, such as decentralised decision-making processes or autonomous work teams.

A study by Green et al (2003), investigating the impact of computer usage at work and other job features on changing skills requirements of workers, reveals that the spread of computer use is strongly associated with the process of upskilling. A Canadian survey on working with technology, which has mapped the continuous rise in computer-based technologies since 1985, also finds that computer use is linked to upskilling. The study concludes that, due to computer-based technologies, a widespread process of job upskilling is taking place, through both an occupational shift to higher skill jobs and an increase in skills requirements across most occupations (McMullen, 1996).

Recent research by Zijlstra (2007) highlights that insufficient mastery of computer applications may lead to feelings of incompetence and subsequently to lower well-being among workers. If technology is introduced without paying enough attention to the workers concerned, in terms of participation, training and instruction, workers may feel threatened in their jobs.

Autonomy

High-skilled computer work is characterised by increased levels of autonomy, decentralisation of decision-making processes and worker participation (Hempell et al, 2005; Kraan et al, 2000). In their study among a large sample of Dutch workers, Kraan et al show that computer work is associated with greater work autonomy than work which does not involve computer usage. It is well known that high levels of autonomy at work have positive effects on workers' well-being (Bakker and Demerouti, 2007). Worker autonomy is therefore considered an important characteristic of quality of work (Kyzlinková et al, 2007).

The introduction of autonomous teams in organisations can be considered in conjunction with job improvement measures. A study on teamwork and high performance organisations by Eurofound in 2007 did not, however, reveal a clear-cut correlation between the presence of teamwork and increased autonomy (Kyzlinková et al, 2007). The study reveals that the degree of worker autonomy is influenced by the worker's occupation. The study's findings suggest that team workers are more autonomous workers due to their higher concentration in occupations such as legislators, senior officials, managers and professionals. Other professions, namely craft and related trades workers, plant and machine operators and assemblers, report low autonomy at work despite a high incidence of teamwork.

Conceptual framework

As highlighted in the previous sections based on existing research, it appears that changes in technology use and work organisation influence the psychosocial and physical aspects of working conditions. Working conditions, in turn, directly impact on workers' satisfaction, performance, productivity, health and well-being (Houtman et al, 2001).

Working conditions determine to a certain extent the requirements that work imposes on the worker (Dhondt et al, 2002). These requirements are influenced by the technology used and work organisational practices. Abundant scientific evidence confirms that the psychosocial work environment impacts greatly on the health and well-being of workers, as shown in higher levels of work-related stress and musculoskeletal complaints, and lower reported job satisfaction and work engagement. The influence of the psychosocial work environment on workers' health and well-being can be either positive or negative. Combining the predominant theoretical models of work characteristics and health outcomes[1], the most important determinants of psychosocial health and well-being can be listed. Based on these models, the following work characteristics are considered to significantly contribute to a good quality of work and positive health outcomes:

- sufficient skill variety;
- moderate job demands;
- sufficient control over one's own task performance;
- some degree of social support;
- feedback about results and performance;
- sufficient task identity – the job forming a significant entity of activities;
- a work task that is, to a certain extent, significant to others;
- sufficient job security;
- sufficient rewards, for example, pay.

Several principles form the basis of these theoretical models which link work characteristics to workers' health outcomes. First, it is their multidimensional aspect: job demands, job resources and work-related health outcomes consist of physical, cognitive and emotional dimensions. Secondly, most theories start from a balance principle, considering that job strain is the result of an imbalance between the demands workers are exposed to and the resources they have at their disposal. On the other hand, personal growth, creativity and learning develop when job demands and job resources are balanced. Some models have extended this 'balance principle', which can be considered as a compensatory relation between job demands and job resources in causing work-related health outcomes. Such theories assume that the job demand–job resources relation is rather specific: for instance, an emotional demanding task is best regulated or compensated for by an emotional resource – such as social support – while non-specific resources – such as physical strength – are thought to be less effective in compensating emotional demands.[2]

1 Predominant theoretical models in this regard are: the job characteristics model (Hackman and Oldham, 1980), the Michigan model (Kahn et al, 1964), the job demand-control-(support) model (Karasek and Theorell, 1990), modern socio-technique (Sitter, 1982; Sitter et al, 1994; Kuipers and van Amelsvoort, 1990), effort-reward imbalance model (Siegrist, 2001) and the vitamin model (Warr, 1994; Schaufeli et al, 2003).

2 In 2003, de Jonge and Dormann interweaved these principles in their so-called demand-induced strain compensation (DISC) model (Jonge et al, 2007).

Apart from these psychosocial working conditions, the physical working conditions also influence the health and well-being of workers and will thus equally be considered in this study. Physical work factors – such as local mechanical stresses, work postures and musculoskeletal loads – are related to the use of computer and machine technology by workers. Such work characteristics strongly influence the risks of developing musculoskeletal problems, such as back pain and upper extremity disorders (Karwowski and Marras, 1999).

Aim of study

This study aims to investigate the relationship between the use of technology, working conditions and the health and well-being of workers in Europe. As it is known that characteristics of work organisation may reinforce or impair both positive and negative effects of technology use, the role of these characteristics is also considered in this study. The research will provide an insight into the trends and changes in technology use and working conditions in European countries. It also aims to outline the processes that are currently taking shape, as well as to identify the opportunities and threats within the emerging trends.

Chapter 1 sets out the study's analytical framework and measurements, followed by an analysis of the results for each research question in the following chapters. Chapter 2 provides an insight into which type of technology is used by whom and where it is provided. Chapter 3 then examines the trends in technology use over the period 1995–2005. Different economic sectors and countries will be considered in the analyses. In Chapter 4, the use of technology is related to working conditions and its impact on the health and well-being of individual workers. In addition, the role of work organisational characteristics is also looked at, since these characteristics may reinforce or buffer both positive and negative effects of technology use. Chapter 5 concludes the report with a discussion of the most important findings in terms of potential interventions and policy-making.

Analytical framework 1

In this study, secondary analyses are carried out on the successive waves of the EWCS, which provide a comprehensive overview of the state of working conditions across 31 European countries (Parent-Thirion et al, 2007).

Survey sample

The fourth wave of the EWCS was conducted in 2005 in all 25 EU Member States, in the then two acceding countries, Bulgaria and Romania, and in the then candidate countries, Croatia and Turkey, as well as in Norway and Switzerland. Workers were interviewed face-to-face in their homes using a structured questionnaire comprising over 100 questions relating to their employment situation and working conditions. The previous surveys were carried out in 1991, 1995 and 2000. In 2001, the survey was extended to include the 10 NMS (the then acceding countries), as well as Bulgaria and Romania (the then candidate countries) which joined the EU in 2007 (Parent-Thirion et al, 2007).

Data collection

In each country, the EWCS sample followed a multi-stage, stratified and clustered design with a 'random walk' procedure in most countries for the selection of the respondents. In Belgium, the Netherlands and Sweden, the selection of the respondents was made using a phone register (Parent-Thirion et al, 2007). The overall response rate stood at 48%, while the cooperation rate – the proportion of completed interviews to all eligible units ever contacted – was 66% according to the definitions of the American Association for Public Opinion Research (AAPOR). In each country, about 1,000 interviews were carried out, except for Cyprus, Estonia, Luxembourg, Malta and Slovenia, in which about 600 interviews were undertaken per country. The EWCS sample is representative of the workers, including those who are employed and self-employed, during the fieldwork period in each of the countries covered. In order to enhance the representativeness of results, weighting has been applied to the data.

Samples used in the current study

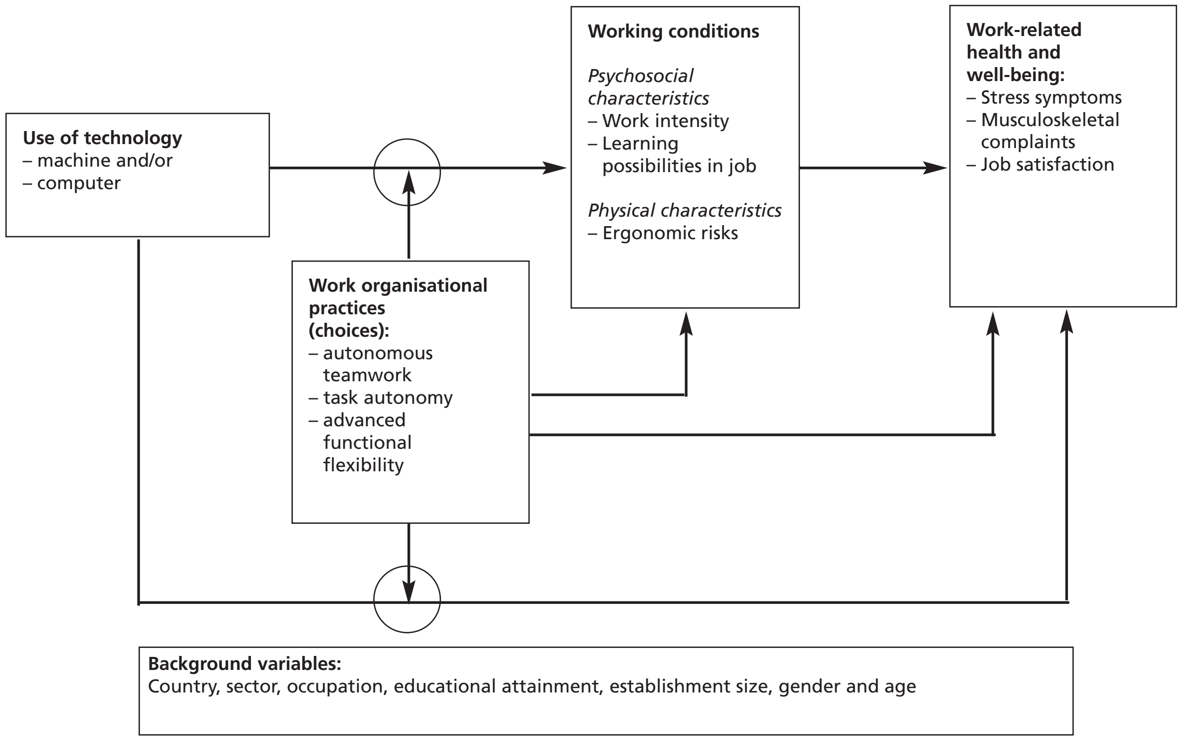
This study uses the data from the EU27 for its analyses. The sample used consists of the salaried employees in organisations or establishments with two or more employees. The selection criterion of two or more employees was based on the study's aim to examine technology use in relation to organisational practices, such as task autonomy, autonomous teamwork and advanced functional flexibility. These practices can only be present in organisations with more than two employees. For the same reason, freelance and self-employed workers have been excluded from the sample. Furthermore, it can be assumed that freelance and self-employed workers are free in their choice of working with, for example, machine-paced work or other types of technology.

However, for harmonisation purposes, all employees, regardless of organisational size, are included in the trend analyses since the survey question on establishment size was not included in the 1995 wave of the EWCS. The trend analyses are performed over 1995, 2000/2001 and 2005.

Analytical framework and operational definitions of variables

Figure 1 shows the analytical framework for this study and the following sections outline the way in which the main concepts are operationalised.

Figure 1 Analytical framework



The three main research questions for the analysis of the relationship between technology use, working conditions and workers' health and well-being are:

1. Which type of technology is used by whom and where?
2. What are the trends in technology use?
3. How is technology use related to working conditions, as well as to workers' health and well-being?

The operational definitions of the variables are based on the indicators available in the fourth EWCS. The exact definitions and corresponding questions in the EWCS 2005 are presented in the technical report (*Working conditions in Europe: Technology use and workers' health and well-being – Technical report*, 2008).

Technology

Regarding the different types of technology used at workplaces, the following four categories have been established (see also Dhondt et al, 2002):

- machine technology – any work situation without computer use, but in which machines or automation are present. These work situations are identified using the EWCS indicators on vibrations from hand tools, machinery and the automatic speed of a machine or movement of a product, which paces the carrying out of one's tasks;
- computer technology – any work situation in which a PC, network or mainframe is used;
- the combined use of machine and computer technology;
- the remaining work environments are classified as 'technology-free' – that is, without the use of machine or computer technology.

Work organisational practices

Three practices are distinguished relating to the way work is organised in a company: autonomous teamwork, task autonomy and advanced functional flexibility. The latter is linked to the practice of task rotation. If job rotation is practised, a follow-up question asks whether the tasks require different skills and/or multi-skilling.

Working conditions

The effect of technology use and work organisational practices on working conditions of individual workers is considered. In this respect, the study differentiates between psychosocial and physical characteristics of working conditions, namely between work intensity, learning opportunities offered by the job and ergonomic risks.

Health and well-being

The following three outcomes in terms of health and well-being are taken into account: stress symptoms, musculoskeletal complaints and job satisfaction.

Skills level

The skills level will be assessed using two distinct but accepted methods that are described in available literature (see Spenner, 1990; Chenells and Reenen, 1999), namely by looking at:

- the occupational level, based on the International Standard Classification of Occupations (ISCO);
- self-reported measures regarding monotony and repetitiveness of work of the technical report – both are related to the required skills level of the work.

Analyses

To answer the first research question concerning which type of technology is used by whom and where, descriptive analyses have been carried out. The use of technology in different countries and sectors is described, as well as considering differences in technology use between men and women, different educational qualifications and other background factors. With regard to the categories of technology use, these characteristics are profiled against the mean of the total group (represented by the zero-axis). In doing so, it is possible to determine which features characterise the different technology users.

Differences from the mean total group are considered significant and relevant if the probability values (p-values) are smaller than 0.05 and the measure of relevance (d) is greater than 0.20 (Cohen, 1977).

With regard to the second research question exploring the trends in technology use, the situation in 2005 is compared with that in 2000, 2001 and 1995. Trend analyses have been conducted for:

- the 15 EU Member States prior to enlargement in 2004 (EU15) – Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom (UK);
- the 10 new Member States (NMS10) that joined the EU in 2004 (previously the 10 acceding countries (AC10)): Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia;

- the two latest EU Member States, Bulgaria and Romania, which joined the EU in 2007; these were the two candidate countries (CC2) in the 2001 EWCS and the acceding countries (AC2) in the 2005 EWCS.

The EU15 were surveyed in 1995, 2000 and 2005, and the NMS10 and AC2 in 2001 and 2005.

The country clusters that were formed for the trend analyses are based on the clustering put forward by Eurofound (Parent-Thirion et al, 2007). However, for the trend analyses, the different data gathering in 2000 and 2001 is taken into account, as it relates to the EU membership status of the countries surveyed at that time.

The country groups are formed as follows:

- continental European countries – Austria[3], Belgium, France, Germany and Luxembourg;
- Ireland and the UK;
- eastern European countries – the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia;
- Cyprus and Malta;
- southern European countries – Greece, Italy, Portugal and Spain;
- Scandinavian countries – Denmark, Finland and Sweden – and the Netherlands;
- Bulgaria and Romania.

Trends in skills levels will also be assessed, using both ISCO as the expert evaluation of occupational skills levels and the self-report method regarding monotony and repetitiveness at work. The research focuses on the share of jobs at the two extremes of the constructed skills level typologies where each typology consists of four categories. Therefore, the trends in skills levels are examined according to the following:

- low-skilled blue-collar work versus high-skilled white-collar work;
- monotonous, short repetitive work versus non-monotonous, not short repetitive work.

