

**ECONOMY, EMPLOYMENT
AND SKILLS:
EUROPEAN, REGIONAL
AND GLOBAL PERSPECTIVES
IN AN AGE OF UNCERTAINTY**

Edited by
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First Italian edition: Rome (Italy), September 2018
Printed in Italy

How to order publications of Fondazione Giacomo Brodolini

To order publications, please contact the publisher at the following email address: info@fondazionebrodolini.it.

ISBN 9788895380452

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Quaderni della Fondazione Giacomo Brodolini

“Studi e ricerche” series

Editor Anna Maria Simonazzi

The *Quaderni della Fondazione Giacomo Brodolini* present results of research activities carried out by Fondazione in the fields that, over time, have become the core of its cultural initiatives: employment, local development, evaluation of public policies, social policies, equal opportunities, history.

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Foreword

Diego Teloni

Director, Fondazione Giacomo Brodolini

Human capital and education are at the centre of a knowledge economy. More than ever, our level of education and skills will determine future social cohesion, prosperity and sustainability.

Skills affect people's lives and economic and social development in many ways. Skills improve labour market outcomes both in terms of employment rates and earnings. But the positive role of skills extends beyond its impact on career prospects: adults with low levels of foundation skills have a higher likelihood of reporting poor health and participate much less in community groups and organisations; and adults with high levels of foundation skills are much more likely to feel that they have a voice that can make a difference in social and political life. These results are consistent across a wide range of countries, confirming that skills have a profound relationship with economic and social outcomes across a wide range of contexts and institutions. Skills are also key to tackling inequality and promoting social mobility. Investing in human capital is the single most effective way of not just promoting growth but also of distributing its benefits more fairly.

Investing in skills is far less costly, in the long run, than paying the price of poorer health, lower incomes, unemployment and social exclusion – all of which are closely tied to lower skills.

Governments face a number of challenges to make the most of available skills. Getting the best returns on investment in skills requires the ability to assess the quality and quantity of the skills available in the population, determine and anticipate the skills required in the labour market, and develop and use those skills effectively in better jobs that lead to better lives. These represent major challenges where data on the available skills is of poor quality and the demand for skills, present and future, is often a black box.

In addition, skills policy requires coherence and co-operation across all areas and levels of government, as well as with the private sector, social partners, teachers

and parents. Skills development is more effective if the world of learning and the world of work are linked. Compared to purely government-designed curricula taught exclusively in schools, learning in the workplace offers several advantages: it allows young people to develop “hard” skills on modern equipment in a workplace, and “soft” skills, such as teamwork, communication and negotiation, through real-world experience. Hands-on workplace training can also help to motivate disengaged youth to stay in or re-engage with the education system and to smooth the transition from education into the labour market. Workplace training also facilitates recruitment by allowing employers and potential employees to get to know each other, while trainees contribute to the output of the training firm and earn some income. Employers have an important role in training their own staff; but some, particularly small and medium-sized enterprises, might need public assistance to provide such training. Achieving this co-operation and ensuring it is fruitful is a major challenge in both developed and developing nations. Key issues concern the development and management of a coherent skills strategy, the involvement of the private sector and social partners in the setting of curricula that are more relevant to labour demand, the splitting of financing responsibilities between government, students and their families and the private sector.

Maintaining skills throughout each individual’s lifecycle is another key challenge as it requires setting up high-quality, easily accessible opportunities for adult learning – both up-skilling and re-training. The traditional employer-employee relationship is being replaced by the emergence of a diverse work-force *ecosystem* – a varied portfolio of workers, talent networks, gig workers, and service providers that offers employers flexibility, capabilities, and the potential for exploring different economic models in sourcing talent.

While it may be appealing to hire contractors quickly or to outsource technical or service work, taking advantage of the emerging workforce ecosystem’s benefits brings a variety of new challenges. The challenge is not just the tactical one of finding enough of the right people to execute particular tasks at particular times. To drive real value through the new workforce ecosystem, organisations need to understand how to appeal to and engage with workers of all kinds.

AI, robotics, and automation have gained a rapidly expanding foothold in the workplace, faster than many organisations ever expected. While organisations are increasingly using these technologies to automate existing processes, true pioneers are radically rethinking work architecture to maximize the value of both humans and machines – creating new opportunities to organise work more effectively and to redefine the human workforce’s skills and careers. Leading com-

panies increasingly recognise that technologies are most effective when they *complement* humans, not replace them. There is also growing recognition that AI tools require human oversight. Behind the scenes, major tech firms have tens of thousands of humans continuously watching, training, and improving their algorithms.

What's more, in many cases, the newly created jobs are more service-oriented, interpretive, and social playing to the essential human skills of creativity, empathy, communication, and complex problem-solving.

Rather than replacing humans outright, the introduction of new machines *changes* the skills and requirements the workforce needs to be able to take advantage of the new technologies. The greatest opportunity this may present is not just to redesign jobs, but to fundamentally rethink "work architecture".

If Europe's workforce of tomorrow is to take advantage of new technologies, then we need to have an understanding now of what skills it will need. This book – with chapters written by experts from across Europe and beyond – not only provides key insights into the way in which technological change is affecting the demand for skills but draws attention to how the supply-side can effectively respond. In particular it draws attention to the way in which young people can be effectively prepared for a working life which is likely to be longer than that experienced by those from their parents' generation. And, at the same time, there is a need to make sure that older people remain economically active, should that be their wish, and have access to the opportunities for upskilling that ensure that their skills are up to date. Developing policies to respond to the technological change will require initiatives not just at the national level, but at the regional, local, and urban level too. Over recent years, it is readily apparent that there has been much policy innovation at the urban level.

We – at FGB – are devoted to improving and supporting any policy that recognises the pivotal role of human capital; be this working at the urban level in creating and animating Innovation Hubs dedicated to new skills, or by contributing to the analyses and evaluation of how technological change impacts upon on skills and labour.

Introduction

Terence Hogarth

Automation in its various forms has been around for centuries, and so too have been concerns that its introduction is harbinger of job loss, skill loss, and an overall decline in the quality of employment. For the most part its introduction seems to have been benign. It has increased the efficiency with which goods and services are produced and, in doing so, has contributed to economic and employment growth. At the same time, many repetitive, sometimes dangerous tasks are now undertaken by machines rather than people. If the overall impact of automation and technological change on the world of work has been broadly positive up to now, a certain feeling abounds that things may be about to change. The combination of robotics, artificial intelligence and Internet, which has ushered in the fourth industrial revolution over the early part of the 21st century, is seen to be something which is different from the previous industrial revolutions. It is different in the sense that the technologies which comprise the fourth industrial revolution might have the potential to replace jobs but not necessarily lead to the creation of new ones. And the jobs that may well be lost are not just those of the 21st century's horny handed sons and daughters of toil, but a swathe of jobs held by highly educated and qualified members of the middle classes. There is a large measure of hyperbole here of course; a straw-man who can be readily toppled when one looks more closely at the evidence.

Evidence is needed about the likely impact of robotics and artificial intelligence on employment and the skills people will need if the potential these technologies hold for economy and society is to be realised. This is the purpose behind the collection of essays contained in this book. It provides evidence of the way in which the technologies, which brought about the fourth industrial revolution – Industry 4.0 if you will – are affecting the demand for employment and skills and how the supply-side is responding. This viewed not only from the perspective of employment skills policy, but also from one which looks at the employment and skill implications resulting from people spending longer in the labour market, and how to provide information to individuals so that they can renew their skills at key junctures and so avoid skills obsolescence. Increasingly

local and regional policies are playing an important role in this arena. Finally, and importantly, the book is about social inclusion and the quality of working life.

