DISRUPTING EFFECTS OF AUTOMATION: IN EUROPEAN COMPARIVE PERSPECTIVE[1]
(Which jobs are at risk of automation?)[2]

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Introduction

Examining the social consequences of innovation has surprisingly been neglected in labour science and employment policy until recently. Most exceptions can, however, be found in the literature on national innovation system initiated by the Scandinavian model. Apart from them, there are various theoretical and empirical analyses stressing the impact of technological advancement on destroying workplaces on the one extreme, and innovation mystified as a panacea for all problems, on the other. The more balanced evaluations somewhere between the two are relatively rare. The significance of the topic was further enhanced by two recent events. The ten-year strategy of the European Union accepted in 2010 placed smart, inclusive and sustainable growth in the centre of its development policy (European Commission, 2010). Of these objectives *smart* is the almost permanent characteristic of the most modern technological development, *inclusivity* obviously refers to widening social inequalities, while sustainability draws attention to considering the environmental and socio-economic impacts of human activity. In connection with this, the 2014 publication 'Employment and Social Development in Europe' by the European Commission explicitly stresses 'the significance of labour quality and labour organisation in the intelligent and inclusive growth while discussing the future of labour' (European Commission, 2015:137).

Another related factor that has drawn attention in the industrial, agricultural and service sectors relates to examining the social impacts of technological changes caused by automation, digitalisation and robotisation.

The 'Quality of Jobs and Innovation Generated Employment Outcomes' (QuInnE)[3] project supported by EU Horizon 2020 research programme analyses these correlations by using both qualitative and quantitative methods simultaneously. The objective of the research is the joint analysis and assessment of innovation with the qualitative and quantitative aspects of employment. A separate analysis was carried out on the 20-year development of the European and national innovation strategies on the basis of which we surprisingly concluded that the social aspects of innovation do not only appear in public policy with the exception of North Europe and some Continental, as well as Anglo-Saxon countries, which restricts the scope of these policies to a great extent (Makó – Illéssy – Warhurst, 2016).

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[1] In: Simai Mihály – Lukács Eszter (szerk.) ***Az ENSZ jövője a szétesőő világban,*** Budapest: Magyar ENSZ Társaság, 47 – 59. o.

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Our study presents the complex social impacts of technological innovations through the example of automation by using American, European and Hungarian quantitative analyses. Our paper is structured as follows. The first part shortly reviews the history of automation and the second part deals with the effects on automation on jobs and working task structures. The third part tackles the so-called '*skill-biased*' technological changes while concentrating on the European processes. The topic of the fourth part is the European comparison of work forms before and immediately after the 2008 credit crunch. Finally, in addition to the summary the most important research challenges of the future are forecast.

The history of automation

The pessimistic forecast of the negative impact of technological changes on employment, the so-called '*automation anxiety'* has significant traditions in social sciences.[4] John Maynard Keynes (1931) signalled technological unemployment as the new disease of economic development in the first third of the 20th century. Moreover, he also drew attention to the possibility that countries lagging behind in development may find themselves in a more disadvantaged situation in the long term while the hardships of adapting to technological changes are temporary. Leontief (1952) represents a more pessimistic view when he states that work will become less important in the future; machines can replace more and more workers although the new industries that would be able to employ the redundant labour force did not appear at that time.

While changes in the labour are always in flux, for nearly half a century forecasts on technological changes resulting in mass unemployment did not come true. The employment problems accompanying new techniques and technological unemployment were regarded as temporary, short term hardships of adaptation. In addition, failures also signalled the barriers hidden in the opportunities of automation. For instance, in the 1980's Volkswagen launched its project known as 'Halle 54' that was announced as the 'automated factory' of the future and within which Computer Integrated Manufacturing (CIM). However, the experiment failed as the number of car rejects increased enormously and repairing them made the factory uneconomical. By the end of the 1980's attempts to totally automating production were halted and solutions to entirely phase out the human factor failed. According to Hack and Pfeiffer (in Kopp et al., 2016) the unsuccessful VW attempt for radical automation was mentioned as the guinea pig of the narrow minded technological aspect of rationalisation and modernisation where every work organisation is interpreted as technological. In their opinion, this approach also reached its limits similarly to Taylorism in the past. The basic reason for both failures is that their rationalising strategy was based on the radical questioning of human centred work organisation (Hack, 1994; Pfeiffer, 2010; in: Kopp – Howaldt – Schultze, 2016). The big issue has remained unchanged since then: to what extent can human labour be cut out of the production processes or organising services?