To answer the third research question on how technology use is related to working conditions and workers' health and well-being, several multiple linear regression analyses are performed. Subgroup analyses are carried out to assess whether the effect of technology use differs in different work organisational contexts.

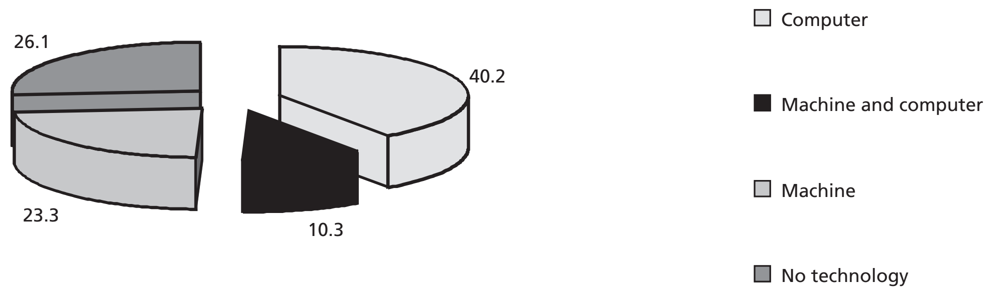
The study's most important findings on the relationship between technology use, working conditions and workers' health outcomes are outlined in Chapter 5. For reasons of clarity, the findings are mostly presented in figures and summary tables. All of the estimation results and figure descriptives are given in the accompanying technical report.

[3] For country codes, see 'Abbreviations used in this report' on p. (viii).

Types of technology and user profiles 2

This chapter provides an insight into which type of technology is used by whom and where it is provided. Figure 2 shows the level at which each of the four types of technology under examination – namely, machine; computer; machine and computer; and no technology – are used at worksites in the EU27. According to the findings, computers are the type of technology most used by workers in the EU27 in 2005, while about a quarter of the workers surveyed (26.1%) do not use technology at work.

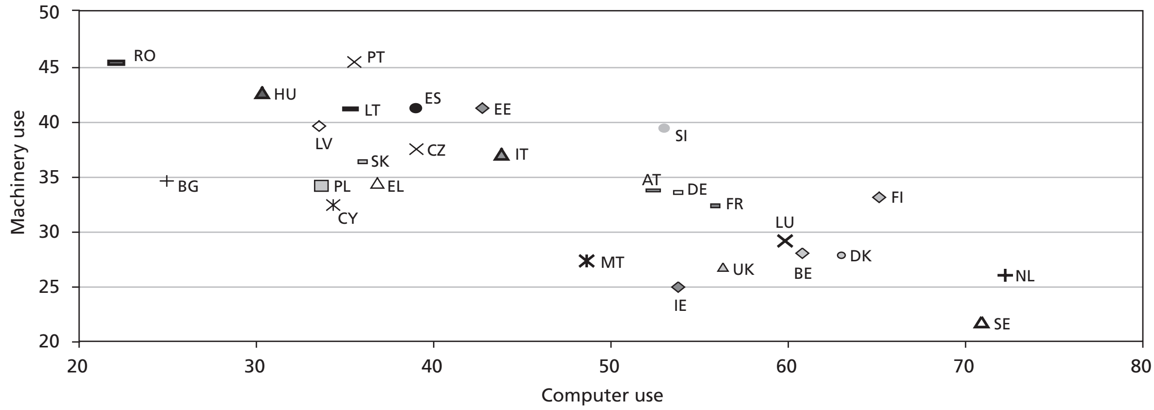
Figure 2 Use of technology at work, by type, EU27 (%)



Note: N=1,938.
Source: EWCS, 2005 and authors' own calculations

Figure 3 illustrates the use of machine and computer technology in different EU countries. A negative association is found between the use of computers and the use of machinery. More computers and less machinery are used in the Scandinavian countries and the Netherlands, while the opposite – less computers and more machinery – holds true in eastern European countries, including NMS such as Bulgaria, Hungary, Latvia and Romania, as well as in some southern European countries such as Portugal and Spain.

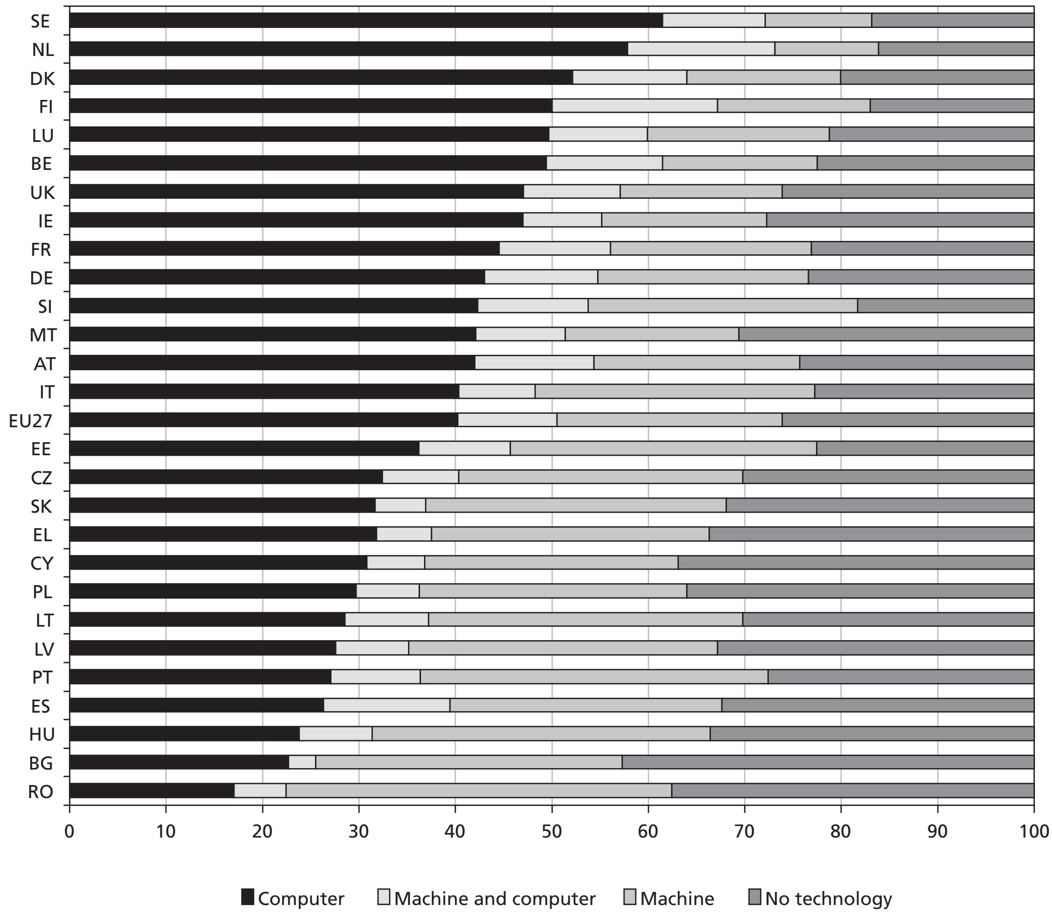
Figure 3 Use of machinery and computer, by country, EU27 (%)



Source: EWCS, 2005

A more detailed distinction of technology use by country is given in Figure 4, which also shows the share of technology-free situations at work in each country. Sweden ranks in first place in terms of computer use, followed by the Netherlands. These two countries also have the lowest share of technology-free situations at work. The opposite is the case for Romania and Bulgaria, each showing a relatively small proportion of computer users. Romania has a relatively high proportion of machine users, while Bulgaria has a relatively high share of technology-free work situations.

Figure 4 Use of technology, by type of technology and country, EU27 (%)



Source: EWCS, 2005

User profiles of different types of technology

When comparing the groups of computer users, machine users and non-users of technology, several striking differences emerge. This section briefly describes the profile of the different groups of technology users in the EU27. It then provides a more detailed outline of the relation between technology use and aspects such as economic sector, workers' age, gender, educational and skills levels, and career prospects, as well as between technology use and work organisational practices (for extensive results and accompanying tables, see technical report).

Computer use is more common among women aged 30–49 years, people with higher educational qualifications, professionals, technicians and associate professionals or clerks. In terms of sector of activity, computers are used to a greater extent among people employed in sectors such as education and health, public administration and defence, real estate or financial intermediation.

About 10% of all workers are required to work with both machines and computers as part of their job (see Figure 2); this includes, for example, those working with programmable robots, computer-aided manufacturing (CAM) and other more advanced machines. It also concerns jobs in which workers mainly perform assembly line work or mostly work with automated (vibrating) hand tools, but in which they also have to perform some supporting tasks on computer. Such supporting computer tasks may be administration tasks, placing orders or planning work tasks through company-wide software systems, for example, through enterprise resource planning (ERP) systems like SAP. This type of combined machine-computer work is more common among male workers aged 30–49 years and among workers in the manufacturing and mining sectors.

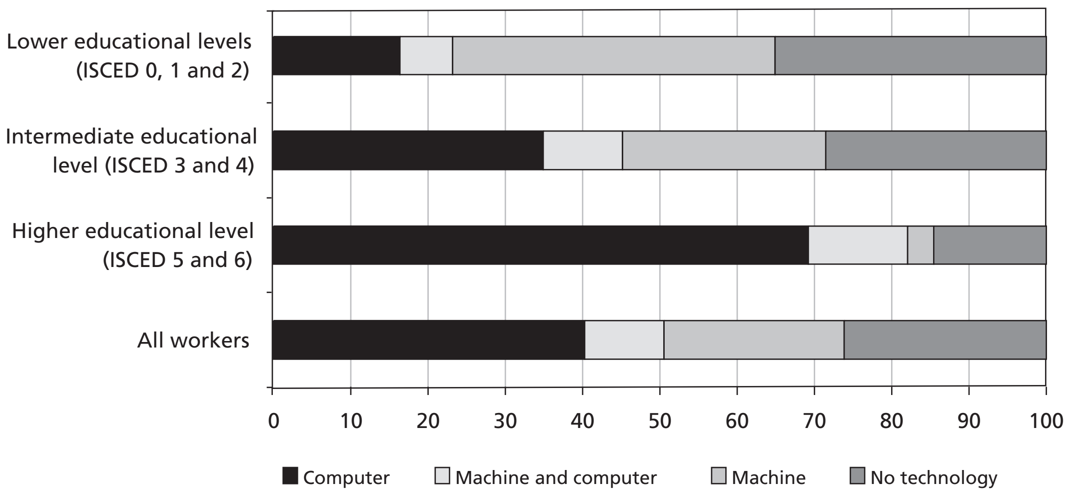
On the other hand, machine use is more common among men in the 15–29 and 30–49 age groups, people with relatively low educational qualifications, craft or related trades workers, plant or machine operators or assemblers. In terms of economic sectors, machines are more frequently used by workers employed in the manufacturing, mining or construction sectors. In the framework of this study, machine work without the use of computers could be, for instance, assembly line work or working with automated (vibrating) hand tools.

The non-use of technology at work – machinery or computers – is more common among women aged 50 years or older, workers doing unskilled work, service workers, shop and market sales workers, as well as those working in micro-enterprises. Technology-free situations at work are more widespread in the wholesale and retail trade, hotels and restaurants or in the education and healthcare sectors. It should be noted, however, that some of the workers in these sectors of activity may work with cash registers, for example, but this work is usually not their main task in their job. Given the fact that the current study faces limitations regarding the measurement of 'machine' use, people working with non-vibrating machinery and/or machinery that does not dictate the pace of work are necessarily classified as working in a technology-free situation.

Technology use by educational level

Looking at the use of technology in relation to the educational level of workers, the findings show that computer use is more common for higher educated people. Computer use is less widespread for people with lower educational levels. Moreover, technology-free situations at work are more common for people with lower educational levels (Figure 5).

Figure 5 Use of technology at work, by educational level, EU27 (%)

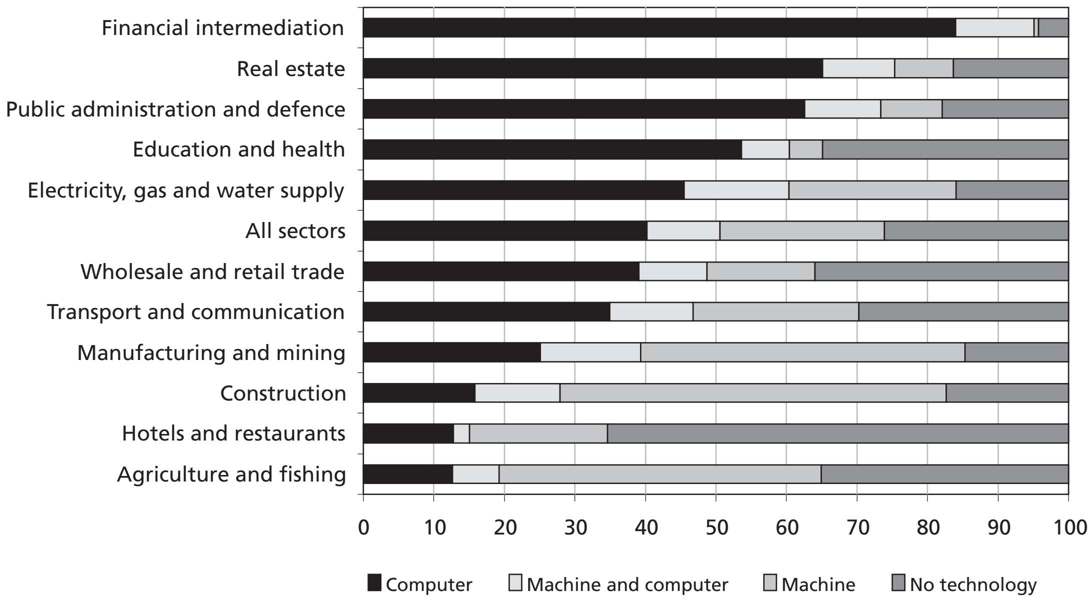


Source: EWCS, 2005

Technology use by sector

In terms of sectors of activity, the use of computers is by far more widespread in the financial intermediation sector, with 84% of workers using a computer at work, followed by real estate, and public administration and defence. In the latter two sectors, 65% and 62% of workers, respectively, use computers at work. Machine use is most common in the construction, and manufacturing and mining sectors, where respectively 54% and 46% of workers use machines at their workplace. The hotels and restaurants sector stands out due to its great proportion of technology-free work situations, with 65% of employees working in such situations (Figure 6).