By way of introduction, the book starts with an assessment of automation's likely future impact on employment and the occupational distribution of employment. Suta and her colleagues reveal the extent to which automation will affect employment in the period up to 2030. While automation has the capacity to substitute for those jobs in the middle reaches of the occupational hierarchy, it is those jobs which require their incumbents to be highly qualified that will fare best of all in the brave new world that lies ahead. This of course begs questions about the specific skills in which individuals and employers should invest. It is all very well and good to know that the demand for the highly skilled will be relatively strong in the future, but what are the specific skills which employers will be increasingly looking for? For policy makers with a responsibility for employment and skills policy, typically faced with rising levels of skills mismatch, this is typically the sixty four thousand dollar question. The book provides a number of interesting observations in this regard. Pouliakas' fascinating analyses of data from Cedefop's European Skills and Jobs Survey reveals the actual skill needs associated with technological change. While surveys provide an accurate and precise estimate of the scale and characteristics of skills demand – the importance of which should not be underestimated – the fieldwork and subsequent analysis take time to conduct and it is not always possible to conduct the surveys as regularly one would like. Big data analysis complements survey based research in this respect. The chapters by Gaultiero et al. and Fareri, et al. respectively, demonstrate the way in which algorithms can be constructed to collect information about the technologies which comprise Industry 4.0 and the skills associated with them. Drawing on various big data sources, these chapters reveal the way in which jobs roles are changing based on real-time data analysis that is not necessarily bound by the statistical classifications of jobs and industries that do not always lend themselves to the codification of new, emerging jobs. The pace of technological change is, in some respects, so rapid that classifications of job and skills cannot keep pace. The big data analysis provided by Fantoni et al. begins to solve this particular problem.

As well as understanding the impact of new technologies on the demand for employment and skills there is a need to consider how the supply-side is responding. Gambin and Hogarth's chapter looks at how the apprenticeship system in England has sought to satisfy the demand for the STEM (science, technology, engineering and mathematics) skills required to design, manufacture, and operate a wide range of the new technologies encompassed within the Industry 4.0 paradigm. The chapter reveals how the funding system makes em-

ployers risk-averse when it comes to investing in apprenticeships resulting, potentially, in a socially sub-optimal supply of apprentices. Picking upon this theme, Muehleemann's chapter looks at the operation of the apprenticeship market in German speaking countries and how the systems in these countries are configured with respect to bringing about high quality training and skill outcomes. Novella and Rosas-Shady provide evidence of the way in which human capital investments in Latin American countries, which face a different, more complex set of problems than those typically found in Europe, have the potential to address the issue of inequality; especially so, if the signals relating to the skills demands likely to emerge from technological change are acted upon.

Apprenticeships in most countries are a form of post-compulsory education. If the goal is to persuade more young people to enter, say, a STEM apprenticeship – or other post-secondary programmes that will result in their skills being matched to those required by Industry 4.0 – then their appetite to undertake such a programme of learning will need to have been whetted at some point. Menogli and Russo's chapter looks at an innovative approach to engaging young people's interest in technology through the provision of robotics workshops run jointly with industry. The workshops are seen to have a significant impact in piquing young people's interest in technology. Information advice and guidance is of critical importance here. While young people need to have their appetite for technology whetted, they also need to have access to the information that will guide them to taking courses and acquiring the skills that will grant them a return in the labour market. Barnes's chapter outlines the contours of effective career guidance and its role in preventing skill mismatches arising.

The focus on apprenticeships is mainly, though not exclusively, focused on younger people. Given changes in society, not least longer life expectancy and the consequent financial pressures faced by many pension systems, older people are increasingly expected to remain for longer in the labour market. Added to which, ageing population structures in some countries results in a need to delay the exit of older people from the labour market to offset labour shortages. Duell's chapter looks at the wide variety of measures which have been used to make sure older people have access to training to avoid skills obsolescence. The importance of this cannot be stressed enough where jobs are being radically transformed by new technologies. Where skills obsolescence leads to premature exit from the labour market, then there can be a wealth of experience lost to the labour market. Retaining older people in the labour market can pose a number of problems. De Koning et al., based on evidence from the Netherlands, draw attention to the problems which are faced when raising the pension age in order to boost labour supply.

The subject matter of the chapters discussed so far are national or international in their scope. But consideration needs to be given the regional and local levels too. Some challenges are regional and local in scale and some solutions are more effectively and efficiently designed and implemented at the local or regional level. In his chapter on the challenges faced by many urban areas related to, amongst other things, human capital development, Barbato summarises the innovative and collaborative development of policy and its subsequent implementation at the level of municipality. Similarly, Livanos et al. in their analysis of involuntary part-time and temporary work draw attention to the need for intra-national and regional analysis to tackle regional issues.

The chapters provide a number of different perspectives related to the demand for labour and skills resulting from rapid technological change and the capacity of the supply-side to keep pace. Over the long-run the supply side is usually able to respond, but often the policy imperative is to deal with matters over the short-to medium-term. The chapters here provide food for thought in this regard. There are, however, no easy answers. But the chapters provide illuminating insights that might yet stimulate innovative policy solutions at supra-national, national or local levels with respect to how the labour market can effectively respond to rapid technological change in way that is socially inclusive.

Future Employment and Automation¹

Cornelia Suta, Luca Barbieri and Mike May-Gillings

1. Introduction

The European Union has different strategies and initiatives both to improve the employability of Europeans and to increase the competitiveness of the European economy through sustainable growth. One strategy, the EU's Strategic Framework for Education and Training 2020 (ET2020), has attached clear targets. One of the targets of ET2020 relates to the share of employed 20-34 year-olds having successfully completed ISCED 3-8 (European Commission, 2012). At EU level, the target of 82% for 2020 is close to being achieved. Discussions about revising this target (to probably increase it) and on the further improvement of skills in the EU have begun (European Commission, 2017). One European Commission initiative, the New Skills Agenda (European Commission, 2016), recognises the need to promote learning in the workplace and to further improve the foundation of basic literacy and numeracy skills (European Commission, 2017). It appears that EU labour market policy is learning from the impacts of the last financial crisis on a significant part of the labour force – i.e. young graduates and the low skilled. Does this mean that the European labour force will be ready to face the future challenges of the labour market?

Since the 1980s, several developed countries have seen a rise in labour market polarisation – i.e. a rise in the employment share of low-skilled and high-skilled jobs alongside a decline in the share of middle-skilled ones. Bárány and Siegel (2018) found that in the United States polarisation of occupations in terms of wages and employment started as early as the 1950s and was driven by the long-

1. The authors would like to thank Terence Hogarth, Ilias Livanos, Sudipa Sarkar, Eva Alexandri, Chris Woolliscroft, Richard Lewney and Hector Pollitt for their comments and feedback on an early draft of the paper. Special thanks for Crystal Chu who has helped with the data preparation. This work was carried out under the Monroe project, which was funded by the European Commission's Horizon 2020 research and innovation programme (grant agreement 727114).

term structural change taking place in the economy. At the heart of the structural change was technological progress. Moreover, from the 1980s onward, information and communication technologies (ICT) have replaced primarily routine middle-skilled jobs (Bárány & Siegel, 2018), and thereby brought about the hourglass shaped distribution of skills labour market (much demand at the top and bottom but much less in the middle). Current technological developments, such as new developments in Artificial Intelligence (AI), pose more of risk to low-skilled jobs than the previous waves of technological progress (Nedelkoska & Quintini, 2018). So, will the labour market change its shape from that of an hourglass to one shaped like a lightbulb as the demand for labour at the lower end of the skills distribution begins to shrink too?

Together with other notable findings, Nedelkoska and Quintini (2018) found that the risk of automation is higher among young people's jobs than those of older workers². Therefore, the authors conclude that automation is much more likely to result in youth unemployment than in early retirements. Of course, this outcome might be mitigated through young people being better skilled and so can adapt more easily to the new jobs created as a result of the introduction of new technologies.

The current chapter aims to go beyond providing an estimate of the share of jobs in the EU at high risk of automation. The underlying purpose is to raise the awareness of policy makers of the significant changes that jobs will undergo as a result of the adoption of new technologies. The study builds on the task analysis work undertaken by Eurofound and exploits the Cedefop Skills Forecast 2018 data to analyse the distribution of risk among different population groups with a special focus on education attainment needs. The Cedefop Skills Forecast is based, among others, on the assumption that all vacant jobs will be replaced and this chapter puts into question this assumption.

2. Understanding the relationship between technology, employment, and skills

In this chapter automation is defined with reference to the replacement of people working in some jobs by robots, artificial intelligence or machine learning technologies. The potential impact of job automation on a country is driven by its industry composition (i.e. employment shares across sectors) and the relative

2. In OECD countries, most of the entry level jobs for young people are either in elementary occupations and sales and personal services, both occupations found by Nedelkoska and Quintini (2018) with high risk of automation.

proportion of jobs at high risk of automation in each of those sectors (PwC, 2017).