With the advent of intelligent robots, driverless cars, 3D printing, etc., we again can witness the resurrection of views on technological replacement causing unemployment, or, more generally, automation anxiety (Brynjolfsson – McAfee, 2014; Ford, 2015). Nevertheless, in contrast with previous views experts of various forms of digitalisation stress

[4] However, it is important to point out now that although automation and digitalisation are used interchangeably, they slightly differ in content. In a stricter sense, *automation* is a phenomenon when manpower is replaced by machines for the same task. *Digitalisation,* on the other hand, means the process when sensors and other digital instruments are used to transform certain processes of production or logistics into digitally conveyable and processable forms. What they have in common is the use the efficiencies of digital technologies; so consequently, their impact on work and employment is similar in many cases.

that nowadays and particularly in the future, robots will be partners and not enemies of man. Estimates vary on the impact of technological changes on employment. Andrea Szalavetz (2018) likens these competing prophecies that envisage a proximate employment disaster to a 'numbers war'. For instance, according to Frey and Osborne (2015) in the USA almost half of the employees (47%) will be replaced by computers and algorithms in the forthcoming one or two decades. Bowles (2014) states that 45-60% of the jobs in Europe will be automated. Experts say that within Europe more than every second (59%) job of the German economy is threatened by the risk of automation (Brzeski – Burk, 2015).

The most recent analyses draw attention to the more differentiated consequences of the impacts of automation and robotisation on employment and also reject the scenarios that represent and simplify radical changes. For example, one of the most recent researches of the internationally renowned consultancy firm, McKinsey & Company, which analysed more than two thousand activities of nearly 800 jobs in the USA, found that in the following decade automation will result in the total disappearance of very few jobs. Instead, a thorough transformation is underway affecting all jobs to a greater or smaller extent regardless the tasks at work (Chui – Manyika – Miremadi, 2016). The most recent analysis on OECD 21 (Arntz – Gregory – Zierhan, 2016) drew very similar conclusions to the previous research, in contrast to Frey and Osborne (*2015*)'s estimation (47%) only one-tenth (9%) of the jobs in America are likely to be made extinct by the digital revolution.

A more differentiated approach to the impacts of automation: substitution or supplement?

Throughout the sciences, different methodologies for analysis often lead to varied, sometimes conflicting results. The field of labour sciences is no different, but domineering concepts can be distinguished. The first is to survey the presence of information-communication technologies (ICT) in certain industries or jobs and based on these data estimates are forecast for the further development of these technologies and their future impact on employment. A more differentiated approach surveys exposure to automation/digitalisation on the level of typical tasks at work, from which aggregated estimates can be made. Our paper deals with the latter one in detail.

One of the most significant analyses on this topic was carried out by David H. Autor (2014), an economist of Massachusetts Institute of Technology (MIT) who interpreted the possible impacts of automation on the level of tasks at work. Michael Polanyi's work was used as a theoretical framework. The internationally renowned scientist of Hungarian origin in researching the structure of personal knowledge came to the conclusion that we know more than we can tell in words while examining the role of tacit knowledge (Polanyi, 1966). Polanyi made a difference between two main groups of human knowledge: *explicit* knowledge that can easily be codified and transferred formally and *tacit* (personal) knowledge that are hard or impossible to codify. Autor (2014) divided jobs into three large groups while examining the proportion of explicit and tacit knowledge elements necessary to perform duties: *abstract-intensive*, *routine-intensive and manual-intensive* physical jobs. According to his argument, these three groups are exposed to the danger of automation to different extents. 'Given their ubiquity, it is tempting to infer that there is no task to which computers are not suited. But that leap of logic is unfounded. Human tasks that have proved most amenable to computerization are those that follow explicit, codification procedures – such as multiplication – where computers now vastly exceed human labour in speed, quality, accuracy, and cost efficiency. Tasks that have proved most vexing to automate are those that demand flexibility, judgment, and common sense – skills that we understand only tacitly – for

example, developing a hypothesis or organizing a closet. In these tasks, computers are often less sophisticated than preschool age children' (Autor, 2014: 129).