Figure 6 Use of technology at work, by sector, EU27 (%)



Source: EWCS, 2005

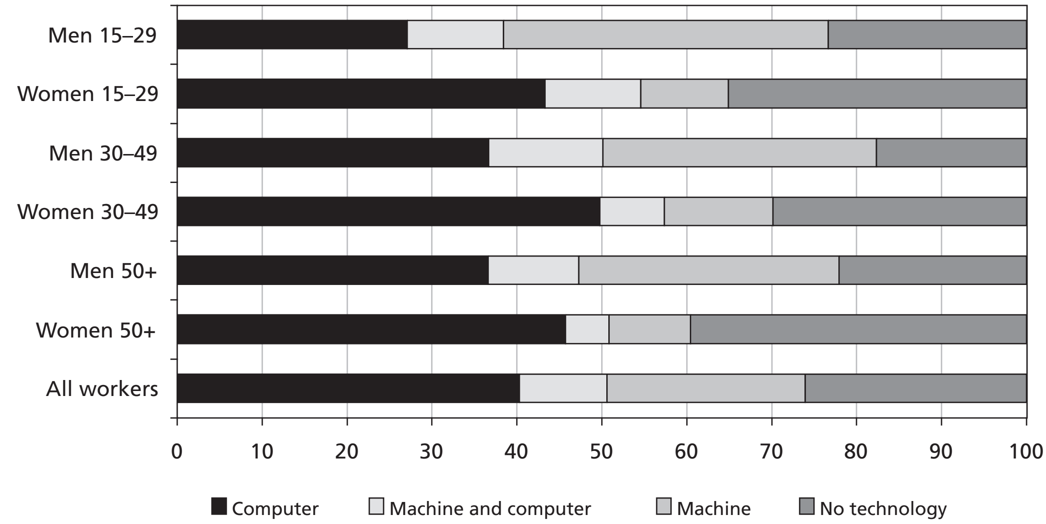
Technology use by gender and age

Figure 7 shows the distribution of technology use between men and women, and among different age groups. According to the EWCS findings, in all age groups, women report greater use of computers at work than men. Women also work more frequently than men in technology-free situations.

In light of these findings, the question is whether and how this gender difference in computer use is related to the economic sector in which men and women work, or to differences in their educational and occupational levels. These issues will be further explored in the next set of figures.

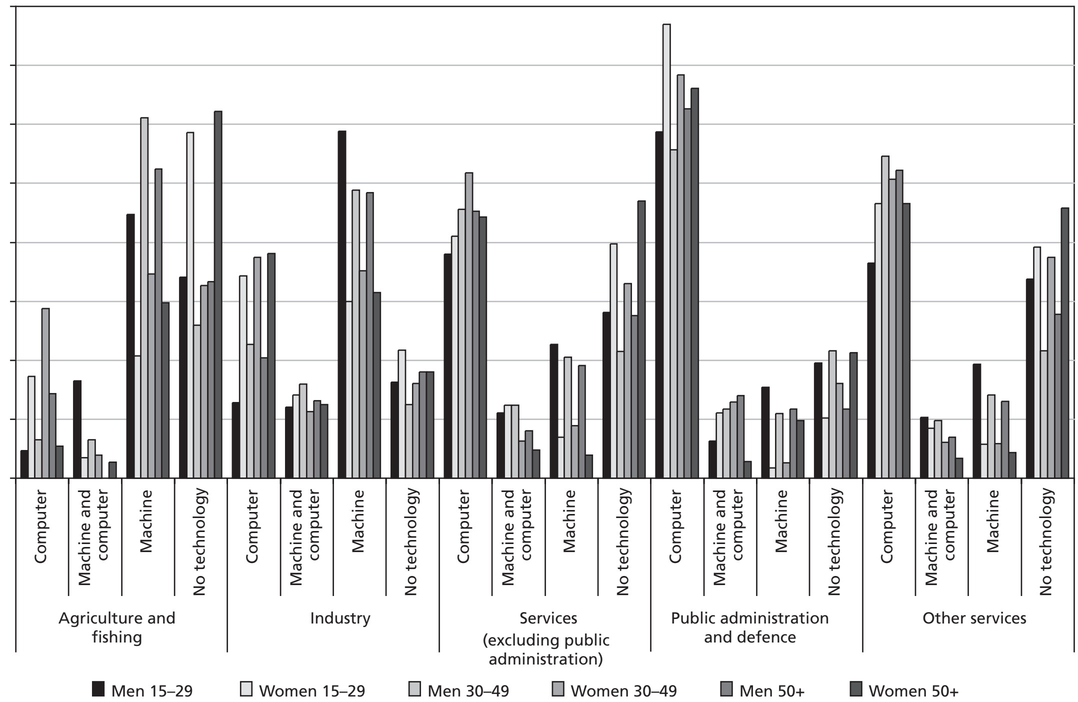
Figure 8 outlines the use of technology by gender-specific age groups and sector of activity. In sectors such as agriculture and fishing, industry, services, public administration and defence, a greater use of computers has been recorded for women, in particular for women under the age of 50 years. Only in the 'other services' sector, do men over the age of 30 years report a higher rate of computer use than women in the same age group. In general, however, the gender difference in terms of computer use does not seem to be explained by the sector of activity.

Figure 7 Use of technology at work, by gender and age group, EU27 (%)



Source: EWCS, 2005

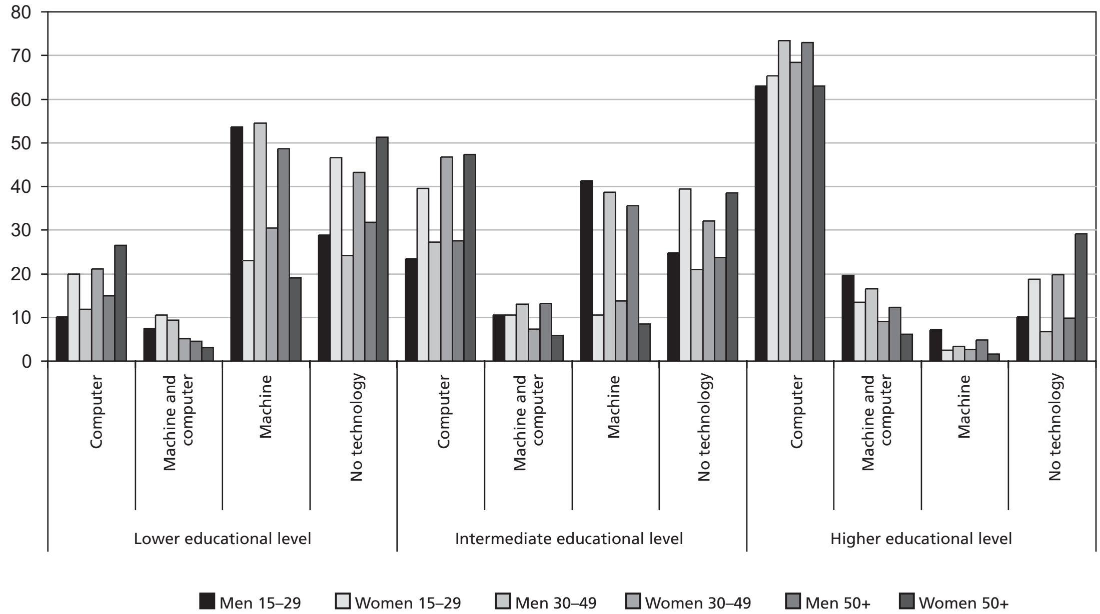
Figure 8 Use of technology, by gender, age group and sector, EU27 (%)



Notes: Cell sizes in the four main technology categories – machine, computer, machine and computer, and no use of technology – per level of sectoral cluster are all sufficiently large (n > 50). In some subgroups, which are mainly related to some subgroups in the agriculture and fishing sector, sample sizes are relatively small (n < 50).
Source: EWCS, 2005

Figure 9 shows technology use by gender-specific age groups and educational level. Women with lower educational qualifications report a greater use of computers at work than their male counterparts. The same gender difference is found for intermediate educational levels, comprising upper-secondary and post-secondary qualifications. Lower and intermediate educated men use more machinery at work than their female counterparts. For higher educational levels, gender differences in computer use are significantly smaller and also show a reverse picture in the 30–49 and 50 years and over age groups: highly educated men in these age groups report working with computers at work more frequently than highly educated women in the same age group.

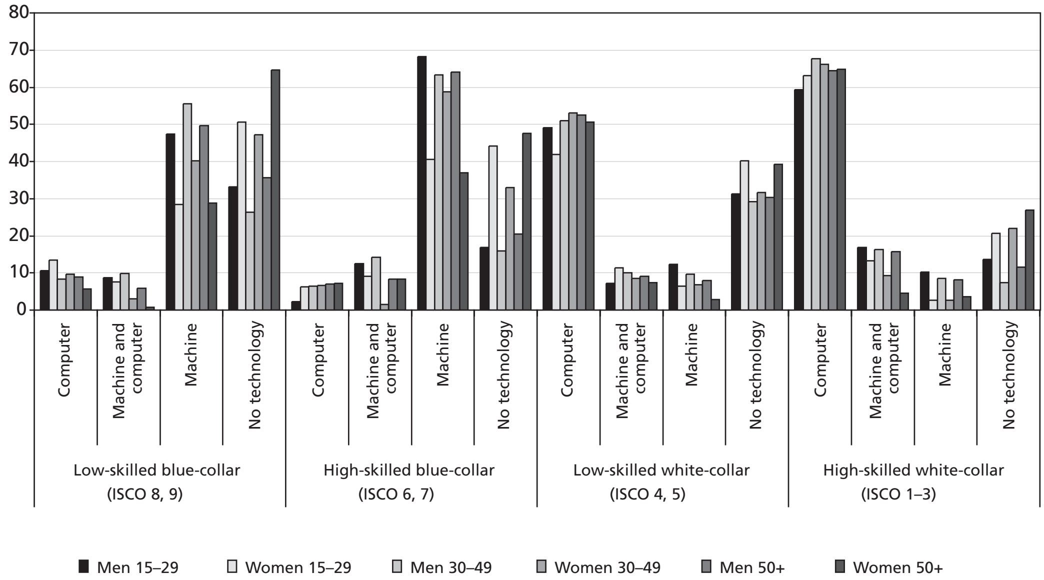
Figure 9 Use of technology, by gender, age group and educational level, EU27 (%)



Notes: Cell sizes in the four main technology categories per level of education are all sufficiently large (n > 50).
Source: EWCS, 2005

Overall, gender differences in the use of technology for the lower and intermediate educational levels are much greater than for the higher educational level. These findings seem to point towards a correlation between occupation and technology use. Figure 10 illustrates the effect of occupation in this regard; however, gender differences appear to be less prominent when taking occupation into account. Computer use is greater for men in high-skilled white-collar occupations, in particular for men aged between 30 and 49 years. This figure suggests that differences between men and women regarding computer usage are explained by gender differences in the occupational level.

Figure 10 Use of technology, by gender, age group and skills level, EU27 (%)



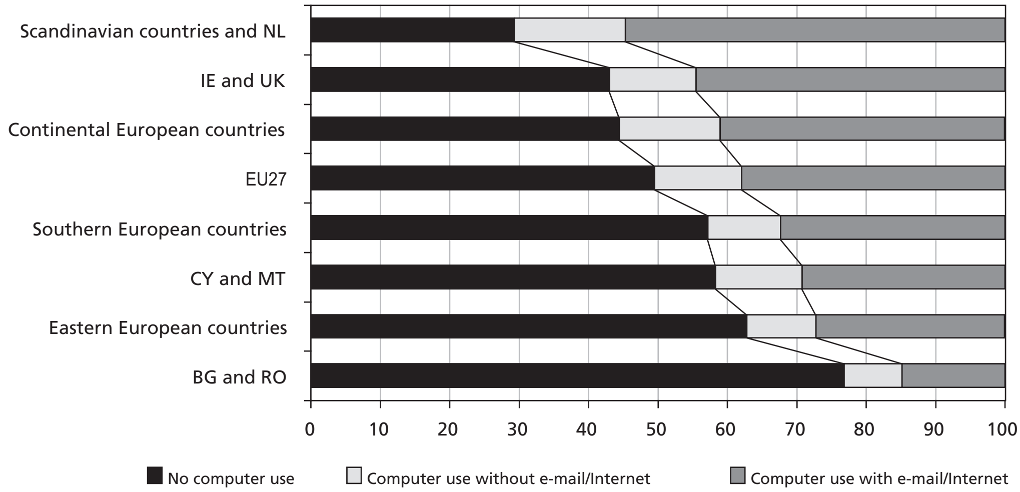
Notes: Cell sizes in the main technology categories per level of skills use are all sufficiently large (n > 50). In some subgroups, such as women over 50 years of age working with machine and computer technology, sample sizes are relatively small (n < 50).
Source: EWCS, 2005

Use of e-mail and Internet

To assess the extent to which e-mail and the Internet has penetrated at workplaces in different EU countries, Figure 11 highlights the proportion of computer users using both technologies at work in the different country groups (Figure 11). The Scandinavian countries and the Netherlands show the highest share of e-mail and Internet use at work, with 55% of workers in these countries reporting that they access both at work. In the continental European countries, some 40% of workers use e-mail and the Internet at work. Overall, Bulgaria and Romania have the lowest rate of workers accessing e-mail and the Internet at work, with only 14% of the workers in these countries reporting the use of these facilities.

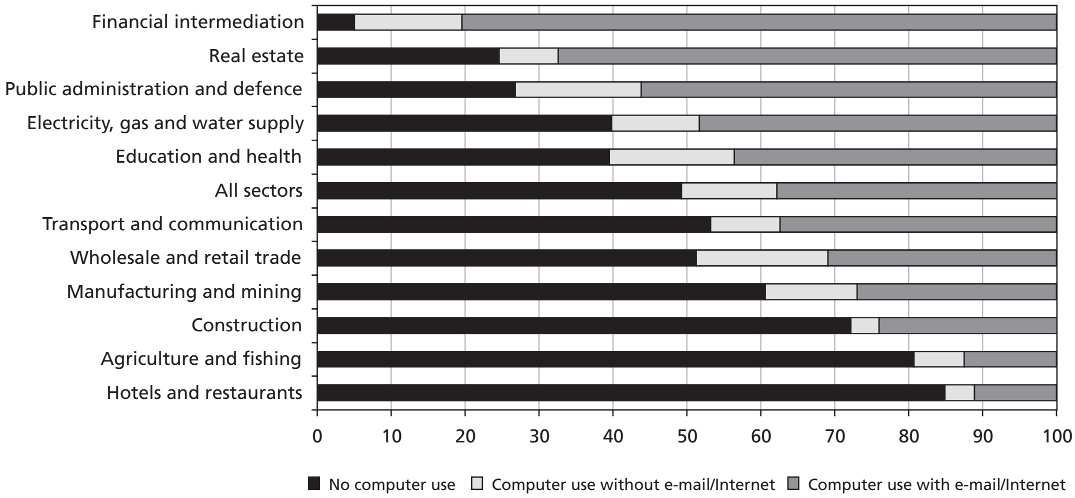
When looking at the use of e-mail and Internet by sector of activity, it is particularly high in the financial intermediation, real estate, and public administration and defence sectors. On the other hand, employees in sectors such as hotels and restaurants, and agriculture and fishing, report a relatively low level of e-mail and Internet use (Figure 12). This seems to be a logical finding, given that the use of e-mail and the Internet is low in sectors with relatively little computer use and high in sectors with significant computer use. This is due to the fact that working with a computer is conditional for using e-mail and the Internet.