In the literature, all previous studies on automation commence with an assessment by experts of the risk of automation for a subset of occupational titles based on the tasks these occupations involve (Nedelkoska & Quintini, 2018). Frey and Osborne (2013) were the first to identify the so-called automation bottlenecks i.e. the tasks that, given the current state of technology, are difficult to automate. The bottlenecks to automation identified stemmed from the fact that some jobs required: social intelligence, such as the ability to effectively negotiate complex social relationships, including caring for others or recognising cultural sensitivities; cognitive intelligence, such as creativity and complex reasoning; and perception and manipulation, such as the ability to carry out physical tasks in an unstructured work environment (Nedelkoska & Quintini, 2018). Nevertheless, Frey and Osborne (2013) found 47% of jobs in the United States were at high risk of being automated.

Starting from the occupational-based approach of Frey and Osborne (2013), Arntz et al (2016). developed a task-based approach to estimate the risk of automation for jobs in 21 OECD countries. The approach is based on the idea that the automatibility of jobs ultimately depends on the tasks which workers perform in these jobs, and how easily these tasks can be automated. Moreover, there is considerable variation in the tasks involved in jobs having the same occupational title (Nedelkoska & Quintini, 2018). With the task-based approach, Arntz et al. (2016) showed that the share of jobs at was 9% in the United States; substantially below the previous estimate of 47% by Frey and Osborne. Using the same methodology as Arntz et al. (2016), Nedelkoska and Quintini (2018) increased the coverage to 32 countries (from 22) and slightly modified the methodology. Their results showed that about 14% of jobs in those OECD countries which participated in PIAAC were highly automatable (i.e., with a probability of automation of over 70%), with high across countries variation (from 33% in Slovakia to 6% in Norway). Task-biased technological change due to automation will have similar implications to ones of skill-biased technological change on real and relative wages, and employment levels and relative employment³. In task-biased technological change case, the important dimension will not be the

3. Skill-biased technological change means the substitution of low-skilled labour and the increase in productivity of the high-skilled workers by technology, while task-biased technological change means the substitutability of tasks (and jobs) by technology is determined by the amount of routine that they involve, more than the skills that they require (Fernández-Macías & Hurley, 2017).

level of education of the labour force (as it is in skills-biased case), but the task content of jobs/ occupation, meaning the degree to which the tasks in a job/ occupation can be routinised (Nedelkoska & Quintini, 2018).

The report published in January 2017 by McKinsey (2017) starts by assessing technical automation potential occupations in a similar way to Frey and Osborne (2013), but by disaggregating of occupations into constituent activities reflecting a combination of 18 performance capabilities (such as sensory perception, cognitive capabilities, natural language processing, social and emotional capabilities, and physical capabilities). The technical automation potential of these capabilities is assessed based on existing technologies. For each capability, McKinsey defines four possible levels of requirement, ranking from not required to essential. By estimating the amount of time spent on each of these work activities by humans, McKinsey was able to estimate the automation potential of occupations in sectors across the economy, comparing them with hourly wage levels (McKinsey Global Institute, 2017). Their analysis focused on work activities rather than whole occupations and found that 49% of the activities that people are paid to do in the global economy have the potential to be automated. Moreover, based on this approach less than 5% of occupations can be fully automated, while about 30% of the tasks in 6 out of 10 current occupations can be automated (McKinsey Global Institute, 2017).

Furthermore, McKinsey (2017) considers that automation will not happen overnight since five key factors will influence the pace and extent of its adoption: (i) technical feasibility, (ii) cost of developing and deploying solutions, (iii) labour market dynamics (including the supply, demand, and costs of human labour as an alternative to automation), (iv) economic benefits (labour cost savings), and (v) regularity and social acceptance. The report published in December 2017 by McKinsey (2017) looks at the number and types of jobs that might be created under different scenarios through to 2030, and compares this with jobs that could be displaced by automation. Their analysis is based on several trends that are likely to serve as catalysts of future labour demand and which could create demand for millions of jobs by 2030. These includes caring for others in ageing societies, raising energy efficiency and meeting climate challenges, producing goods and services for the expanding consumer class, especially in developing countries, not to mention investments in technology, infrastructure, and buildings needed in all countries. To bring about job creation, businesses and governments will be required to seize opportunities to boost job creation and for labour markets to function well.

Another approach was taken for Germany by Wolter et al. (2016). Their study was focused on the economic effects of the digitalisation of the economy as a

whole (called “Economy 4.0”) and was based on a five-step scenario analysis. Each scenario adds different impacts and is built upon the previous one. The results of Wolter et al. (2016) show that Economy 4.0 will accelerate structural changes towards the expansion of the service sector. In the digitised world, 1.5 million jobs will be eliminated in 2025 compared with the baseline, i.e. no advanced development path towards the digitalisation of the economy as a whole. At the same, Economy 4.0 will create 1.5 million new jobs (not included in the baseline projection).

The International Federation of Robotics (International Federation of Robotics, 2017) has summarised the findings in the literature and concluded that many studies show that productivity will increase alongside demand, which in turn will create new job opportunities. Some impact, however, will be noticed on the labour market since the structure of employment will change in favour of high-skilled workers who will benefit from higher demand and wages, while middle- and low-skilled workers will face downward wage pressures (caused by other structural factors in the economy). Moreover, robots will complement labour, rather than substituting it, and that job losses in one sector are likely to be compensated by gains in others, so that the aggregate employment growth could well be positive.

In addition to estimating the share of workers whose jobs are at very high risk of being automated using the task-based methodology, Nedelkoska and Quintini (2018) shed light on a number of other crucial issues, such as the substantially large number of workers whose job tasks are likely change significantly as a result of the current wave of technological innovations; and the characteristics of the workers whose jobs are risk of automation. One surprising finding by Nedelkoska and Quintini (2018) is the relationship between automation and age is U-shaped in the sense that the elementary jobs many young people find employment in – including student jobs, internships and low-skilled summer jobs – are more likely to be affected negatively by automation. However, the effect on the overall youth employment is mitigated by the fact that in many countries the younger cohort is more highly educated and, accordingly, are more likely to adapt to technological change compared with their older counterparts.

Low-skills jobs are at risk (McKinsey Global Institute, 2017; Nedelkoska & Quintini, 2018) but they are not the only ones to be affected. Rapid developments in technology will lead to the automation of jobs in middle-skilled activities such as accounting, clerical work and repetitive production tasks (OECD, 2017). Moreover, the least automatable occupations almost all require professional training and/or tertiary education (Nedelkoska & Quintini, 2018). Therefore, the potential impact of job automation varies according to the

characteristics of the workers (skills and education) and jobs (tasks and activities). The OECD (2017) and World Economic Forum (2016) recommend investing in both education and training, and to make better use of skills, and better co-ordinate skills-related policies.

The European Jobs Monitor Task Indicator dataset (Eurofound, 2016) has information on both content of tasks (what is done) and on the methods and tools used for carrying out the tasks (how it is done). The content is related with the output of the economic sectors, while the methods of work are related more to the technology used or organisation of the work (Eurofound, 2016). Each task is converted into a job-level index measuring the extent to which a job involves a particular task. The indices are constructed by aggregating information on the task from different sources (e.g. European Working Conditions Survey (EWCS), OECD's Survey of Adult Skills (PIAAC), Occupational Information Network dataset (ONET)). Each score takes a value between 0-1 and it reflects the intensity of each type of task content in each job (Eurofound, 2016). Moreover, the task scores for a job should not be understood as the breakdown of total labour input into distinct and mutually exclusive categories of tasks, therefore the sum of tasks scores will not add up to one (Eurofound, 2016).

Eurofound (2016) found that there is a strong correlation between the occurrence of the physical tasks, working with machines, and routine tasks. While historically, computerisation has largely been confined to manual and cognitive routine tasks involving explicit rule-based activities, recent developments in machine learning and robotics allow for substitution of labour in a wide range of non-routine tasks (Frey & Osborne, 2013).