After distinguishing three groups Autor started to examine American employment statistics and tried to fit the ten non-agricultural main groups into his typology of three. The *first category* includes managerial positions, and jobs that require higher education qualification or secondary school certificate that offer higher salary in general and call for a high level of vocational education. Autor classifies employees in sales, office work and administration, production, assembling, repairing and other jobs that require manual skills in the *second category*. They are typically white collar jobs with secondary education where the proportion of women is high and also some blue collar jobs filled in by men with typically secondary or lower education The *third group* of jobs include security, the professions of personal assistance, cleaning, hospitality etc. These are jobs that offer lower salary and/or require lower education level. According to Autor digitalisation primarily threatens jobs in the second category as they are the tasks that can be routinized the most.

Afterwards, Autor analysed the employment trends of the United States from 1979 in three employment groups. Data justify his hypothesis according to which the proportion of those employed in the second category has been decreasing historically. While these employment statistics are nearly four decades old, they show typical hollowing out in the second group, i.e. the white collar positions with secondary education and blue collar jobs with secondary or lower education level. A similar trend can be traced down from the European employment data as well. According to Autor, this decrease can partly by explained by increasing automation and digitalisation.

However, the impact of automation is not merely destruction, i.e. phasing out jobs; rather, it prevails in a more complex way. 'The fact that a task cannot be computerized does not imply that computerization has no effect on that task. On the contrary: tasks that cannot be substituted by computerization are generally complemented by it. This point is as fundamental as it is overlooked' (Autor, 2014: 136). In these case digitalization does not have a direct impact on employment but obviously it influences job quality. As can be seen, the impact of automation prevails via a more complex mechanism that cannot be simplified merely as anxiety and fear of technological unemployment that returns from time to time. Autor's analysis shows that within four decades we would see substantial employment polarisation, i.e. the growing number of those in high education with high wage jobs, and low education with low wage jobs, and a hollowing out in the middle where a significant reduction can statistically be noticed.

The European scenario: do technological changes result in polarisation or the general increase of education level?

However, not everyone agrees with the polarisation argument. Fernández-Macías, Hurley and Bisello (2016) in their study published with the support of the European Foundation for the Improvement of Living and Working Conditions (Eurofound) have examined the possible impact of automation on the European employment structure. By analysing the literature on employment shifts generated by technological development they concluded that there are two wider-scale approaches within it: skill-biased vs. routine-biased technological change. The former one appreciates education and contributes the employment tendencies of the past decades to skill upgrading while the latter one (including Autor's analysis) envisages the decreasing significance of routine tasks and analyses the same data within the theoretical framework of employment polarisation and looks for proofs of justification. 'With upgrading employment shifts, the expected pattern is a more or less linear improvement in employment

structure, with the greatest employment growth in high-paid (or high-skilled) jobs, the weakest growth in low-paid (or low-skilled) jobs, and middling growth in the middle. With polarisation, the main difference is that the relative positions, in terms of employment dynamics of the middle and bottom levels of the job distribution, are swapped: employment growth is weakest in the middle and relatively stronger at both ends of the job–wage distribution, leading to a "hollowed middle" (Fernández-Macías – Hurley – Bisello, 2016: 11).

This polarisation effect has prevailed in the European, small and medium sized enterprises (SME) sector: 'The crisis period of 2008–2010 was characterised by significant job loss in Europe (…). The overall trend towards job polarisation could also be observed for SMEs, with a lower level of job loss among the lowest-paid and highest-paid jobs compared with the medium wage categories' (Mandle et al., 2016: 19). A similar trend is noted in the most recent IMF review, which concludes that it is the service sector (financial services, public administration, healthcare, education) that is worst affected by polarisation. There are signs that more detailed data will need to confirm that polarisation is the most powerful in the sectors most exposed to technological changes (International Monetary Fund, 2017).

In order to obtain a more accurate picture about the European employment shifts after the financial and economic crisis (2008) than the too general analyses available, Fernández-Macías, Hurley and Bisello (2016) combined the approach of employment groups with industrial analyses so their basic unit of observation were jobs within specific industries. They were then classified into quintiles on the basis of average salaries so that the employment level could be examined before, during and after the crisis. Due to the constraints of the study neither methodology nor the results after the analysis can be presented in details so only the three most important statements for us are briefed.