Figure 11 Use of computer and e-mail/Internet at work, by country group (%)



Notes: Scandinavian countries – DK, FI and SE; continental European countries – AT, BE, DE, FR and LU; southern European countries – EL, ES, IT and PT; eastern European countries – CZ, EE, HU, LT, LV, PL, SI and SK.
Source: EWCS, 2005

Figure 12 Computer users using e-mail and Internet at work, by sector, EU27 (%)



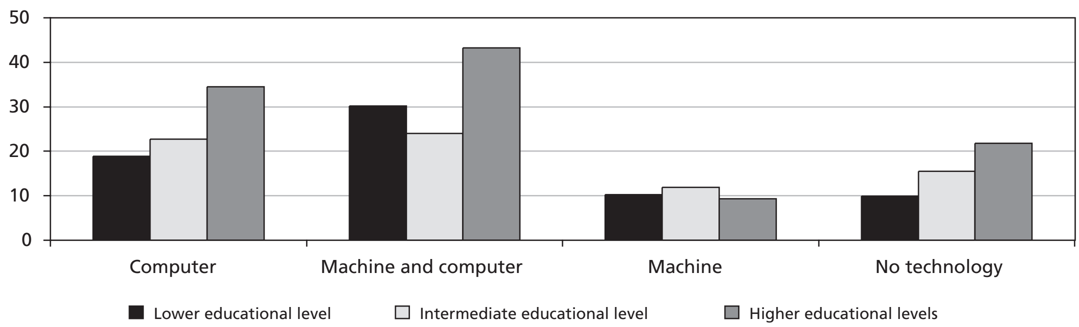
Source: EWCS, 2005

Technology use and work-home interference

To explore the idea that advanced technology such as ICT may cause a blurring of boundaries between work and private life, the use of technology has also been analysed in terms of the reported 'contactability outside work' (Figure 13). As it can be expected that such contactability is more common among higher educated workers, the analysis in this regard has been carried out according to the educational level of workers. The survey findings show that highly educated computer users, as well as users of both machinery and computers, more often report being contacted for work matters outside their normal working hours than people with a lower and intermediate educational level. Some 43% of highly educated workers using both machinery and computers at work are contacted outside their normal working hours.

While computer use increases the possibility of being contacted outside work, educational level also has an impact on whether a worker is contacted outside normal working hours. The effect of education on a worker's contactability outside work is particularly visible in the case of no technology being used at work: in this category, highly educated workers report a higher rate of out-of-hours contact than those with a lower or an intermediate educational level. Workers of all educational levels who mainly use machinery in their job, as well as those with a low educational level who do not use technology at work, are contacted less often outside their normal working hours than the other groups of workers.

Figure 13 Use of technology and contactability outside work, by educational level, EU27 (%)



Note: The survey question was whether one was contacted, for example, by e-mail or telephone, in matters concerning the job outside the normal working hours (in the past 12 months), a couple of times a month or more often.
Source: EWCS, 2005

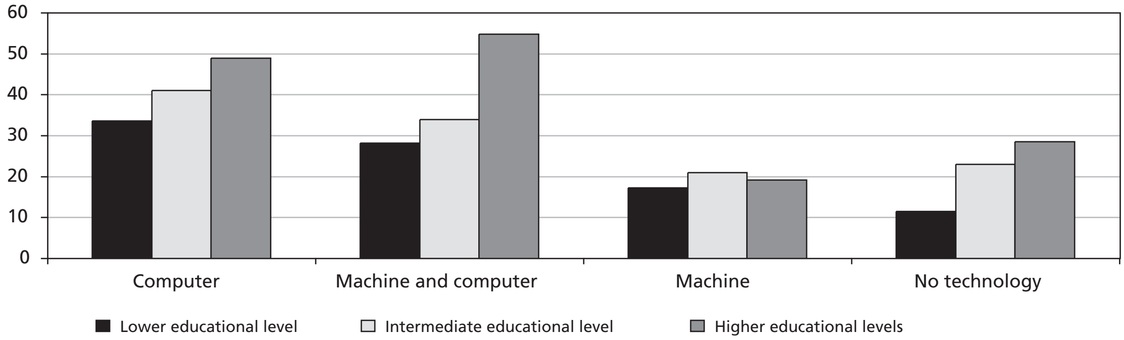
Technology use and career prospects

The prospects of career advancement differ depending on the type of technology used by the workers. Computer users and workers who use both machines and computers more often report having good prospects of career advancement, compared with those using machines only and those who do not use technology at work (Figure 14). An educational effect can again be perceived: highly educated people more often report good prospects of career development than people with an intermediate or lower educational level.

Technology use and work organisational practice

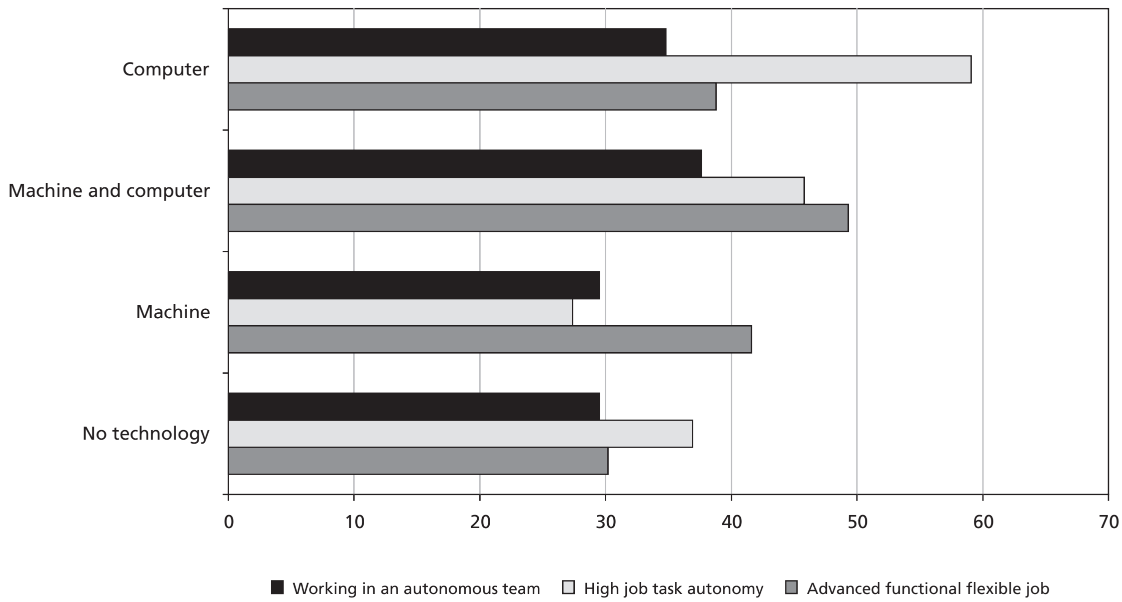
In terms of work organisational practices, computer users more often work in autonomous teams than workers using machines only, machines and computers, or workers who do not use technology at work. A relatively high proportion of workers who work with both machines and computers experience advanced functional flexibility at work (49%); this means that their job involves rotating tasks requiring different skills. Moreover, computer users more often have high job task autonomy, with 59% of computer users reporting this (Figure 15).

Figure 14 Use of technology and prospects of career advancement, by educational level, EU27 (%)



Note: The workers were asked whether or not they agreed that their job offered good prospects for career advancement. The results shown here reflect the proportion of those workers who strongly agreed with this statement.
Source: EWCS, 2005

Figure 15 Prevalence of autonomous teams, high job task autonomy and advanced functional flexible jobs, by use of technology, EU27 (%)



Source: EWCS, 2005

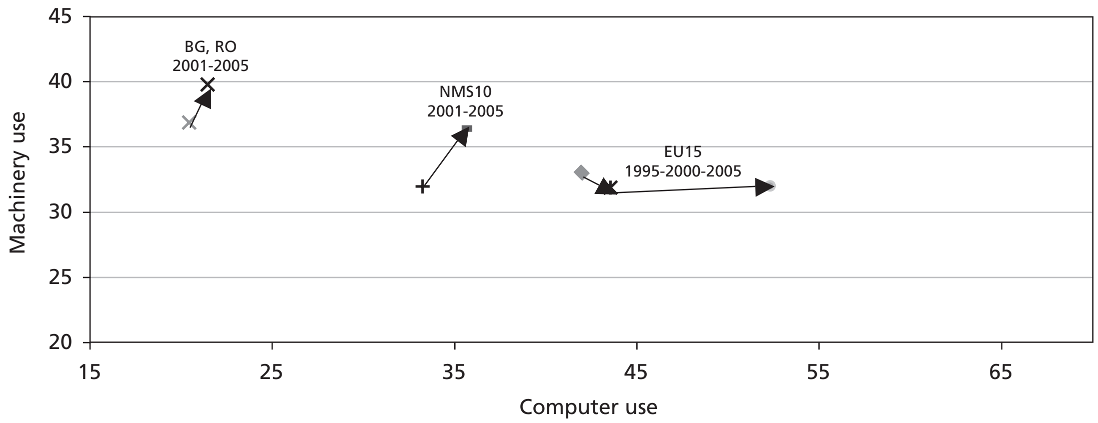
Trends in technology use 3

As highlighted in the introduction to this report, developments in the use of technology take place in the context of the knowledge-based economy. In 1996, the European Commission confirmed that the pace at which new technologies have been introduced varied between countries, regions, sectors, industries and enterprises (European Commission, 1996). This section will focus on developments in technology use between 1995 and 2005 and will aim to shed light on the impact of these trends at each individual level. Moreover, it will look at developments in skills use in the European countries under examination, since the relationship between the introduction of new technologies and required skills of the labour force has caused some concern at policy level.

Technology use in different countries

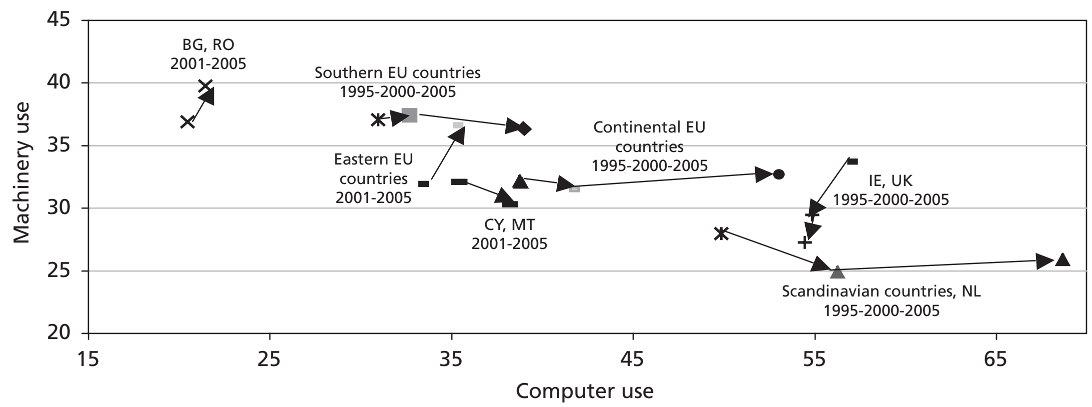
Figures 16 and 17 outline possible shifts in technology use across the different European countries between 1995 and 2005. The figures illustrate whether technology use increased or decreased in the country groups under examination, as well as the direction of the change in machine or computer use (the exact proportions are provided in the technical report).

Figure 16 Trends in the use of technology, by EU membership status, 1995–2005



Source: EWCS, 2005

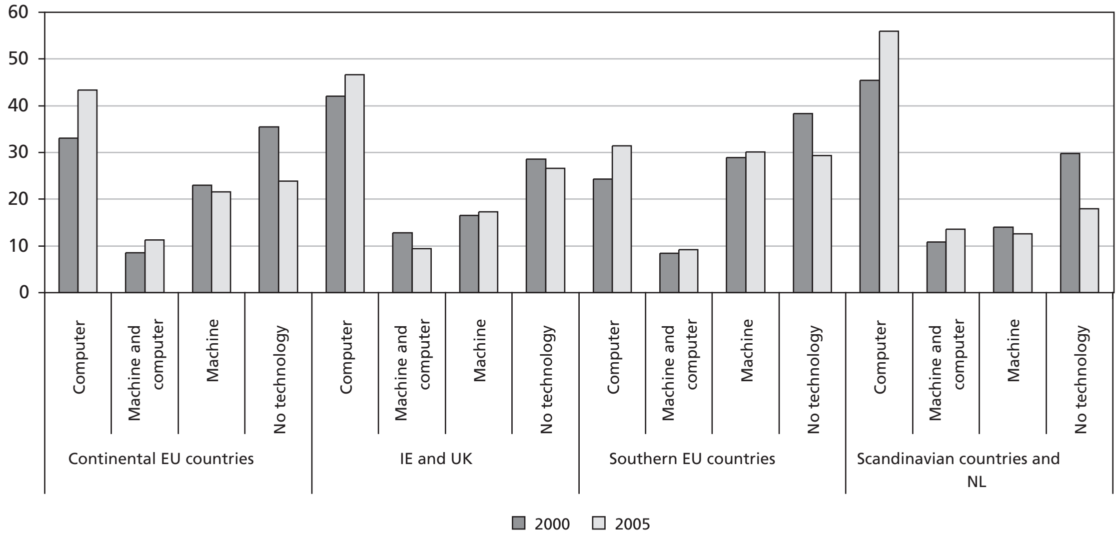
Figure 17 Trends in the use of technology, by country group, EU27, 1995–2005 (%)



Source: EWCS, 2005

When looking at the trends in technology use within each of the EU15 country groups, computer use has increased in all of these clusters over the years 2000–2005 (Figure 18). The greatest increase in computer use is noted in the Netherlands and the Scandinavian countries, as well as in the continental European countries – that is, Austria, Belgium, France, Germany and Luxembourg. In all of these country groups, a simultaneous sharp decrease in technology-free situations has been observed. The southern European countries – namely, Greece, Italy, Portugal and Spain – and Ireland and the UK show the same trend, although the observed changes are somewhat smaller. However, only in Ireland and the UK is the combination of computer and machine use decreasing.

Figure 18 Trends in the use of technology within country groups, EU15, 2000 and 2005 (%)



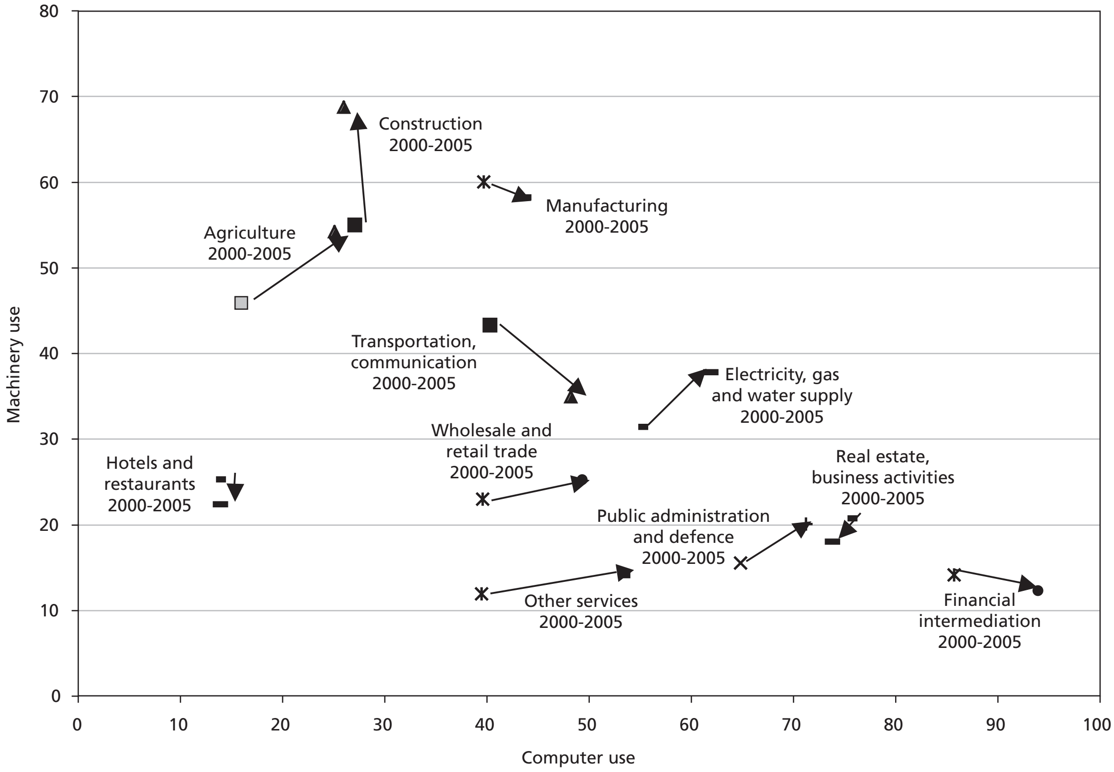
Source: EWCS, 2005

Technology use in different sectors

Figure 19 shows the changes in technology use in different sectors of the economy over the period 2000–2005. In several sectors, both machine use and computer use have been increasing in the following sectors: electricity, gas and water supply; wholesale and retail trade; public administration and defence; and other, non-commercial services (for exact proportions for all sectors, see tables in technical report).