Eurofound (2018) used the Cedefop Skills Forecast 2018 and looked at the changes in the distribution of tasks over the forecast period. The task assignment is fixed at the beginning of the forecasting period and remains constant up to 2030. According to this analysis, in the EU, the task distribution will change towards: less physical tasks and more intellectual and social ones; more business literacy, selling/persuading and serving/attending; more ICT skills; and some increase in autonomy and decrease in routine work (Eurofound, 2018). The reported changes in the distribution of tasks are only attributable to the compositional changes in the employment by occupation and sector and do not measure how the tasks in specific jobs change over time (Eurofound, 2018).

The findings above are consistent with those of Autor (2016) who mentions that the tasks that have proved most difficult to automate are those demanding flexibility, judgment and common sense, skills that humans understand only tacitly. Brynjolfsson and Mitchell (2017) identify eight key criteria that help

distinguish “suitable for machine learning” tasks from tasks where machine learning is less likely to be successful, at least when using the currently dominant machine learning paradigm. Moreover, although parts of many jobs may be “suitable for machine learning”, other tasks within these same jobs do not fit the criteria for machine learning well; hence, the effects on employment are more complex than the simple replacement and substitution of jobs sometimes found in the literature suggests (Brynjolfsson & Mitchell, 2017).

A similar view on partial automation and substitution of jobs is taken by Bessen (2016) when investigating basic relationships between computer automation and occupations. By looking at detailed occupations since 1980 to explore whether computers are related to job losses or other sources of wage inequality, Bessen (2016) finds that occupations that use computers grow faster, even for highly routine and mid-wage occupations. Moreover, computer automation is not found as a source of significant overall job losses.

Table 1 summarises the activities/tasks that were found in the literature to belong to one of the two groups and that will be used to identify of occupations with a high likelihood of being automatable by 2030 (see Section 3.1).

Table 1 - Summary of automatable and non-automatable task/activity descriptions in the literature

Non-automatable	Automatable
Applying expertise to decision making, planning, and creative tasks	Processing data
Interacting with stakeholders	Collecting data
Managing and developing people	Performing physical activities and operating machinery in predictable environments
Performing physical activities and operating machinery in unpredictable environments	Routine, codifiable tasks
Finger dexterity, i.e. tasks that involve making precisely coordinated movements of the fingers of one or both hands to grasp, manipulate, or assemble very small objects	Tasks that provides clear feedback with clearly definable goals and metrics
Manual Dexterity, i.e. tasks that involve quickly moving your hand, your hand together with your arm, or your two hands to grasp, manipulate, or assemble objects	Tasks that do not need long chains of logic or reasoning that depend on diverse background knowledge or common sense

>>>

Table 1 >>>

Non-automatable	Automatable
Working in cramped work spaces, or in awkward positions	Tasks that do not require detailed explanation of how the decision was made
Creative intelligence-originality	Tasks that do not require specialized dexterity, physical skills, or mobility required
Creative intelligence-fine arts	The phenomenon or function being learned should not change rapidly over time
Social perceptiveness	
Negotiation	
Persuasion	
Assisting and caring for others	
Tasks requiring problem solving capabilities, intuition, creativity and persuasion	

Source: Cambridge Econometrics based on review of the literature.

In conclusion, many studies in the literature use the task-based approach to estimate the impact of automation on employment. Most studies assume complementary between labour and the new technologies behind automation, rather than perfect substitution; therefore, it is likely that some of replacement labour demand will be affected negatively. No studies were identified using pan-European data sources, and there is the gap that the analysis in this chapter is filling.

The following research questions arise from the literature review.

- How many jobs from the replacement demand will be replaced by people and how many by robots?
- What are the main challenges that the policy makers should address in view of the automation?

3. Estimating the impact of automation on future employment

There is consensus in the literature (Frey & Osborne, 2013; Nedelkoska & Quintini, 2018; PwC, 2017; McKinsey Global Institute, 2017) that artificial intelligence and machine learning will replace partially or fully many of the ex-

isting jobs. The methodologies used in these studies are based on existing jobs and the existing tasks/activities that the workers are performing in those jobs. Most of these studies acknowledge the fact that there is not enough information to estimate the impact on future jobs and tasks. Following the existing literature and the descriptions of tasks performed by the workers available from the European Jobs Monitor Task Indicator (Eurofound, 2016), a methodological approach to identify how many of the future jobs in the Cedefop Skills Forecast 2018 projections are likely to be affected by automation is specified. The methodological approach consists of three main steps:

1. Identification of occupations with a high likelihood of being automatable by 2030;
2. Adjusting the Cedefop Skills Forecast 2018 employment demand by removing the replacement demand in automatable occupations from 2025 onwards;
3. Implications for the labour supply by 2030.

3.1 Identification of occupations with a high likelihood of being automatable by 2030

Similar to other studies (Nedelkoska & Quintini, 2018; Arntz, et al., 2016; Ambrosetti Club, 2017), the starting point in the approach is using the automation label for occupations of Frey and Osborne (2013) as provided in Nedelkoska and Quintini (2018)⁴. The Frey and Osborne (2013) list of occupations is then aggregated to 2-digit ISCO-08 occupations since the European Jobs Monitor Task Indicator dataset (Eurofound, 2016) has this level of aggregation. In order to map the Frey and Osborne (2013) automation label to the 2-digit ISCO-08 occupations, it is assumed that if two or more 3-digit occupations can potentially be automated then the entire parent 2-digit occupation is at risk of being automatable⁵.

4. See Table 2 in the mentioned study which contains the correspondence with the list of 3-digit ISCO-08 occupations.

5. This strong assumption is taken since the automation label information does not exist for many of the 3-digit occupation that belong to the 2-digit group. Moreover, for occupation “42 Customer services clerks”, there is information on two of the 3-digit occupations and one (Telephone switchboard operators) is described be being automatable and the other (Hotel receptionists) is not labelled as automatable. In this case, it is assumed that the entire 2-digit group is susceptible for automation given the other 3-digit occupations that belong to this group and which are mentioned in the literature as being automatable.

Table 2 - Tasks corresponding to PIAAC variables and engineering bottlenecks

Engineering bottleneck (Frey and Osborne, 2013)	Variable in PIAAC (Nedelkoska and Quintini, 2018)	Eurofound Task Analysis (Eurofound, 2016)
Perception manipulation	Fingers, dexterity	Physical Dexterity
Creative intelligence	Simple problem-solving	Information-processing: Processing of codified information
Creative intelligence	Complex problem-solving	Problem-solving: finding solutions to complex/new issues
Social intelligence	Teaching	Social: Teaching/ Coaching
Social intelligence	Advice and Communication	Social: Serving/ attending
Social intelligence	Plan for others	Social: Managing/ coordinating
Social intelligence	Negotiate, Influence, Sell	Social: Selling/ persuading

Source: Cambridge Econometrics adaptation based on Table 4.2 in Nedelkoska and Quintini (2018) and Table 2 in Eurofound (2016)

Following the approach in Nedelkoska and Quintini (2018) and using European Jobs Monitor Task Indicator dataset (Eurofound, 2016), an automation label is used to split 2-digit occupations into automatable and not automatable and then regression analysis is used to identify which task indicators better describe the automatable characteristics of different occupations. For this purpose, analysis of variance and logistic regression⁶ are run to identify which engineering bottlenecks from Table 2 have the highest influence on an occupation being labelled automatable or not.

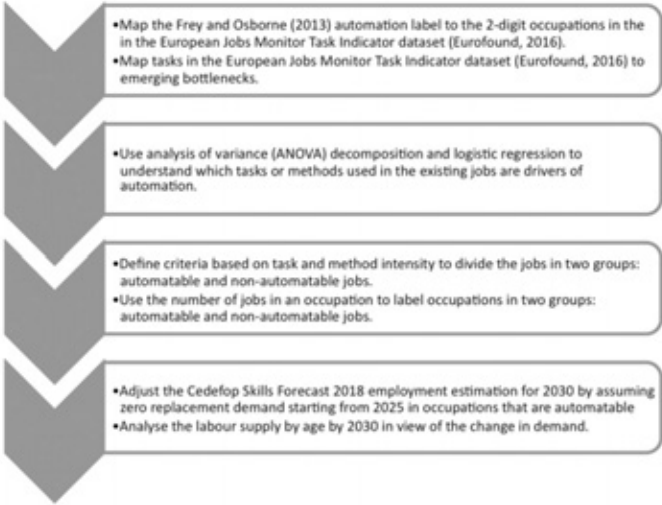
Once the main drivers of automation are identified and using others from the literature review, some criteria are defined to divide the list of jobs (occupations by sectors) into two groups:

1. automatable jobs and
2. non-automatable jobs.