- First, according to the authors the European employment trends have always been characterised by the simultaneous presence of skill upgrading and polarisation, although their extent has been changing dynamically throughout the years. Before the crisis, upgrading skills dominated while polarisation also took place although with a residual value. As an aftermath of the global economic crisis, polarisation obviously increased while employment was also rising in the jobs of the upper quintile so upgrading also prevailed. The most recent phenomenon (from the second quarter of 2013 to the second quarter of 2015) was a well-balanced employment increase with a minimum shift to higher skilled jobs. For the time being, there is no sign of lowering skill demand on an aggregate European level but it also holds true, however, that the increase of the level demanded is much less obvious than in the years before the crisis (Fernández-Macías – Hurley – Bisello, 2016).
- Second, though the most recent trends of employment shift are less compatible with skills upgrade than before the crisis, skill downgrade was obvious only in two countries. 'Over the four-year period 2011–2015, Hungary and Italy both experienced an obvious downgrading pattern of employment shift. In each of these countries, employment growth was strongest in the lowest-paid jobs and weaker in higher-paid jobs (…). At aggregate EU level over 2011–2015, there was upgrading with some polarisation – relatively faster growth in the bottom than in the middle. However, this involved a more even spread of job gains across the wage distribution, as employment growth accelerated from mid-2013 onwards' (Fernández-Macías – Hurley – Bisello, 2016: 13).
- Third, while the greatest growth was produced by the service sector, employment was also increasing in some areas of the processing industry, such as in food processing or in car manufacturing, which is of special importance in Hungary. Moreover, in these sub-industries the biggest growth was observed in the highest paid jobs.

Automation and creativity

The labour science community still lacks consensus on whether the overall impacts of automation are positive or it supports the more problematic polarisation argument that generates social conflicts. We have reason to suppose that whether a county gains or loses depends on its institutional context. If automation supplements or makes human labour easier by letting them concentrate on the most important tasks, it also means a greater role of creativity, particularly in countries where the altered technological conditions were properly anticipated by, for example, restructuring education and trainings, drafting new innovation political objectives, developing labour relations or renewing public administration/the public sector. The opposite case may also hold true. Where challenges of disruptive technological breakthroughs have resulted in radical changes compared to the previous technological paradigm and changes have been inadequately managed or with some delay such as automation, it is likely negative impacts will substantially outweigh the positive ones.

In the global labour marketplace, however, counties do not have equal chances or a level playing field, so we can presume that in countries that are well positioned in the global economy centre conditions have greater ability for transforming the political, social and economic systems, while those on the periphery will suffer. We also have to note that identifying and implementing responses to the challenges of digitalisation also mean a special and historic challenge for the economically developed, capitalist countries in the centre. In this process, dialogue with the social and economic stakeholders is of vital importance. For instance, the most recent British governmental reviews stress the importance of further trainings that impact one million employees in maintaining long-term economic competitiveness (Made Smarter, 2017). The British analysis also draws attention to the fact that 'the pace of change unleashed by digitalisation means that around two-thirds of children in primary school today will work in jobs which do not even exist yet' (Made Smarter, 2017: 75).

In another study of ours to be published soon the experienced trends on the labour market are analysed (Makó – Illéssy – Borbély, 2018). To this end, data of several European Working Conditions Surveys (EWCS) were analysed. The survey is based on interviews of almost forty thousand European employees that is carried out every five years (Eurofound, 2015). Part of the survey instrument focuses on identifying cognitive parts of working conditions as well as the autonomy level of employees. These two dimensions are especially important to identify the level of exposedness to automation as on the basis of Autor (2014), who suggested that till machines do not learn to study, only activities whose rules can relatively easily be programmed can be automated such as the ones based on transparent, explicit routines and do not require human interactions in ad hoc situations.

The novel feature of our present study in comparison with the above mentioned one is that since then the results of the 2015 survey were also analysed and compared with the 2005 data. Among the respondents, those who are not employees (such as the unemployed or housewives) are disregarded, together with those employed by an organisation with fewer than 10 employees. Employees of some of the sectors of agriculture, fishery and the public sector (education, healthcare) are not included, either. To be simple and brief, the data of Malta and Cyprus are not listed separately in the tables but as part of the European average. On the basis of Lorenz and Lundvall *(2010),* the following six variables have been used to identify the cognitive dimensions of work tasks and the level of employee autonomy: i) the importance of problem solving ability at work, ii) the opportunity for studying new things, iii) the complexity of work tasks, iv) the possibility of using ideas at work, v) the level of

autonomy in selecting working methods, and vi) the order of work tasks (the detailed methodology is included in the original article, Makó – Illéssy – Borbély, 2018).