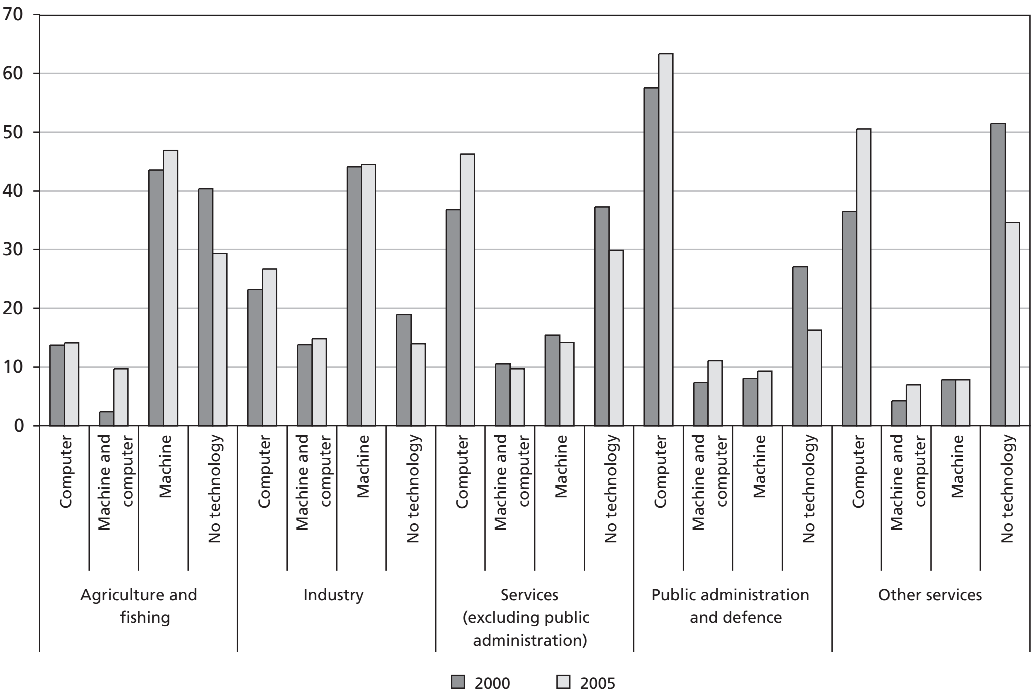
When condensing the sector variable into the four categories of technologies used at work, changes in technology use within these categories can be sketched out (Figure 20). Between 2000 and 2005, the agriculture and fishing sector records a decrease in technology-free situations at work and an increase in machine use. The greatest increase in the use of computers at work took place in the services and ‘other services’ (community, social and personal activities) sectors.

Figure19 Trends in the use of technology, by sector and type of technology, EU15, 2000–2005 (%)



Source: EWCS, 2005

Figure 20 Trends in the use of technology, by sector, EU15, 2000 and 2005 (%)

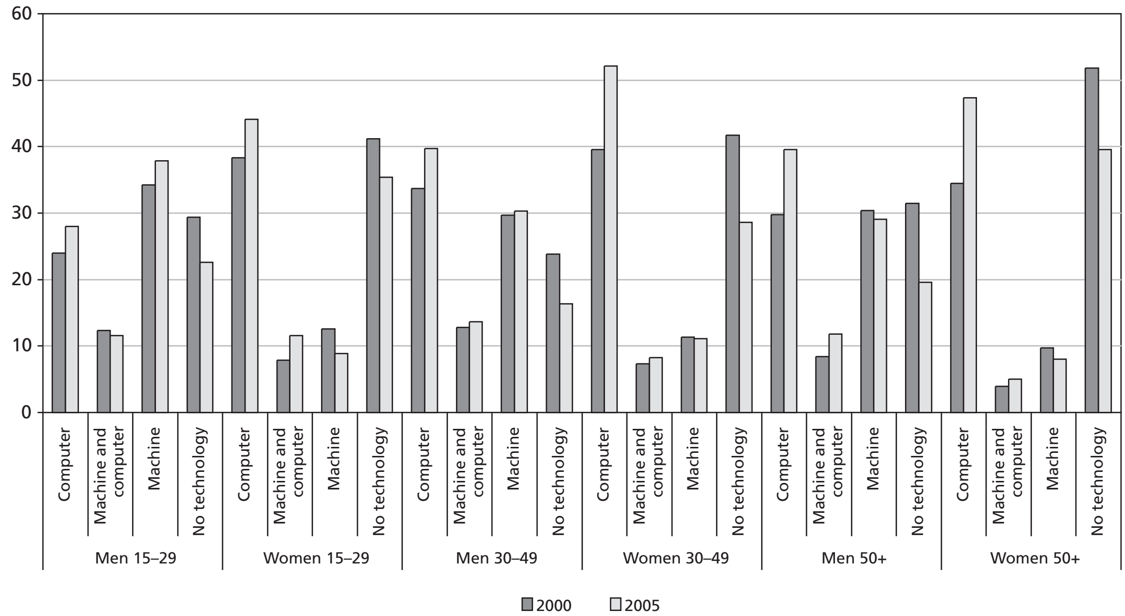


Source: EWCS, 2005

Technology use by gender and age

The trend reported earlier regarding the increase in computer use and decrease in technology-free situations at work applies to both men and women in all age groups (Figure 21). Furthermore, the increase in machine use for young men aged 15–29 also stands out. Within the EU15, this is the only group of workers for whom the use of machinery has increased.

Figure 21 Trends in the use technology, by gender and age group, EU15, 2000 and 2005 (%)

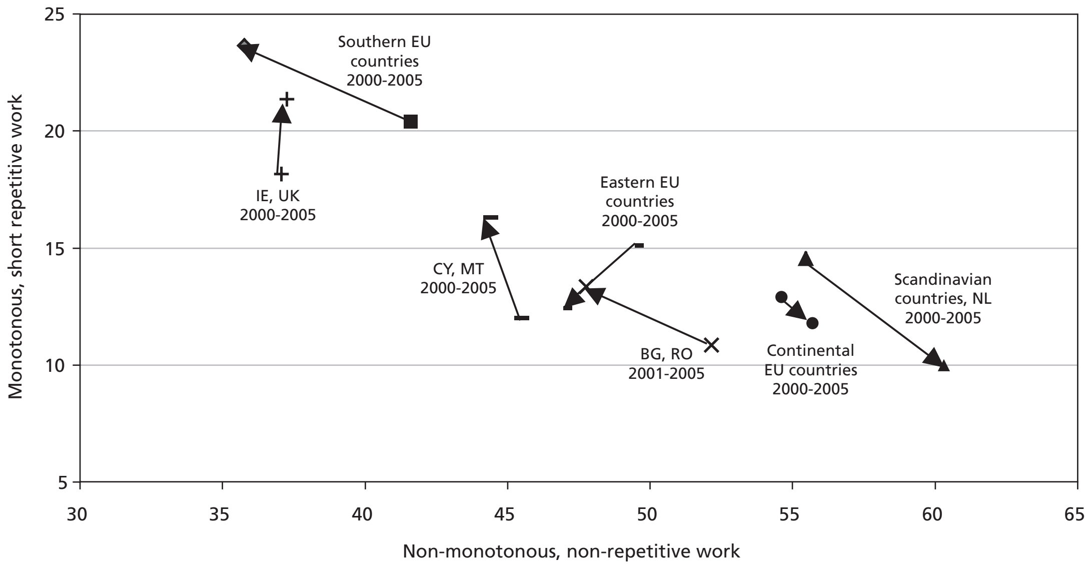


Source: EWCS, 2005

Skills use

Two methods of looking at trends in skills use are explored in this research: the first relates to the proportion of monotonous and repetitive work, and the second looks at skills use at the different occupational levels as defined by ISCO. Figure 22 outlines the trends in skilled work – that is, non-monotonous and non-repetitive work – and unskilled work – that is, monotonous, short repetitive work – in the various country groups over the period 2000–2005 for the EU15 and 2001–2005 for the NMS. To make the comparisons clearer, the two mixed categories – those reporting monotonous work but non-repetitive tasks and those reporting non-monotonous work but repetitive tasks – are not included for consideration. Southern European countries appear to have the highest share of monotonous, short repetitive work (unskilled work) and a relatively low proportion of non-monotonous, non-repetitive work (skilled work). The trend line shows a further increase in unskilled work and a further decrease in skilled work in the southern European countries since 2000. Bulgaria and Romania, as well as Cyprus and Malta, face the same trend – notably, an increase in unskilled work and a decrease in skilled work – although these countries record a higher share of skilled work than the southern European countries. In Ireland and the UK, a relatively low amount of skilled work is found and an increase in unskilled work is observed between 2000 and 2005. At the other end of the spectrum, the Scandinavian countries and the Netherlands experience a relatively high and increasing proportion of skilled work, while also showing a relatively low and decreasing share of unskilled work. The eastern European countries show both a decrease in skilled and unskilled work. This result, at first sight contradictory, is attributable to the rise in the proportion of the mixed categories (non-repetitive/monotonous and repetitive/non-monotonous) in these countries over the period 2001–2005. The continental European countries record a minor increase in skilled work and a small decrease in unskilled work.

Figure 22 Trends in skilled and unskilled work, by country group, EU27, 2000–2005 (%)



Notes: Monotonous, short repetitive work is considered as unskilled work, and non-monotonous, non-repetitive work as skilled work.
Source: EWCS, 2005

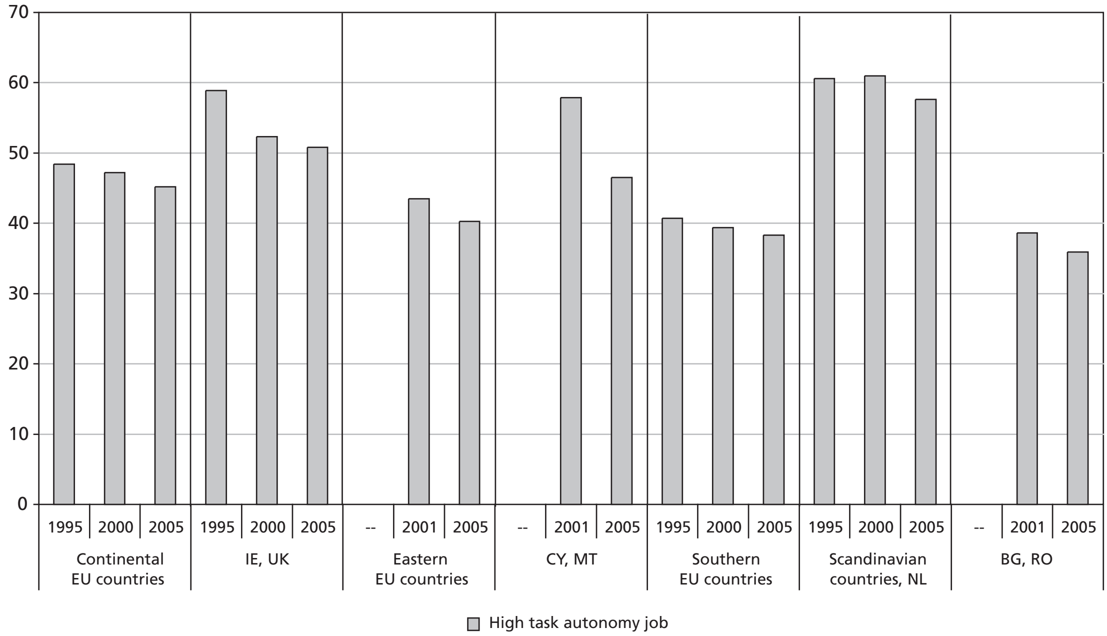
Another way of looking at trends in skills use is to establish worker divisions according to their occupational level based on assigning ISCO 1-digit categories to white-collar and blue-collar workers. In doing so, the following four categories have been defined: high and low-skilled blue-collar jobs and high and low-skilled white-collar jobs (see technical report for figures showing these trends).

Between 1995 and 2005, the southern European countries experienced a decrease in white-collar jobs, in the case of both high and low-skilled work. On the other hand, the share of low-skilled blue-collar work has increased in southern Europe. Eastern European countries also faced an increase in low-skilled blue-collar work, while experiencing a decrease in high-skilled white-collar work. The same holds true for Bulgaria and Romania, which recorded a decrease in high-skilled white-collar work and an increase in low-skilled blue-collar work. Nonetheless, for the Scandinavian countries and the Netherlands, the situation appears to be relatively stable. The continental European countries also experienced a noticeable increase in high-skilled white-collar work.

Task autonomy and its relationship with technology use

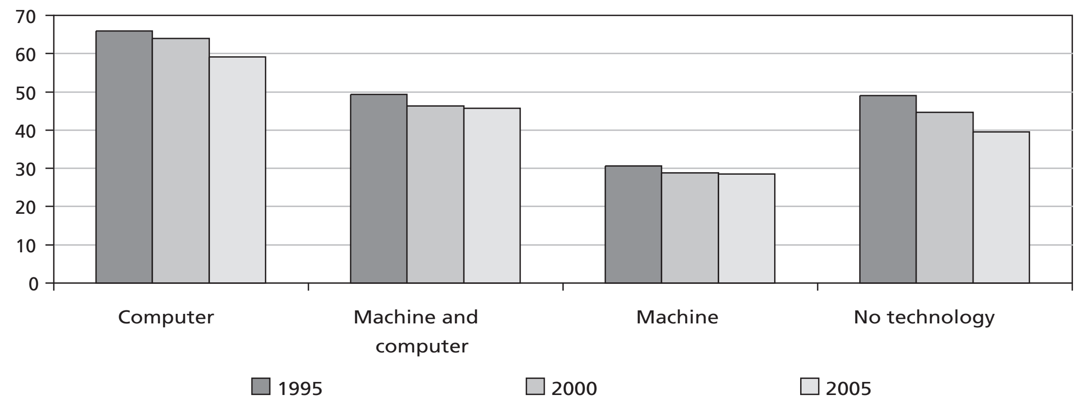
Trends in task autonomy at work in the individual country groups between 1995 and 2005 are presented in Figure 23. It is striking that, in all of the country groups, a decrease in high task autonomy jobs is observed. In order to explore whether this is related to the type of technology used at work, trends in task autonomy are also analysed in this regard (Figure 24). However, the findings do not clearly indicate that the decrease in task autonomy is related to the type of technology used: a decrease in task autonomy is observed in three of the four categories of technology used in European worksites – the exception is in the category of machine use, which shows a low but stable task autonomy. In general, computer users are more likely to experience higher work task autonomy.