6. The probability of an occupation being automated is modelled as a function of the tasks indicators using the logit model: $P(y = 1|x_1, \dots, x_n) = 1/(1 + \exp(b_0 + b_1x_1 + \dots + b_nx_n))$, where y is the automatable binary variable and x_j are the task indicators.

The labelled occupations are then used to analyse the employment projections in the Cedefop Skills Forecast 2018 dataset. In the forecast dataset, the increase/decrease in jobs by 2030 is split in two categories: new jobs and replacement jobs. While new job creation is based on the macro-economic assumptions, the replacement jobs take into account the age distribution of the labour force. The methodological approach is summarised in Figure 1.

Figure 1 - Methodological approach summary



Source: Cambridge Econometrics

The task scores from the European Jobs Monitor Task Indicator dataset (Eurofound, 2016) take values between 0 and 1 and reflect the intensity of each type of task content in each job. A score above 0.7 is considered very high and that reflects the importance of that task within the job, without prejudice to other task intensities. Therefore, if a task which is unlikely⁷ to be automated with the existing technology has an intensity higher than or equal to 0.7, then the job will have a low probability of disappearing by 2030. In turn, if a task which is likely⁸ to be automated with the existing technology has an intensity

7. The unlikelihood of a task to be automated is based on the literature review. See Table 1.

8. The likelihood of a task to be automated is based on the literature review. See Table 1.

higher and equal than 0.7 and the job does not have any non-automatable high intensity tasks, then the job will have a high probability of low employment demand by 2030.

Based on this reasoning, the following ordered criteria are considered to split the jobs in the two above-mentioned groups. The criteria are based both on the ANOVA and logistic regression results, but also on the literature review. Each time a job is assigned to one of the two groups, then it is removed from the list of available jobs on which the next criterion is applied.

1. If the intensity of social managing task is higher than or equal to 70%, then the job is put in the non-automatable group.
2. If the intensity of social serving and attending task is higher than or equal to 70%, then the job is put in the non-automatable group.
3. If the intensity of creativity task is higher than or equal to 70%, then the job is put in the non-automatable group.
4. If the social teaching intensity in the job is higher than or equal to 70% then the job is put in the non-automatable group.
5. If the social selling and persuading task is higher than or equal to 70% then the job is put in the non-automatable group.
6. If ICT programming is used on the job with an intensity higher than or equal to 70%, then the job is put in the non-automatable group.
7. If teamwork is used on the job with an intensity higher than or equal to 70%, then the job is put in the non-automatable group.
8. If the intensity of using machinery on the job is higher than or equal to 70%, then the job is put in the non-automatable group since it assumed that it has already reached a high level of automation and therefore jobs in the sector/ occupation will not disappear by 2030.
9. If information gathering and evaluation task is higher than or equal to 70% then the job is put in the non-automatable group.
10. If the intensity of repetitiveness of the task is higher than or equal to 70%, then the job is put in the automatable group since it was found in the literature that repetitive tasks are the easiest to replicate by computers.
11. If the intensity of standardisation of the task is higher and equal than 70%, then the job is put in the automatable group since it was found in the literature that standardised tasks are the easiest to replicate by computers.
12. If the numeracy accounting task is higher than or equal to 70%, then the job is put in the automatable group.

13. If the technical literacy task is higher than or equal to 70%, then the job is put in the automatable group.
14. Any jobs left that were not assigned to one of the two groups, will be evaluated using the mean probability of automation by occupation and sector found in Tables 4.3 and 4.4 of Nedelkoska and Quintini (2018). If the average of the two mean probabilities is higher and equal to 0.5, then the job is added in the automatable group.
15. Any jobs remaining unassigned are put in the non-automatable group.

Once all the jobs are assigned to one of the two groups, the occupations will be assigned to one of the two groups. A job is a combination of sector and occupation. Therefore, if more than two thirds of the jobs in an occupation are automatable, then the entire 2-digit level occupation is more likely to be automatable by 2030. Although, a task-based approach was used so far to identify jobs with a high likelihood of being automatable, the aggregation of the jobs in 2-digit level occupation is necessary for the next step of the analysis as Cedefop forecast data for replacement demand is made by occupation and not sector.

3.2 Adjusting the Cedefop Skills Forecast 2018 employment demand

In this chapter, it is assumed that if the occupation is automatable, then there is a high probability that the job opportunities based on the replacement of retired or exit workers (i.e. replacement demand) will no longer materialise. In other words, the tasks in these occupations will be performed no longer by people but by a form of automation (such as robot, machine learning software, artificial intelligence, etc.). This will have an impact of the future number of jobs that will be available to young people (20-34 year olds) in the period up to 2030.

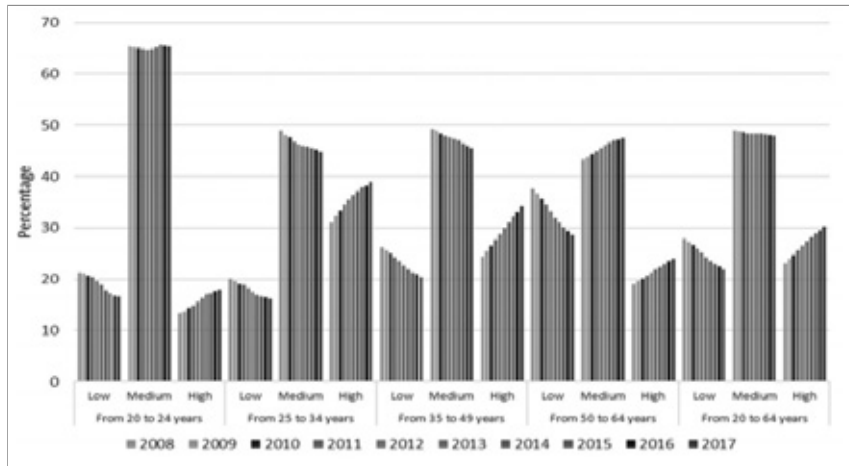
Based on the literature review, it is assumed there will be a delay in the pace and extent of adoption of technology that will displace jobs. The delay is due to technical feasibility, cost of developing and deploying solutions, and labour market dynamics. Therefore, in this chapter it is assumed that the job displacement will not start until 2025 and that it will have an impact only on replacement demand. The latter assumption is based on the strong assumptions made during the labelling of occupations into automatable and non-automatable. Moreover, several studies (i.e. Bessen, 2016) imply a stronger complementarity between people and technologies, i.e. meaning the same or an increased more amount of work will be carried out by fewer workers as they will be assisted by technology. The choice of the year, i.e. 2025, is in line with the early scenario from McKinsey (2017), in which all of the modelling parameters are flexed to the extremes of the set of plausible assumptions that would result in faster automation development and adoption.

4. Data sources

The data on task analysis is from the European Jobs Monitor Task Indicator dataset, Eurofound 2016. Data for employment and replacement demands for the period 2016-2030 are from the Cedefop Skills Forecast 2018 (Cedefop, 2018).

In order to make sense of future changes in employment and skills, consideration needs to be given to the supply side. shows that across all age groups in EU-28 the share of lower educated persons has decreased in the 2008-2017 period while the share of higher educated persons has increased. Moreover, for the 20-24 years-old group follows the same distribution pattern as the 20-64 years-old groups, i.e. the distribution of the share of lower-educated in the population is being mirrored by the distribution of the share of the higher-educated in the population, the middle staying almost constant over the period. The 25-34 and 35-49 years-old groups show a different distribution: both the lower and middle educated groups have decreased over time while the higher educated group has sharply increased over the period.