As the result of the cluster analysis three larger groups of employees could be distinguished. The *creative* workers consist of employees who have to make use of their cognitive abilities at work to a large extent and they enjoy a large degree of autonomy. The jobs organised on the principles of Taylor represented the other end of the scale where utilising cognitive abilities and autonomy were the least typical. Between these two groups *constrained problem solvers* can be found whose work is characterised by relatively high cognitive expectancies and an extremely low level of autonomy. We assume on the basis of the above that the Taylorean employees are the most affected by automation while the job of creative workers and to a slighter extent, constrained problem solvers is less dramatically affected by the processes of automation.

When analysing the changes in the EU-27 average it can be seen that within the examined ten years hardly any changes may be experienced in the single jobs. Almost one quarter of the European employees have jobs defined as the jobs of constrained problem solvers[5] and half of them have creative jobs. As can be seen from ***Table 1*** the stable European average covers significant differences and dynamics between the country groups. Not surprisingly, most creative jobs can proportionally be found in the *Scandinavian* countries. Almost three quarters of the jobs significantly rely on the cognitive abilities of the employees and ensures high level of autonomy. Their proportion was also increasing in Denmark and Finland of the three countries during the examined ten years, while in Sweden the proportion was decreasing but originally it was the highest there. In parallel, the proportion of the Taylorean jobs is the lowest in Europe and it was significantly decreasing or levelled off in Sweden between 2005 and 2015.

Table 1.
Types of workplaces: country group comparison – EU-15 (EWCS 2005, 2015)

	2005			2015		
	CW	CPS	TW	CW	CPS	TW
Nordic countries						
Denmark	74	13	13	77	14	9
Finland	67	20	13	73	18	9
Sweden	80	10	10	74	15	11
Continental countries						
Austria	51	29	20	57	25	19
Belgium	56	20	23	59	19	21

[5] Although it is not noted separately but it is important to stress that it is not the employees but the jobs that are characterised as creative or Taylorean. An under-skilled employee can also have a creative job like, unfortunately, a lot of highly qualified professionals have less creative jobs. Our analysis is trying to highlight that examining how innovative work organisations are, to what extent they utilise their employees' knowledge and how they motivate them to improve and share their knowledge are as important issues as the education level of the employees.

France	59	19	21	62	24	14
Netherlands	72	16	13	63	16	21
Luxemburg	63	18	19	65	24	11
Germany	51	25	24	49	23	29
Mediterranean countries						
Greece	40	32	28	28	32	40
Italy	40	28	33	45	16	38
Portugal	42	24	34	41	28	31
Spain	37	28	35	47	28	25
Anglo-Saxon countries						
Ireland	58	19	22	55	21	24
United Kingdom	50	20	30	59	21	20
EU-27	50	24	26	52	24	24

Source: Own calculation. Legend: CW = Creative workers; CPS = Constrained problem-solvers; TW= Taylorized workers.

The *Continental* country group shows a much more heterogeneous picture. A bit surprisingly, Germany stands out of this cluster with its downward position as the number of creative jobs does not reach 50% while the share of the Taylorean ones is nearly 30%. The proportion of the latter one is the lowest in Luxembourg, almost at the level of the Scandinavian countries that can be explained by its developed financial sector. A great difference in comparison with the Nordic countries is that the proportion of the constrained problem solvers here is much larger. Approximately the extent to which more people work in jobs with restricted autonomy is the same as fewer people who work in creative jobs and the same holds true for France. In the case of the Netherlands similarly to Germany this difference obviously results in the higher proportion of the Taylorean jobs. This is noteworthy as in 2005 the Netherlands was still closer to the Scandinavian county group than the Continental. However, the years of the crisis have brought a radical change but, unfortunately, in the negative direction.[6] In contrast, the proportion of creative jobs in Austria has significantly increased.