Figure 23 Trends in high task autonomy jobs, by country group, EU27, 1995–2005 (%)



Source: EWCS, 2005

Figure 24 Trends in high task autonomy jobs, by use of technology, EU15, 1995–2005 (%)



Source: EWCS, 2005

4 Effects of technology on health and well-being

Research has revealed that technology use is related to working conditions and thus influences the health and well-being of individual workers. The EWCS has shown that, in general, computer use is associated with better working conditions and lower occupational health risks than machine use at the workplace (Parent-Thirion et al, 2007, pp. 45–46). Work that is determined by machinery use is typically more repetitive and monotonous; it also has less task autonomy and is physically more demanding. In the presence of high job demands, low levels of task autonomy may imply higher psychological costs as well.

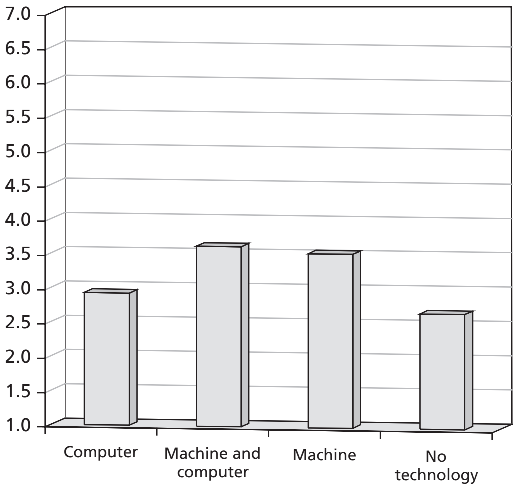
This chapter further analyses the relationship between technology use, working conditions and workers' health and well-being outcomes. First, a description is provided of the state of working conditions and the health and well-being of different technology users (and non-users) in the EU in 2005. Secondly, bivariate associations between technology use and the following working conditions are calculated: work intensity, learning opportunities and ergonomic risks. Finally, multivariate regression analyses are performed in order to assess the role that is played by other factors such as age, education and occupation, as well as work organisational characteristics.

Working conditions and health outcomes of different technology users

Figures 25–30 show the state of working conditions for different types of technology users in the EU in 2005, including in Bulgaria and Romania. Of all workers using technology and those who do not use it, people working with computers score the most favourably in terms of working conditions and the health and well-being indicators under examination. The group of workers using both machinery and computers rank in second place, scoring somewhat lower than computer users in this regard. Working conditions of people who work without using technology are worse than those of the previous two categories of technology users; however, those who do not use technology at work still score better than workers who primarily use machinery. In terms of health and well-being indicators, people working with machinery have the least favourable working conditions: they show the highest levels of work intensity, combined ergonomic risks, musculoskeletal complaints and stress symptoms. They also report the lowest satisfaction with their working conditions and the lowest learning opportunities and challenges offered by their job.

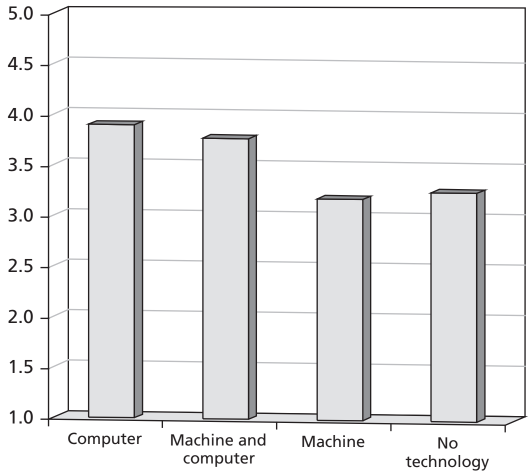
Figures 25-30 Perception of working conditions and health and well-being, by use of technology, EU27, 2005

Figure 25 Work intensity (Scale 1–7)*



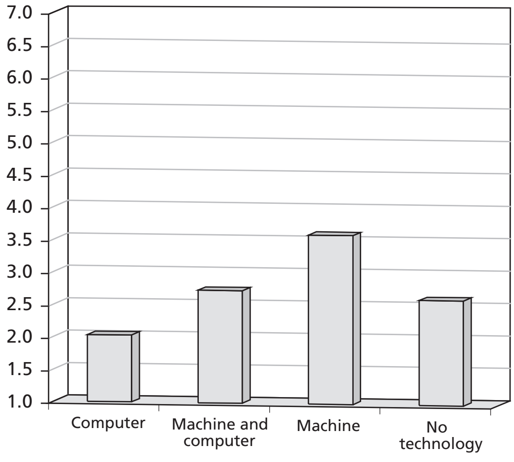
* Work intensity was assessed on a Scale 1–7 based on two items: Does your job involve working at high speed/working to tight deadlines? (both 1=never and 7=all of the time) (EWCS 2005 Questions 20A and B).

Figure 26 Learning opportunities (Scale 1–5)*



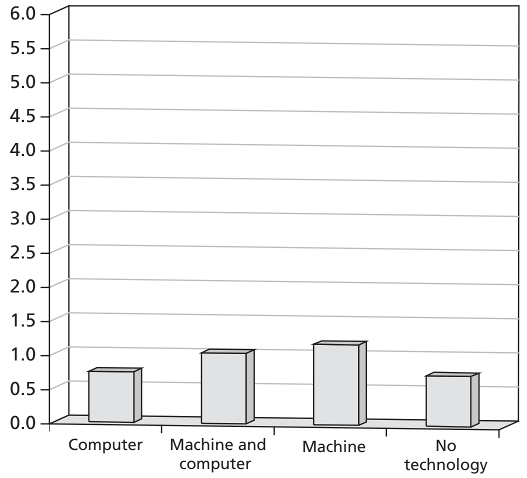
* Learning opportunities offered by the job were assessed on a Scale 1–5, based on four items: At work, I have opportunities to learn and grow (1=strongly disagree; 5=strongly agree)/you are able to apply your own ideas in your work/you have the feeling of doing useful work/you find your job intellectually demanding (1=almost always; 5=never) (EWCS 2005 Questions 37E, 25J, K and L).

Figure 27 Ergonomic risks (Scale 1–7)*



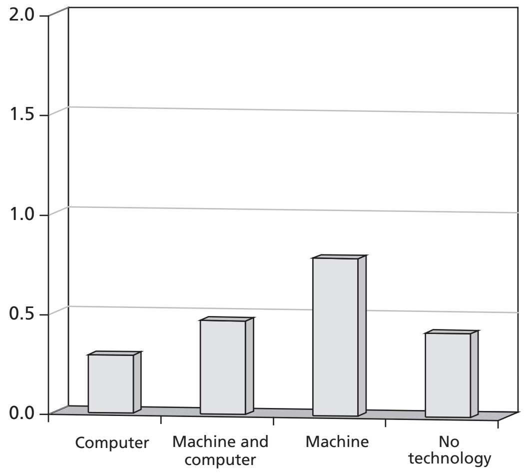
* Combined ergonomic risks were assessed on a Scale 1–7 based on three items: Does your main paid job involve painful or tiring positions/carrying or moving heavy loads/repetitive hand or arm movements (1=never and 7=all of the time) (EWCS 2005 Questions 11A, C and E).

Figure 28 Stress symptoms*



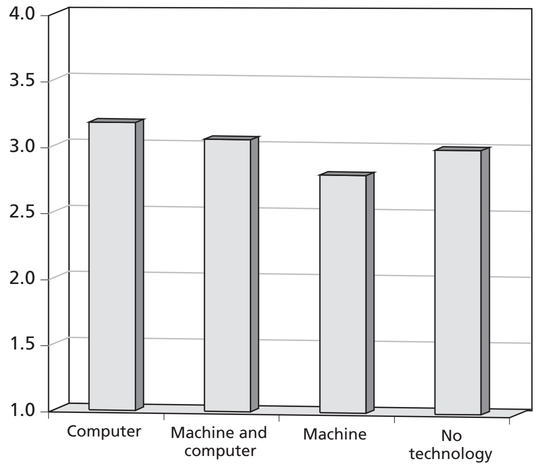
* Stress symptoms were assessed on the basis of 6 indicators: headaches, stress, overall fatigue, sleeping problems, anxiety and irritability (1=mentioned and 0=not mentioned) (EWCS 2005 Questions 33A_E, K, L, M, O, P).

Figure 29 Musculoskeletal complaints*



*Musculoskeletal complaints were assessed on the basis of 2 items: backache and muscular pains in shoulders, neck and/or upper/lower limbs (1=mentioned and 0=not mentioned) (EWCS 2005 Questions 33A-D and G).

Figure 30 Satisfaction with working conditions (Scale 1–4)*



*Satisfaction with working conditions was assessed on a Scale 1–4 based on the EWCS Question 36: On the whole, are you very satisfied, satisfied, not very satisfied or not at all satisfied with working conditions in your main paid job? (1=not at all satisfied, 2=not very satisfied, 3=satisfied, 4=very satisfied).

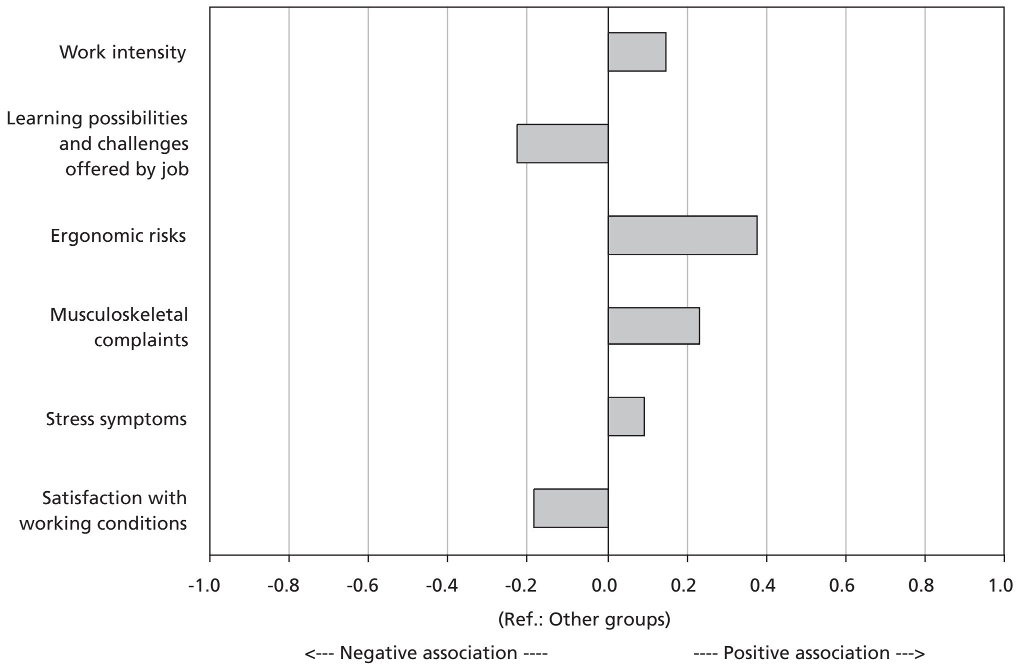
Notes: The vertical axes of Figures 25-30 differ, but reflect the minimum-maximum range in answering categories per item of the particular scale, thus providing some information on the average prevalence of these variables.
Source: EWCS, 2005

Relationship between technology use, working conditions and workers' health outcomes

For the purpose of this study, bivariate associations between technology use, working conditions and workers' health outcomes are presented in the form of profiles. These profiles are based on a correlation matrix, linking each of the four technology types with the variables determined to measure working conditions and workers' health outcomes – namely, work intensity, learning possibilities, ergonomic risks, musculoskeletal complaints, stress symptoms and satisfaction with working conditions (see Table A3 in technical report). The resulting profiles thus show which working conditions and health and well-being outcomes are significantly associated with which type of technology used at work, based on calculating the Pearson correlation coefficients (r).

Figures 31 and 32 outline the profiles in terms of working conditions and health and well-being for machine and computer users, respectively. Machine use is negatively associated with learning opportunities and weakly correlated with job satisfaction in terms of working conditions (Figure 31). It is also associated with higher ergonomic risks and more musculoskeletal symptoms. In this respect, it is important to note that the strong association found between machine use and ergonomic risks may partly be due to the way machine use was measured in this study – that is, an indirect measurement.

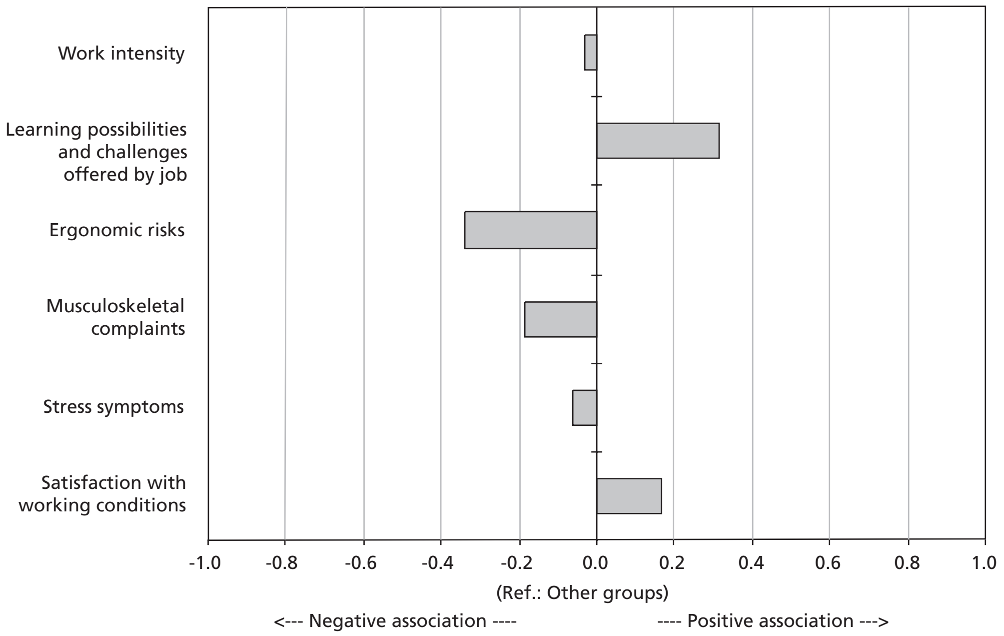
Figure 31 Working conditions and health and well-being profiles for machine users (Pearson r)*



* The bars represent the Pearson correlation coefficients (r) with machine use at work (yes/no).
Source: EWCS, 2005

Computer use is associated with higher learning opportunities and lower ergonomic risks, and weakly with less musculoskeletal complaints and higher job satisfaction (Figure 32). Non-use of technology is weakly associated with lower work intensity (Pearson r = -0.16) and less learning opportunities (Pearson r = -0.17). It can be considered that machine and computer use are not correlated with ergonomic risks and job satisfaction in terms of working conditions (all Pearson correlation coefficients range between -0.10 and +0.10).

Figure 32 Working conditions and health and well-being profiles for computer users (Pearson r)*



* The bars represent the Pearson correlation coefficients (r) with computer use at work (yes/no).