Figure 2 - Share of population by educational attainment level⁹ and age, EU-28, 2008-2017



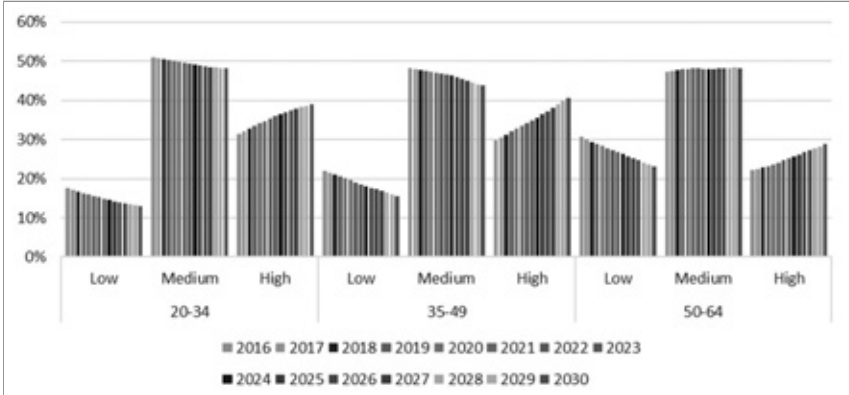
Source: Eurostat (*lfsa_pgaed*)

9. Low qualification corresponds to ISCED 0-2 level; Medium qualification corresponds to ISCED 3-4 level; and High qualification corresponds to ISCED 5-8 level.

Moreover, the share of middle-educated in the population remains the highest across all age groups though in the higher-educated in the 25-34 years-old is getting closer to the middle-educated share.

The education upgrading of the population will impact upon the future education attainment of the labour force over the forecast period, i.e. 2016-2030. Figure 3 shows that for the age groups 20-34 and 35-49, the share of lower-educated keeps decreasing while the higher educated reach the same share in the labour force as the middle educated.

Figure 3 - Share of labour force by qualification level¹⁰ and age, 2016-2030



Source: Cedefop Skills forecast 2018

Moreover, Figure 3 shows that by 2030, the share of low educated young people (20-34 year olds) is expected to decrease close to 10%. This is encouraging in view of the expected decline in low-skill young people’s jobs due to automation (Nedelkoska & Quintini, 2018). The overall tendency for decrease in the lower-educated will result in less emphasis on up-skilling policies and more emphasis on the re-skilling and re-qualification policies for the middle- and higher-educated to help them face the new skills needs of the automated economy.

Throughout this chapter, a special attention will be given to the 20-34 age group. The analysis of this age group is necessary since over the forecast period this age group is meant to be the labour supply for most of the replacement jobs that are assumed to be displaced by automation. Therefore, from the entire labour supply

10. Low qualification corresponds to ISCED 0-2 level; Medium qualification corresponds to ISCED 3-4 level; and High qualification corresponds to ISCED 5-8 level.

this age group is assumed to be the most affected by the changes in the economy due to automation. Moreover, when analysing the qualification level of the labour supply, this age group will be further split in two groups: 20-24 and 25-34 year-olds since it is assumed that some of the 20-24 year-olds might still pursue further education and therefore they are not yet part of the active labour force¹¹. This trend can be observed in Figure 2: the share of medium-qualified 20-24 year-olds is much higher in this age group than in the 25-34 year-old age group.

5. Analysis, results and implications

Logistic regression and ANOVA are run on a sample of 2-digit occupations to identify which engineering bottlenecks have the highest influence on an occupation being labelled automatable or not. The dependent variable is the au-

Figure 4 - Logistic regression results: Automation as a function of engineering bottlenecks

	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
Dexterity	-1.01	1.00	-1	0.313	-2.96	0.95
Information Processing	7.17	1.24	5.8	0.000***	4.7	9.6
Problem Solving	-5.60	0.84	-6.7	0.000***	-7.2	-4
Teaching	-4.61	1.06	-4.4	0.000***	-6.7	-2.5
Serving/Attending	-11.37	0.90	-13	0.000***	-13	-9.6
Managing/ Coordinating	-8.97	1.03	-8.7	0.000***	-11	-7
Selling/Persuading	5.10	0.91	5.6	0.000***	3.3	6.89
_cons	8.74	0.82	11	0.000***	7.1	10.4
Number of obs.	1,182					
LR chi2(7)	560.3					
Prob > chi2	0.0					
Pseudo R2	0.3					
Log likelihood	-532.4					

Note: Significant at: *** p<0.01, ** p<0.05, * p<0.1

Source: Cambridge Econometrics analysis based on data from European Jobs Monitor Task Indicator dataset (Eurofound, 2016) and Nedelkoska and Quintini (2018)

11. In their analysis of future changes in labour supply, Harris *et al.* (2018) identify a past trend of younger workers delaying entry into the workforce that is expected to continue due to automation.

tomation binary variable (1 if the occupation is automatable, 0 otherwise), while the independent variables are Eurofound tasks indicators that correspond to the engineering bottlenecks. Figure 4 shows the results of the logistic regression estimation. As expected, most of the engineering bottlenecks have a negative impact on the extent to which the jobs in an occupation can be automated. However, processing of codified information (literacy and numeracy) and social selling/persuading tasks have a positive impact on the extent to which an occupation can be automated. Both tasks were expected to be negatively associated with automatability. Physical dexterity is not a statistically significant driver of occupation's susceptibility to automation. It might be due to the high positive correlation with physical strength task intensity.

Similar results as above were found by Arntz et al. (2016) and Nedelkoska and Quintini (2018).

Figure 5 shows the analysis of the variance (ANOVA) decomposition on the extent to which jobs are susceptible to automation as a function of engineering bottlenecks. The results show that the tasks "Serving/attending" and "Managing/coordinating" explain the largest share of the variance.

Figure 5 - The results of ANOVA analysis

Source	Partial SS	df	MS	F	Prob>F
Model	112.19	7	16.03	104.56	0.000
Dexterity	0.20	1	0.20	1.34	0.248
Information Processing	8.08	1	8.08	52.73	0.000
Problem Solving	7.59	1	7.59	49.51	0.000
Teaching	4.16	1	4.16	27.14	0.000
Serving/ Attending	38.91	1	38.91	253.85	0.000
Managing/ Coordinating	15.27	1	15.27	99.64	0.000
Selling Persuading	4.83	1	4.83	31.5	0.000
Residual	179.96	1,174	0.15	104.56	
Total	292.14	1,182	0.25	1.34	
Number of obs.	1,182		8.08	52.73	
Root MSE	0.4		7.59	49.51	
R-squared	0.4		4.16	27.14	
Adj R-squared	0.4		38.91	253.85	

Source: Cambridge Econometrics analysis based on data from European Jobs Monitor Task Indicator dataset (Eurofound, 2016) and Nedelkoska and Quintini (2018)

Caring and entertaining is not included as a separate task, however it is partially included in social serving and attending (Eurofound, 2016).

The key assumptions in the analysis that follows are:

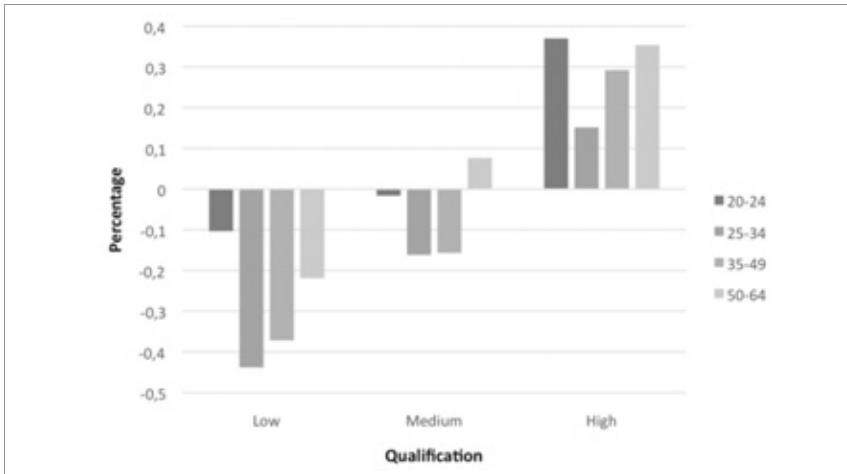
- some 2-digit occupations have a high potential of being automated in the medium term;
- the automation will start in 2025 and will affect, at the beginning, only the replacement jobs; and
- lower and middle educated workers in these occupations are more likely to be affected than higher educated ones.