The period of the crisis also launched convergent processes in the *Anglo-Saxon countries* within the cluster. In 2005 58% of the jobs in Ireland were creative which decreased to 55% by 2015. In contrast, during the same period in the United Kingdom this ratio increased from 50% to 59%. Interestingly, this significant growth exclusively impaired the Taylorean jobs while the proportion of the constrained problem solvers did not change. Numerically, it means that in the United Kingdom the number of the least creative jobs decreased from 30% to 20% within 10 years.

[6] To decide what role the crisis, the technical changes' gaining ground or a third factor played in these changes are beyond the limitations of the study. Our paper makes a reference to the crisis as it is obvious that such shocks do have an impact on jobs, especially the creative dimension of work tasks and the extent of employees' autonomy.

Not surprisingly, the proportion of creative jobs is the lowest in the *Mediterranean* countries. It is more interesting; however, that most of these countries could catch up with the EU-27 average during the crisis. Spain takes the lead where the proportion of creative work increased from 37% to 47%, but in Italy their share also grew from 40% to 45%. In Portugal their proportion did not change. Only in Greece was it dramatically reduced from 40% to 28%.[7] In parallel, the proportion of the Taylorean jobs was strikingly high, not only in comparison with the old member states but also most post-socialist countries The two ends are represented by Spain and Greece, respectively. The proportion of the least creative jobs decreased by 10 percent in the former one and increased by 12 percent in the latter one. Another interesting fact is that in Italy not only did the proportion of the most innovative jobs increase but the least innovative ones did as well at the same time period between 2005 and 2015.

The group of the *Post-Socialist* countries also shows a very interesting and varied picture (***Table 2***). Estonia stands out of the *North Eastern European* counties, i.e. the Baltic countries as the high ratio of creative jobs and the general distribution of job types are similar to the more developed countries of the Continental cluster. Lithuania is in the middle as less than half of the jobs are creative and the rest is evenly distributed among the other two types of jobs. The case of Latvia is really surprising since in this aspect it is one of the least developed countries of the EU, although it was one of the leaders of the region in 2005. While 2010 data are not included in the table, it is worth remarking that the country strengthened its position at that time and the drastic decrease occurred in the last 5 years.

Table 2.
Types of Workplaces: country group comparison – post-socialist countries (EWCS 2005, 2015)

	2005			2015		
	CW	CPS	TW	CW	CPS	TW

[7] The latter one also signals that in addition to the technological changes the crisis also played a great role in forming clusters at work.

North Eastern Europe						
Estonia	57	25	19	62	21	18
Latvia	52	19	29	35	17	48
Lithuania	39	30	31	45	28	27
East Central Europe						
Czech Republic	43	30	27	38	32	30
Poland	46	32	22	41	30	29
Hungary	44	29	27	37	30	33
Slovakia	37	32	31	35	35	31
Slovenia	52	24	24	55	26	19
South Eastern Europe						
Bulgaria	40	30	29	38	34	28
Romania	37	39	24	35	37	28
EU-27	50	24	26	52	24	24

Source: Own calculation. Legend: CW = Creative workers; CPS = Constrained problem-solvers; TW = Taylorized workers.

The Visegrad countries and Slovenia were termed as the *Central European* countries although the latter one significantly differs from the others regarding innovative jobs. The 55% of creative jobs is similar to the Anglo-Saxon countries and makes Slovenia outstanding of this country group similarly to Estonia. What is striking in connection with the countries of the region is that in all the four member countries the ratio of creative jobs decreased. Unfortunately, this decrease was the strongest in Hungary from 44% to 37%. Another cause for concern is that Hungary is the only one of the five countries where the proportion of the least innovative, Taylorean jobs exceeds those of the constrained problem solvers, whose autonomy is minimal but where the knowledge of the employees is crucial. The ratio of these jobs was increased by 6 percent within ten years. The situation in Poland is similar. The creative jobs' losing ground is due to the increase in the Taylorean jobs. The weaker position of the Visegrad countries resulted in the fact that two *South-Eastern* European member states, i.e. Romania and Bulgaria, could further erode innovative jobs. All this was achieved, while the ratio of creative jobs overall did not increase, with the decrease being to a much smaller extent such as, e.g. in Hungary.