Source: EWCS, 2005

Summary of bivariate analyses

Table 1 summarises the results of the bivariate analyses between technology use, working conditions and workers' health outcomes. It appears that, in general, the use of machinery at work is associated with unfavourable health and well-being outcomes, while computer use is associated with more favourable outcomes.

Table 1 Significant associations between technology use, working conditions and health and well-being outcomes

	Working conditions			Heath and well-being		
	Higher work intensity	More learning opportunities and challenges offered by job	More ergonomic risks	More stress symptoms	More musculo-skeletal complaints	More job satisfaction
Technology category						
Computer use		↑↑	↓↓	↓	↓↓	↑↑
Machine and computer use	↑	↑				
Machine use	↑↑	↓↓	↑↑	↑↑	↑	↓↓
No technology	↓↓	↓↓				

↑↑ = Significant, relevant association (Pearson correlation (r) greater than or equal to +0.10)

↑ = Significant, but weak association (r greater than or equal to +0.05 and smaller than +0.10)

Source: EWCS, 2005 and authors' own calculations

Multivariate analyses regarding role of other factors

The bivariate relationships outlined in the previous sections have to be taken into account in the analyses regarding the effect of technology use on working conditions and health and well-being outcomes. For instance, it emerged that computer users are mostly highly educated women and machine users are mostly men with lower educational qualifications. The bivariate analyses further revealed that computer use at workplaces is more often associated with better working conditions. The multivariate analyses will show whether this effect is, in fact, caused by age and education, or whether the effect of computer use is independent of these and other factors.

In the introduction to this report, evidence was given that work organisation may reinforce or ease both positive and negative effects of technology use. For instance, it has been suggested in the literature that the effects of technological progress are more significant in working environments that support the capacity of workers to adapt to changes (Totterdill et al, 2002). The presence of work organisational characteristics such as autonomous teams, high task autonomy and advanced functional flexibility could, in this perspective, reinforce positive effects of advanced technology, while the absence of these characteristics, as well as low task autonomy, could impair positive effects. The same reasoning might apply to machine technology: the presence of autonomous teams, high task autonomy and advanced functional flexibility could decrease negative effects of machine technology on working conditions. To test these hypotheses, additional subgroup analyses were performed for all outcomes (exact estimation results of all models are presented in the technical report).

Important results for each of the three dimensions of working conditions under examination are described and summarised in Table 2. In the estimation models, other underlying factors such as age, gender, educational attainment, company size, supervisory position and technology use are included. Dependent variables under the heading of 'working conditions' are: work intensity, learning opportunities and ergonomic risks. Health and well-being outcomes under study comprise work-related stress symptoms, musculoskeletal complaints and job satisfaction. The estimation models for these last three outcomes contain background factors, technology use and working conditions.

For all six dependent variables, post-hoc subgroup analyses were performed within strata of the following work organisational practices: autonomous teams, task autonomy and advanced functional flexible jobs.

In general, it is important to note how much of the variance in work intensity, learning opportunities and ergonomic risks is explained by the factors included in each statistical model. Low percentages of explained variance may be related to the way the concepts were measured (that is, validity), but it also indicates that other factors (which are not included) play a role in the explanation of the outcome.

Work intensity

The included background factors, technology use and features of the work organisation explain only 6% of the variance in work intensity. This means that the chance of finding 'false' associations (that is, spurious results) increases. Of these 6%, 5% is accounted for by technology use. Machine users experience relatively high work intensity, which means they work at high speed and to tight deadlines. To test whether work organisational characteristics reinforced or impaired the effects of technology use on work intensity (so-called effect modification), subgroup analyses were performed. The analyses gave no evidence of effect modification. It is frequently assumed that work intensity – working at high speed and to tight deadlines – is associated with computer use. The absence of a significant relationship between computer use and work intensity in this study is therefore interesting and will be further discussed in the conclusions of this report.

Learning opportunities on the job

The included factors in each statistical model explain 24% of the variance in learning opportunities. The hierarchical analysis shows that of this percentage, approximately 13% is explained by background factors. Technology use corresponds to an additional 5% of the variance in learning opportunities and adding features of the work organisation explains another 7%.

Machine use is negatively related to learning opportunities. Learning opportunities also include the feeling of doing useful work, being able to apply one's own ideas in work and having an intellectually demanding job. Therefore, machine users have access to relatively few learning opportunities, experience less feelings of doing useful work, are less able to apply their own ideas in their work and relatively less often have an intellectually demanding job. Computer users, on the other hand, experience the opposite scenario and often have relatively high learning opportunities.

Subgroup analyses were performed to assess whether and how the effect of technology use on working conditions differs within the different work organisational contexts. The results show that the negative effect of machinery use on learning opportunities is no longer significant in a work organisation with high task autonomy. This finding implies that within a work organisation in which workers are able to choose or change the order of their tasks, their work methods and pace, the negative effects of machine use on learning opportunities are eased.

Figure 33A indicates that low task autonomy is associated with low learning opportunities; however, it also shows that a lower use of computers and higher use of machines are associated with fewer learning opportunities at work. A buffering effect for machine use is visible when working in an autonomous team is considered: machine users who experience high task autonomy have significantly higher learning opportunities than machine users with low task autonomy (Figure 33B). An enforcing effect is also evident for computer users: people who work with computers and in autonomous teams experience much higher learning possibilities than those not working in autonomous teams.

Ergonomic risks

Multivariate analyses were also performed for ergonomic risks. Ergonomic risks imply painful or tiring working positions, carrying or moving heavy loads and repetitive hand or arm movements. Of the variance in ergonomic risks, 21% is explained by the factors included in the model in this study, while 9% is explained by background factors, such as age and educational qualifications, 11% by technology use and less than 1% by work organisational characteristics.

Independent of age, gender and educational qualifications and other background factors, machinery use is associated with relatively high ergonomic risks. Conversely, computer use is associated with relatively low ergonomic risks. This effect does not seem to be influenced by features of the work organisation. While this effect was to be expected, it is important to note that the strong difference which is found in this dimension of working conditions between machine and computer use may partly be due to the way concepts were measured.[4]

Figure 33A Role of task autonomy in the relationship between technology use and learning opportunities (Scale 1–5)*

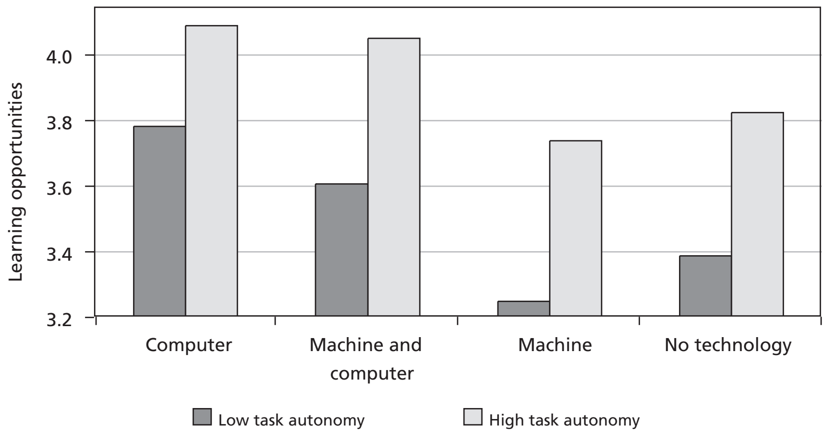
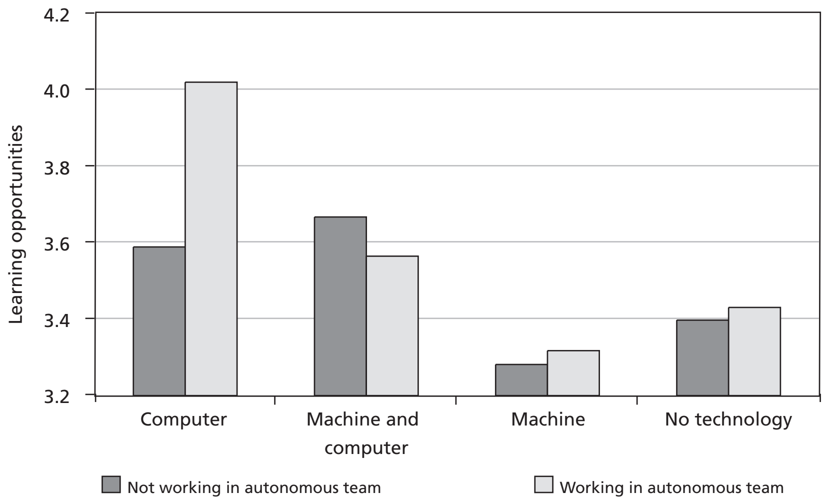


Figure 33B Role of working in autonomous teams in the relationship between technology use and learning opportunities (Scale 1–5)*



* Learning opportunities offered by the job were assessed on a Scale 1–5, based on four items: At work, I have opportunities to learn and grow (1=strongly disagree and 5=strongly agree); you are able to apply your own ideas in your work; you have the feeling of doing useful work; you find your job intellectually demanding (for the latter three, 1=almost always and 5=never) (EWCS 2005 Questions 37E, 25J, 25K and 25L).
Source: EWCS, 2005

[4] As indicated above, this might cause a problem in the interpretation of the relationship between machine use and ergonomic risks, since vibrations are also considered ergonomic risks. Thus, the distinction between both concepts is not clear-cut and the negative relationship between machine use and ergonomic risks may be overestimated.

Work-related stress symptoms

The included background factors, use of technology and work organisational characteristics explain only 9% of the variance in work-related stress symptoms. Technology use explains 2% of the variance. It appears that stress symptoms are mainly predicted by other variables than those that were included in this study. The results show that machine users run higher risks of developing work-related stress symptoms than workers using other technologies or no technology. The subgroup analyses show that this effect of machine use is no longer significant in the presence of autonomous teams or in the presence of high task autonomy. It appears that these work organisational features play a buffering role: the risk of developing stress symptoms due to machine use is lowered when workers work in autonomous teams. Furthermore, the study's findings reveal that higher work intensity and higher ergonomic risks are related to more stress symptoms.

Musculoskeletal complaints

Of the variance in work-related musculoskeletal complaints, 17% is explained by the study's model. Of this figure, 7% may be attributed to technology use and 8% to working conditions. Independent of background factors, machinery use is related to a relatively high probability of developing musculoskeletal problems. The opposite is the case for computer use. The hierarchical regression analysis shows that negative effects of machine use are not changed by features of the work organisation. Negative effects of machine use on musculoskeletal complaints seem, however, to be dependent on the working conditions (work intensity, learning opportunities and ergonomic risks). When working conditions are adjusted for in the analyses, the effect of computer use becomes less favourable, while the effect of machinery use becomes more favourable. This seems to confirm the idea that working conditions mediate the relationship between technology use and health and well-being outcomes. However, given the fact that a cross-sectional dataset is used, this mediation cannot be further examined within the framework of this research. The subgroup analyses do not seem to indicate that effects of technology use on musculoskeletal complaints interact with the work organisational context. As for the effect of working conditions on the development of musculoskeletal problems, it appears that higher work intensity, fewer learning opportunities and higher ergonomic risks are related to more musculoskeletal symptoms.

Job satisfaction

Of the variance in satisfaction with the working conditions in the job, 17% is explained by the variables included in the model. Some 4% of this is explained by the use of technology. Computer use appears to be associated with a relatively high level of job satisfaction. This effect is not altered by work organisational characteristics. However, when adjusted for working conditions, the effect of computer use on job satisfaction is no longer significant. The analyses outlined above showed that computer work is associated with better working conditions. This multivariate analysis shows that better working conditions are more significant in predicting job satisfaction than computer use. This finding points towards the idea that working conditions mediate the effects of computer use on job satisfaction. The subgroup analyses do not indicate moderation – that is, buffering or reinforcing – effects of the work organisational features in the relationship between technology use and job satisfaction.

Summary of multivariate analyses

Table 2 summarises the findings of the multivariate analyses as described in the previous sections. It reflects the effect of technology use on working conditions and workers' health outcomes corrected for age and education, as well as for organisational characteristics such as the presence of autonomous teams, high task autonomy and functional flexibility. It is evident from Table 2 that all effects are references against the 'no technology' category.

In general, effects between the type of technology used and quality of work, and workers' health and well-being remained the same, were less significant or have become insignificantly different, compared with working with no technology. In some cases, machine use at work is more detrimental regarding working conditions or health outcomes compared with using 'no technology', like its relationship to 'learning opportunities' – resulting in a change in direction of the arrow in Table 2 compared to Table 1.

Table 2 Significant results of technology use on working conditions and health and well-being (multivariate analyses)

	Working conditions			Heath and well-being		
	Higher work intensity	More learning opportunities and challenges offered by job	More ergonomic risks	More stress symptoms	More musculo-skeletal complaints	More job satisfaction
Technology category (Ref.: No technology)						
Computer use	↑↑	↑↑	↓↓			
Machine and computer use	↑↑	↑	↑			
Machine use	↑↑	↓	↑↑		↑	↓

↑↑ = Significant, relevant effect (standardised regression coefficient (Beta) greater than or equal to +0.10)
↑ = Significant, but very weak effect (Beta greater than or equal to +0.05 and smaller than +0.10)
Effects on working conditions adjusted for socio-demographic effects; effects on health and well-being also adjusted for working conditions effects.
Source: EWCS, 2005 and authors' own calculations

Conclusions 5

This study aimed to investigate the relationship between technology use at the workplace and working conditions, as well as the effect of technology on workers' health and well-being. The study's findings reveal that significant differences exist between computer users, machine users and non-users of technology.

Profile of technology users

In general, computer use is more prevalent among higher educated workers. This finding is in line with earlier research findings (Steijn, 2001). In terms of economic sectors, the highest proportion of people working with computers can be found in the financial intermediation, real estate, and public administration and defence sectors. Across all age groups, women report greater use of computers at work than men. This gender difference in terms of working with computers is not related to differences in education or to the distribution of men and women across the sectors of activity. Women's greater use of computers at work can rather be explained by the fact that men and women have different occupations and/or work at different occupational levels.

When looking at the various EU countries individually, Sweden appears to rank in first place in terms of computer use at the workplace, followed by the Netherlands, while Bulgaria and Romania are lagging behind, with relatively small proportions of workers using computers at work. A possible explanation for the higher uptake of computer use in the Netherlands and the Scandinavian countries is that these countries also score highest in relation to related (or maybe required) changes in work organisational practices (as referred to in the Commission's Microeconomic Guideline No. 13 and Employment Guideline No. 20 – see pp. 6-7). Other explanations may relate to the countries' labour market or economic situation.

Machine use is most common in sectors such as manufacturing, mining and construction, and among workers with low educational qualifications. The use of machines at work is particularly widespread in eastern and southern European countries, as well as in Bulgaria and Romania which joined the EU in 2007. Technology-free working environments are quite often found in Bulgaria.

The Netherlands and Scandinavian countries show the highest share of workers using e-mail and the Internet, followed by the continental European countries. Bulgaria and Romania have the lowest proportion in this regard.

Trends in technology use

Trends in technology use in the EU27 between 1995 and 2005 show an increase in computer use and a decrease in technology-free working environments and machine use. This trend is found for men and women in all age groups, but not for all countries within the EU27. When different country groups are considered, a shift towards more computer work is observed in all of these country groups. However, in Ireland and the UK, the use of computers at work increased, while the combined use of computers and machines decreased from 2000 to 2005. Eastern European countries, such as Bulgaria and Romania, as well as Cyprus and Malta, recorded small increases in the use of computers at work. In general, the eastern European countries, as well as the latest accession countries Bulgaria and Romania, are at earlier stages of technological development than the continental European countries, the Netherlands and the Scandinavian countries. Eastern European countries and Bulgaria and Romania are the only country clusters in which an increase in machine use is observed. This finding may be related to the sectoral distribution of the labour force in these countries. Eastern European countries have relatively large agriculture and fishing, and manufacturing sectors, in which machine use is common.