After applying the rules described in Section 0, 46% of the 2-digit occupations in the Cedefop Skills Forecast 2018 are susceptible to being automated (see list in Appendix A). To be consistent with the literature, the impact of automation is introduced from 2025 only on the demand for replacements jobs, i.e. demand based on workers retiring or exiting the occupation. This assumption is based on the fact that the methodology to identify occupations as automatable is based on automatable tasks and hence it is assumed that by 2030 individuals will still work in these occupations, but the technological advancements will reduce the time spent on some tasks i.e. due to changing task content in the occupation (in line with Bessen, 2016). Moreover, while overall the EU's labour force is declining, Figure 4 shows that the share accounted for by higher educated individuals across all age groups has been increasing. Therefore, it is expected that it will be harder to find lower and middle educated workers to replace retired ones. Furthermore, the difficulty in replacing retirees might push wages upwards which would, in turn, increase the economic feasibility for automating the jobs they previously undertook.

The Cedefop Skills Forecast is based on certain assumptions regarding ageing, technological change, and the changing composition of GDP (Cedefop, 2018). Replacing workers with automation would require investment. Like other studies, an assumption is made that investment in technologies will start when it becomes economically feasible, i.e. after the cost of the technical solution falls below the level of wages for a given occupation and is offset by reduction in labour force costs.

Over the forecast period, the labour force in all age groups is expected to increase only in the higher educated group – see Figure 6. This future distribution of EU labour force by qualification is in line with the expected automation impacts on low- and medium-skilled jobs. Many studies in the literature (Nedelkoska & Quintini, 2018; McKinsey Global Institute, 2017; Bessen, 2016; OECD, 2017) found that the demand in low- and medium-skilled jobs will be negatively affected by the new developments in technology.

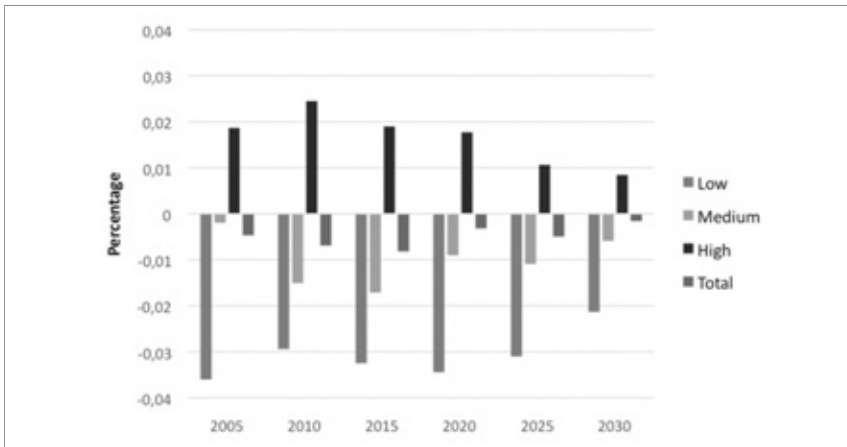
Figure 6 - Labour force growth rate by qualification and age band, 2016-2030



Source: *Cedefop Skills Forecast 2018*

A closer look at the younger cohort (20-34 years-old) in Figure 7 shows that the slow increasing trend in the higher qualified group and the steady decreasing trend in the other two groups was already in evidence at the beginning of the 2000s. Overall this age group is expected to decrease by almost 7% by 2030. In

Figure 7 - Labour force growth rate, 20-34, by qualification, average annual growth by 5 years

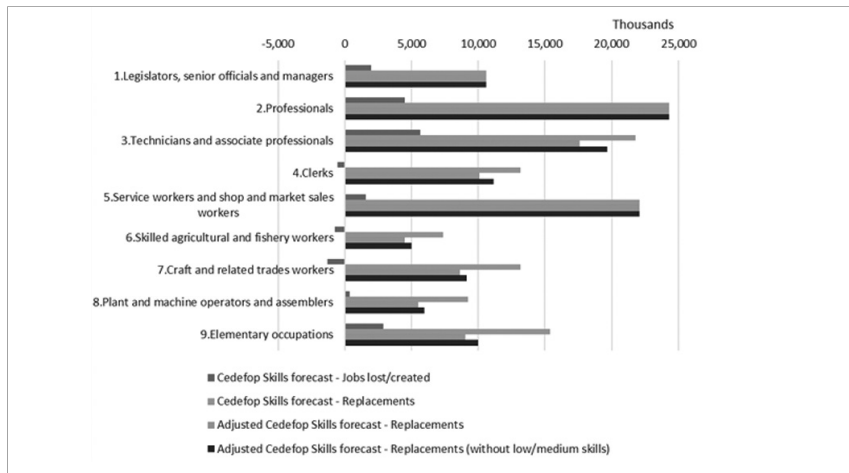


Source: *Cambridge Econometrics analysis based on Cedefop Skills forecast 2018*

2017, the 20-34 year-olds represented 21% of the EU population and almost one-third of the 20-64 years-old population. So, while the share in higher educated is slowly increasing, the overall population in the age group 20-64 is expected to decrease by 4% by 2030. Harris et al. (2018) consider that the ageing of the labour force leads companies and investors to draw increasingly on automation technologies in order to boost productivity.

On the future demand side, Figure 8 shows the magnitude of employment demand for 1-digit occupations over the period 2016-2030. The number of replacement and jobs created/lost is taken from the Cedefop Skills Forecast 2018. The “Adjusted Cedefop Skills forecast 2018 – Replacements” shows the reduction in the forecasted replacement demand (Cedefop Skills forecast - Replacements) due to automation.

Figure 8 - Replacements and jobs lost/created, by occupation, 2016-2030



Source: Cambridge Econometrics analysis based on Cedefop Skills forecast 2018

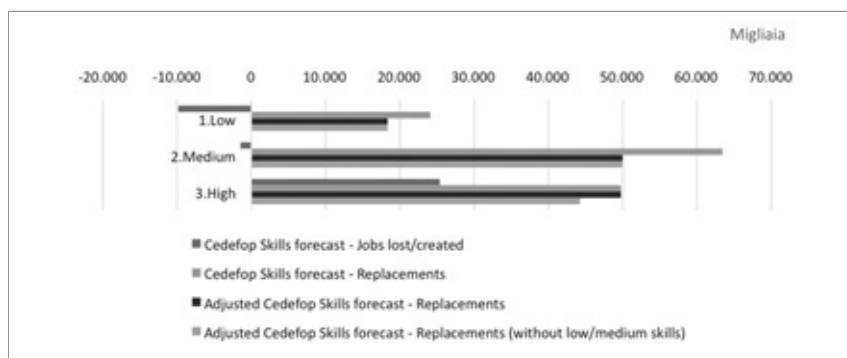
The “Adjusted Cedefop Skills forecast 2018 - Replacements (without low/medium skills)” shows the reduction in the forecasted replacement demand due to automation only for the jobs requiring lower- and middle-qualification. Figure 8 shows that three 1-digit occupations (managers, professionals and service and sales workers) are unlikely to be affected by automation in the mid-term. Skilled trades workers and elementary workers seem to be to ones more likely to be affected by automation by 2030. Except associated professionals and ele-

mentary workers, all the occupations which are likely to be affected by automation are also forecasted to see a decline in size of employment over the period (see Cedefop Skills forecast – jobs lost/created in Figure 8).

Overall, replacements jobs will be reduced by 18% compared with the Cedefop Skills Forecast 2018 replacements if the identified 2-digit occupations are affected by automation as indicated above. If only the jobs requiring lower- and middle-qualifications are replaced then the reduction will be smaller, i.e. 14%. This estimate is in line with the latest estimate of jobs with high automation potential in the OECD countries – 14% (Nedelkoska & Quintini, 2018).

The analysis of the future labour supply shows that there will be more highly qualified workers. In Figure 9 the analysis of the future labour demand (affected or not by automation) shows that most of the jobs to be created will require the highest qualification level. Moreover, in the EU about four in five new job openings will related to high-skilled occupations (Cedefop, 2018).