Summary and challenges for future research

The further gaining ground of info-communication technologies in production and services has drawn attention to examining the social impacts of technological changes again. During the commencing years of 'automation anxiety' generated by automation, digitalisation and robotisation, menacing forecasts have projected the disappearance of complete jobs. The

second generation of reviews have concluded more differentiated findings. In parallel, researchers have started to concentrate on the content of work tasks instead of job groups and make estimations of how many employees are endangered by automation. This has also involved the survey of jobs where automation does not substitute but rather complements human work by making a more differentiated analysis possible.

From this aspect the work of David H. Autor (2014) is of special importance. Autor has worked out a useful theoretical framework on the basis of Michael Polanyi's paradox, analysing job groups to assess the impact of automation on the content of *work tasks*. As he argues, the jobs that will defy automation are the ones that mainly require tacit knowledge. Two main groups of jobs belong here: work tasks that call for manual skills and high level of abstraction. Routinised jobs represent the other side that, either intellectual or physical ones, can easily be replaced by computers or robots.

Relying on the results of the European working condition survey, we wanted to analyse to what extent countries of the European Union are exposed to automation, and whether the danger of phasing out a great number of jobs as a result of technological changes could occur. Two dimensions of the content of the work tasks in the database were analysed on cognitive or learning potential and employees' autonomy. On the basis of this three job clusters could be differentiated: creative jobs with a high level of studying ability and autonomy, Taylorean jobs that require a low level studying ability and autonomy and constrained problems solvers' jobs that call for a high level of learning potential and an extremely low autonomy level. The results of 2005 and 2015 database were analysed with the following most important findings:

1) Although the job cluster patterns of the EU-27 average have hardly been changed in the examined ten-year period, significant differences exist between countries and important shifts may be monitored.
2) Of the European countries, the proportion of the creative jobs is the highest and the ratio of the Taylorean jobs is the lowest in the Scandinavian countries followed by the members of the Continental and Anglo-Saxon country groups. The Mediterranean and the East Central European post-socialist countries are the tail-enders, the former ones in a bit more favourable position.
3) From 2005 to 2015 a strong convergence could be detected within the Scandinavian, Continental and Anglo-Saxon country groups, while differences between the groups remained or even slightly increased. In contrast, a significant divergence could be noted within the Mediterranean and the Post-Socialist country groups.
4) Estonia and Slovenia stand out of the countries where the ratio of creative jobs reaches the values of the Continental and Anglo-Saxon country groups. In contrast, the share of creative jobs significantly decreased in the Visegrad countries and occasionally approaches the level of Romania and Bulgaria that are considered as traditional tail-enders.

Strong negative tendencies prevail in Hungary. While 2010 data are not included in our tables it can clearly be seen from the results that the situation turned unfavourable then. In 2010 the ratio of creative jobs was 48%, the Taylorean 23% respectively, and within five years the proportion of the former ones dropped to 37% while that of the latter ones increased to 33%. All these processes are a cause for concern as technological development may result in the automation exposedness of the Taylorean jobs. Hungary has based its economic competitiveness on cheap but skilled labour force and its geographical proximity to the centre of Europe. This strategy was successful until the beginning of the 2000's, but by the first half of the first decade of the new millennium the sources of further growth have been exhausted. With the exception of some significant examples, the Hungarian enterprises have been unable to attract activities of higher value added. There are signs that the segmented nature of the

Hungarian economy has increased in the past decades as internationally renowned companies producing and providing services for international markets, exist and operate side by side with small and medium sized enterprises living from the Hungarian market and the growing players of the state owned or partly state-owned sectors (Makó – Illéssy, 2016). The weak correlation between these three segments means a barrier to exploiting the economic opportunities of the country. Automation as a new source of danger must be taken into consideration when drafting the competitiveness strategy. For example, in the United Kingdom one of the explicit objectives of the strategy worked out to improve Industry 4.0 is to rebuild the industrial basis of the economy and relocate processing industry activities to the island from the low labour cost countries (Made Smarter, 2017: 8).

If these scenarios come true, such changes may help in organising global value chains that can shake Hungary's position in this field. Although the cheaper and more precise labour force of the Far East posed less serious threats to Hungarian jobs than expected, the German robots mean a much more realistic danger, with predominantly routine tasks in the production and service systems of global value chain becoming automated, leading to the loss of low-skilled jobs.

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