Trends in skills use

Trends related to the skills that are used in jobs show that the proportion of monotonous, short repetitive work – that is, 'unskilled' work – is highest and continues to increase in the southern European countries, while the share of non-monotonous, non-repetitive work – that is, 'skilled' work – remains low and is decreasing in these countries. The Netherlands and Scandinavian countries, on the other hand, have a relatively high and increasing proportion of 'skilled' work, while the share of 'unskilled' work is relatively low and decreasing. In terms of type of occupation in the EU15, an increase in low-skilled blue-collar and high-skilled white-collar work has been observed between 2000 and 2005.

The southern European countries experienced a decrease in both high and low-skilled white-collar work, while the share of low-skilled blue-collar work has increased. Eastern European countries also recorded an increase in low-skilled blue-collar work and experienced a decrease in high-skilled white-collar work. The same trend has been observed in Bulgaria and Romania, which recorded a decrease in high-skilled white-collar work and an increase in low-skilled blue-collar work.

When looking at the overall trend in the EU15 between 1995 and 2005, it appears that computer users, workers who use both machinery and computers, as well as workers who do not use any technology at the workplace, have been facing a decrease in the level of autonomy at work, particularly in their capacity to change tasks. This decline in task autonomy in computerised work situations might be related to the introduction of new software systems. Over this period, there has been a broad uptake of workflow software, ERP or other company-wide software systems, including built-in mandatory fields and automated planning systems. Compared with machine users, computer users are more likely to have higher task autonomy. For machine users, a stable but low task autonomy is reported.

Relationship between technology use, working conditions and workers' health outcomes

Different types of technology users work under different working conditions. Users of machinery, who account for almost a quarter of all workers in the EU, have less favourable working conditions than workers who use computers and those who do not use technology at the workplace. Machine workers are thus disadvantaged in terms of their health and well-being, since working conditions significantly influence the health risks to which workers are exposed.

Regardless of their characteristics, people working with machines run higher risks of developing musculoskeletal disorders (MSDs) and work-related stress symptoms, and therefore report relatively low job satisfaction. For a great proportion of these workers, this low satisfaction is attributable to relatively high work intensity, few learning opportunities in the job and higher ergonomic risks.

On the other hand, workers using computers enjoy better working conditions and show higher levels of job satisfaction. As a result, they have greater chances to be in better health than workers using machines. However, two work organisational characteristics – namely, working in autonomous teams and high task autonomy – appeared to ease the negative effects of machine use at work. In the presence of autonomous teams and high task autonomy, the negative impact of machine use on learning opportunities is lowered and so is the risk of developing stress symptoms.

Measurement issues

The results have to be considered making due allowance for a few restrictions. The first point of discussion concerns the measurements and operationalisations used in this research. The EWCS data form a rich source of information regarding the working conditions and health and well-being of employed persons in Europe. The EWCS mainly aims to provide comparable information on the conditions of work and employment of employed persons in different EU countries. Due to the broad design of the EWCS, it was impossible to measure all of the indicators in depth. Therefore, in some cases, proxy variables were used to put into operation the concepts used in the present study; for instance, this was the case when measuring the use of machines among European workers in employment. Machine use was measured on the basis of proxy variables related to vibration from hand tools and machinery, as well as the way work is paced through machine use. Although this operationalisation has proved to be successful in distinguishing between different work situations and to analyse the consequences of technological change in the past (Dhondt et al, 2002), it may have caused some unexpected results concerning some of the outcomes currently under study. This is the case in relation to the outcomes in terms of work intensity and ergonomic risks.

Research literature frequently suggests that the introduction of computers has led to an intensification of work. However, the descriptive results in this study reveal higher work intensity levels for workers using machines. In order to measure work intensity, it was defined as working to high speed and tight deadlines, and therefore – just like machine use – it includes some form of pacing. As a result, it is not surprising that this study's findings show relatively high associations between machine use and work intensity. The fact that no strong correlations have been found between computer use and work intensity can therefore be related to the way work intensity has been measured in this study. Other research findings suggest that computer use would lead to increased work intensity due to greater information flow, higher work pace and elevated psychological demands. All of these issues are not completely covered by the way work intensity is measured here.

The same reasoning applies to the strong relationship found between machine use and ergonomic risks in this study. Since exposure to 'vibrations' at work has been determined as an indicator of machine use in this research, as well as being considered an ergonomic risk, the strong association between machine use and ergonomic risks may be an overestimation. Nonetheless, it is not clear whether this way of operationalising working conditions' indicators also explains the absence of a significant relationship between computer use and ergonomic risks in this study. Several other studies have shown that computer use is associated with increased ergonomic risks such as increased static load, awkward work postures and short repetitive movements (Karwowski and Marras, 1999). In this analysis, ergonomic risks were operationalised using indicators on painful or tiring work postures, carrying or moving heavy loads and repetitive hand or arm movements. Computer use appeared to have a negative correlation with these indicators; in other words, this study reveals that using computers at work is associated with lower ergonomic risks.

Another point of discussion is the fact that low levels of explained variance generally exist in the outcomes of this study. On average, about 15% of variance in working conditions, stress, musculoskeletal symptoms and job satisfaction are explained by the factors that were included in the analytical models. While this is not deviating from other predictive studies in this field and in the social sciences in general – and therefore not alarming – it deserves some elaboration. Most research findings in social sciences have a multifactorial origin. If the prediction of working conditions and health and well-being risks is to be improved, it will be important to consider in the analysis factors that were not included in this study's models but may theoretically be important in predicting the outcomes. Regarding stress symptoms and musculoskeletal complaints, it is well known that personality factors and coping styles play a role (Bongers et al, 2006; Schaufeli and Bakker, 2007). These factors, however, were not included in the EWCS.

Possible risk factors of stress and musculoskeletal complaints are of a physical, psychosocial or personal origin. These factors can also reinforce each other. Moreover, their influence on individuals can be mediated by cultural or societal factors. According to a recent review by Bongers et al (2006) on the epidemiology of work-related neck and upper limb disorders, it is plausible that behavioural aspects, such as work style, are of importance in the aetiology of work-related upper limb symptoms. Work style may also play a role in the explanation of self-reported work intensity. The issue of using personality features as determinants of (ill) health may be part of a 'working capacity' module in order to better predict which issues could be improved regarding the individual worker.

Topics for future study

The operationalisation of technology use in the EWCS could be improved by including a direct measurement of machine use in the survey. In order to gain greater insight into the effects of technology use on workers' health and well-being but also on productivity, it seems worthwhile to include a number of measures in future surveys, namely the extent to which technology use is complex[5], how well workers master the technology that they use, as well as the control that they can exert over the technology used when disruptions occur. Furthermore, a measure of the extent to which workers (indirectly) have a say in the adoption of new technologies (if any) in the workplace is relevant, both at the employee and employer level.

Literature suggests that insufficient mastery of computer applications and insufficient worker participation in the introduction of new technical systems may lead to feelings of incompetence and subsequently to reduced well-being among workers (Zijlstra, 2007). As a result, it can be argued that insufficient mastery of technical systems will also lead to suboptimal performances and productivity losses. However, although evidence in this regard is lacking because mastery of technology is not yet measured in surveys, it seems worthwhile to explore this issue in future research.

Based on an extensive review of studies on high performance workplace organisations (HPWOs) (Waal, 2005), several technology characteristics were shown to distinguish HPWOs. In terms of technology characteristics, such organisations are, in order of importance, able to:

5 Examples in this respect are, for instance, provided by the British Skills Survey 2006 and the Canadian Workplace and Employee Survey (WES).

- implement flexible ICT systems throughout the organisation;
- apply user-friendly ICT tools to increase usage;
- become a pioneer at applying the chosen technologies;
- constantly identify and exploit new technologies to gain a competitive advantage.

Therefore, flexibility, user-friendliness, novelty and mode of exploitation of ICT and technology are also interesting fields to be covered in future waves of the EWCS and/or in an employer survey, such as a variant of Eurofound's European Establishment Survey. However, these aspects should preferably be covered in linked employer-employee surveys.

Finally, the current EWCS measures only key characteristics of machine use at work, such as machine-paced work. However, it would be interesting to also measure such characteristics for computer and software use in European workplaces. To date, these characteristics are measured as a 'black box' in the EWCS. Examples of key characteristics related to computer use at work, for which indicators could be developed, include measurements of the extent to which:

- workers have programming tasks to optimise the task-technology fit according to their preferences;
- deliverance and scheduling of work activities is done by a computer;
- the work is 'computer-paced'.

Issues for intervention and policy-making

According to the study's findings and scope, several issues emerged relevant to policy-making and achieving the Lisbon Strategy's goals. First, measures should be taken to explicitly promote good working conditions in less computerised regions. Overall, in Europe, a trend is observed towards greater use of computers and less use of machinery at work. However, in the eastern European countries, as well as in Bulgaria and Romania, an increase in machine use has been observed in recent years. Greater attention should be paid to working conditions and work organisation in general and of machine users in particular. As highlighted in this study, it is not so much the technology itself but rather the working conditions associated with these technologies that cause higher risks to health and well-being.

Moreover, work organisational characteristics such as working in autonomous teams and high task autonomy may play a buffering role in terms of workers' health and well-being risks. Policies fostering interventions in terms of work organisation could therefore be beneficial. Regarding interventions aiming to prevent stress and musculoskeletal complaints, research shows that interventions should best be targeted at both the worker – for example, increase knowledge, capabilities, physical state or adaptability – and the work organisation – for instance, increase job task autonomy and other job resources, and improve work processes (Bongers et al, 2006; Schaufeli and Bakker, 2007). Working in autonomous teams, which is considered one of the 'modern' work organisational practices, is positively related to learning opportunities in the job. As a result, the promotion of autonomous team practices may improve working conditions. In fact, the EU microeconomic and employment guidelines already call for the promotion of such work organisational interventions. This call is particularly explicit in Microeconomic Guideline No. 13 and Employment Guideline No. 20 (see pp. 6-7).

Autonomy is also considered an important ‘job resource’. The first chapters of this report have shown that negative effects of job demands on workers’ health and well-being can be compensated by activating such job resources. Theories and empirical evidence suggest that these resources should be matched to the existing job demands. In other words, if a job has high cognitive demands, cognitive resources should be present, such as high job task autonomy; if a job has high physical demands, physical resources should be present – for example, the possibility to call in a colleague to help perform the work or the availability of lifting devices for heavy work. The work should be organised in such a way that these resources are available to workers. As machine use is associated with relatively high work intensity, and therefore relatively high cognitive demands, cognitive resources like task autonomy should be promoted in this case.

Besides reflecting on how to adapt the surrounding work environment to the available technology, it is equally important to keep paying attention to how improvements can be made regarding the customisation of technological solutions to workers and work processes. In order to achieve optimal information technology (IT) solutions in different work organisational practices and for different people, customised or even ‘tailor-made’ solutions are necessary. Such solutions may involve complex implementation processes, requiring sound IT knowledge and financial means, such that financial restrictions force many organisations to implement IT blueprints instead of customised solutions. Policy-makers could play a role in this regard by helping companies to gain competitive advantage, for instance, through broadening the scope of financial options available to enterprises, such as long-term financial loans and instalment plans.

Relevance for Lisbon Strategy

The results of this study are of relevance when it comes to assessing the progress made towards achieving the goals of the revised Lisbon Strategy, more specifically those put forward in the Microeconomic Policy Guidelines Nos. 13, 20, 22 and 23, which focus on ICT uptake (Guideline No. 13), training and educational systems (Nos. 22 and 23) and the adaptability of workers and enterprises (No. 20) in the EU Member States. Overall, the study’s findings reveal a trend towards more computer use at work in Europe. However, this trend seems to be sector- and country-specific: the increase in computer uptake takes place in some countries and sectors, but not in others. An increase in machine use, considered as ‘old’ technology, has been observed in some sectors of the economy which already had a high share of workers using machines. The results of this research indicate that a machine–computer divide exists between the eastern and continental European countries in particular, and between the construction, agriculture and fishing, and manufacturing sectors on the one hand and other sectors on the other. The observed trends in technology use being different between countries and sectors plead for a country- and sector-specific approach in following the Microeconomic Policy Guidelines of the Lisbon Strategy. Some specific recommendations could be drawn from the current study.

First, as almost a quarter of the EU workforce may still be classified as ‘machine users’ and machine use is associated with significantly poorer working conditions than computer use, it remains a high priority for the EU to stimulate healthy working conditions. In particular, countries and sectors with a high and increasing proportion of machine users in their labour force will need continuous and specific support in promoting healthy working conditions. Part of the European workforce will continue to use machines at work, despite the promotion of ICT uptake and an upskilling of the workforce. In order to prevent a polarisation of the workforce in Europe, the health and well-being of workers using machines in the workplace calls for extra attention.

The outcomes of this study reveal that the EU Member States are at different stages of workplace computerisation. This finding implies that, although strategic priorities set out in the Lisbon Strategy are the same for all Member States, operational priorities with respect to health promotion of workers need to differ between countries. Such a diversified approach is in line with the Lisbon Strategy with its emphasis on subsidiarity, room for local diversity and the 'open method of coordination'. The strategy's approach takes into account national differences in, for example, industrial relations, workforce composition and labour markets, as well as education systems. These contextual conditions can result in different capacities for adapting to change, including technological change, and lead to preferences for particular solutions.

Furthermore, alongside the traditional emphasis on education in sciences and technology, the European knowledge policies have been established within a broader social framework. This framework recognises both the importance of developing skills at all company levels and the impact of knowledge development on social cohesion and fighting inequality – two key aspects of the European social model. This broader social perspective was also the starting point for the 2000 Lisbon Agenda, setting the goal for Europe 'to become the most competitive and dynamic knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion' (European Parliament, 2000). In this perspective, the study's findings in relation to skills are of relevance. As the use of advanced technology such as computers is associated with higher skills levels, technological change may actively favour high-skilled workers in the labour market and not favour lower skilled workers to the same extent. The need to address this is reflected in, for instance, Guidelines No. 13 on ICT uptake and No. 23 on the response to new occupational needs, key competencies and future skills requirements. This need can be achieved by improving the definition and transparency of qualifications, their effective recognition and the validation of non-formal and informal learning. Moreover, the uptake of new technology is also related to work organisation and thus a simultaneous promotion of flexible forms of work organisation is warranted.

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Nowadays, technology plays a central role in workplaces, enabling the speedy production of goods and services and facilitating communication and innovation processes. Its use is central to the policy aim for Europe to become 'the most competitive knowledge-based economy in the world' as set out in the Lisbon Strategy. With ongoing changes in the use of machines and computers, the nature of work is changing and so, too, are the demands and requirements placed on workers. This report examines the different categories of technology used in workplaces in order to gauge their influence on working conditions and health outcomes. The analysis is based on findings from the Fourth Working Conditions Survey carried out across 31 countries, including the 27 EU Member States. The findings reveal that it is not so much the technology itself but rather the associated working conditions that put workers' health and safety at risk.

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