Figure 9 - Replacements and jobs lost/created, by qualification, 2016-2030



Source: Cambridge Econometrics analysis based on Cedefop Skills forecast 2018

The share in the population and the future workforce of the middle educated remains high – almost 50% (see Figures 2 and 3 in the previous section). The distribution of replacements jobs by educational requirements in Figure 9 shows that most of the replacements jobs will require a middle-qualification level and these jobs are also likely to be affected the automation. This means that some of those in the middle-qualified group will have to either upskill or compete for low-skilled jobs in a shrinking market for low-skilled labour. This could lead to skills mismatches, if employers employ those who are more highly qualified at the expense of those doing the job now. Moreover, the increase in the qualifica-

tion level of the labour supply accompanying a decrease in overall labour demand may well lead to more high qualified workers competing for those jobs that will not be affected by automation. This abundance of labour supply will lead to a decrease in wages and working conditions. Moreover, the pace at which displaced workers migrate toward higher-skilled jobs is likely to be too slow to alleviate the wage inequality arising on the labour market (Harris, et al., 2018; Bessen, 2016).

6. Conclusions

Previous technological revolutions reduced the demand for labour in old jobs and created new demand for labour in new ones. This chapter has only looked at the existing jobs without any reference to the new jobs that will be created as a result of automation. To be consistent with the literature, the impact of automation is introduced from 2025, although at least in some tasks, the speed of diffusion and likelihood of adoption of such technologies can be faster. The estimates are based on the fact that, given the current state of knowledge, tasks related to social intelligence, cognitive intelligence and perception and manipulation cannot be automated.

Given these assumptions, the results show that by 2030 there might be some job displacement (between 14-18% of employment) in occupations where automatable tasks are important. From the highest demand occupations – i.e. expected to grow by 2030 in the Cedefop Skills Forecast 2018 – only associate professionals are likely to be affected by automation; thus, the projected demand for this occupation might not be realised.

From the point of view of qualification level, most jobs displacement will take place in occupations requiring a middle-level qualification. This group is the most affected because most of the forecast replacement jobs are in this group and the current analysis is based on the assumptions that only these jobs will disappear in the mid-term due to automation.

Overall, 46% of existing 2-digit level occupations were identified being at risk from automation. Since full replacement of workers in these occupations is not assumed in this chapter, then higher complementarities between humans and machine is expected in the fulfilment of the tasks. Therefore, an up-skilling and/or re-skilling of the current workforce might be needed to make the adaptation to the new working conditions easier and ensure that fewer jobs are displaced. Nedelkoska and Quintini (2018) conclude that automation has proven much more likely to redistribute the demand for various skills and jobs than to eliminate work altogether. Analysing the changes brought by computer au-

tomation since the 1980s, Bessen (2016) reached the same conclusion with respect to occupations, i.e. computerised occupations substituting for other occupations, shifting employment and requiring new skills.

More high-skilled workers are needed to work with the new technologies, however even the higher-qualified workers might find it hard to find employment. Labour force up-skilling is already in progress, i.e. a slow increase in the share of higher-qualified for all age groups is already observed and the upward trend is expected to be maintained in all age groups. An analysis of the qualification level of 20-24 age group shows that more than 60% have only middle-qualification level in 2017, while almost 40% of the 34-25 year-olds have higher qualification level. By 2030, over 40% of the entire 20-34 age group is expected to be highly qualified. The 20-34 age group will have to face the challenges from automation in the long run, not only the mid-term analysis here. It certainly begs questions about how to assist these young people to make the transition from school to work and if having higher qualifications is the answer. Another striking result from the analysis is that there could be potentially less demand for even highly educated individuals since some of the identified occupations require people who are highly educated. Therefore, up-skilling policies are not the only answer. If the share of the highly qualified in the labour force will increase beyond 60% and not enough jobs for that qualification level materialises, then there will be an abundance of highly qualified individuals competing either for the same job requiring high level qualifications or for the relatively few low- or middle-wage jobs (not yet affected by automation). Either way it will have a negative impact on wages and increase inequality. The new Education and Training target will need to consider the less than optimistic employment outlook from automation and, at the same time deal with existing issues. While the EU has moved closer to the Education and Training 2020 target of recent graduates in employment, the extent of skills mismatches remains high, particularly among those with bachelor's degree (European Commission, 2017). The over-qualification rate of 25-34 year-old tertiary education (ISCED 5 or 6) graduates in employment is already quite high in the EU – around 26% in the last three years¹². Therefore, re-skilling and re-education programmes are also required. McKinsey (2017) suggest for the future of work in Europe, effective retraining will be critical for mid-career workers who will need to make a transition into new occupations and different types of work. In which case, will the new EU Education and Training 2025 strategy target of 25% of people engaging in learning throughout their lives by 2025 be sufficient?

12. <http://skillspanorama.cedefop.europa.eu/en/indicators/over-qualification-rate>.

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Appendix A: List of occupations

Occupations more likely to be automated
Business and administration associate professionals
General and keyboard clerks
Numerical and material recording clerks
Market-oriented skilled agricultural workers
Market-oriented skilled forestry, fishery and hunting workers
Subsistence farmers, fishers, hunters and gatherers
Building and related trades workers, excluding electricians
Metal, machinery and related trades workers
Handicraft and printing workers
Food processing, wood, garment and related trades workers
Stationary plant and machine operators
Assemblers
Drivers and mobile plant operators
Cleaners and helpers
Agricultural, forestry and fishery labourers
Labourers in mining, construction, manufacturing and transport
Food preparation assistants
Street and related sales and service workers
Refuse workers and other elementary workers

Occupation less likely to be automated
Chief executives, senior officials and legislators
Administrative and commercial managers
Production and specialised services managers
Hospitality, retail and other services managers
Science and engineering professionals
Health professionals
Teaching professionals
Business and administration professionals
Information and communications technology professionals
Legal, social and cultural professionals
Science and engineering associate professionals
Health associate professionals
Legal, social, cultural and related associate professionals
Information and communications technicians
Customer services clerks
Other clerical support workers
Personal service workers
Sales workers
Personal care workers
Protective services workers

The risk of automation in EU labour markets. A skills-requirements approach

*Konstantinos Pouliakas*¹

1. Introduction

Recent years have seen an upsurge in the number of new research and policy studies, and associated media attention, focusing on the impact of technological change on employment, reskilling needs and overall implications about the future world of work (Bessen, 2015; Ford, 2015; World Economic Forum, 2016). Such increasing attention has been a consequence of the acceleration in new technological advances linked to the so-called ‘fourth industrial revolution’ (Schwab, 2016), which is thought to have exerted marked effects on both advanced and emerging labour markets. Recently collected EU-wide data by the European Centre for the Development of Vocational Training (Cedefop) have revealed, for instance, that about 43% of adult employees in the EU labour market experienced changing technologies, such as new ICT systems or machinery, in their workplace in the past five years (Cedefop, 2017, 2018).

Most of the recent literature has alternated between what may be called ‘doom and gloom’ and ‘boon’ scenarios. On the one hand, some scholars have claimed that close to a half of jobs in advanced economies are ‘susceptible’ to automation by robots and new technologies (Frey and Osborne, 2013). Their arguments reflect the fact that economies and societies are said to be at a critical turning point, a ‘second machine age’, in which rapid technological advances associated with machine learning, artificial intelligence, 3D printing, visual-space perception, natural language processing, among others, are likely to cause an expo-

1. Contact information, CEDEFOP, Europe 123, Thessaloniki (Pylaia), 57001; Tel: +030 490 292; email: konstantinos.pouliakas@cedefop.europa.eu. The paper has benefitted from valuable comments by Terence Hogarth, Giovanni Russo, Pascaline Descy and from valuable discussions on automation with Seamus McGuinness and Paul Redmond. The author gratefully acknowledges Daniel Scheuregger and Dafni Georgiou for their assistance with the text mining approach employed in the paper. The views expressed in the paper are solely the authors’ and do not necessarily represent those of the European Centre for the Development of Vocational Training (Cedefop). The usual disclaimer applies.

nential or ‘combinatorial’ social transformation in the near future (Brynjolfsson and McAfee, 2014; 2017). On the other hand, advocates of the positive consequences of technical progress tend to highlight that embodied technical change is usually associated with a net employment and labour market balance (Vivarelli, 2014; Bessen, 2016; Autor, 2015).

The aim of this chapter is to engage in an in-depth investigation of the determinants of ‘automatability risk’ in EU jobs, namely the propensity of EU employees to be in jobs with a high risk of substitutability by computers or other automation processes. Using relevant data on tasks and skill needs in jobs, collected as part of the European Skills and Jobs Survey – a survey of approximately 49,000 EU adult workers in the 28 EU Member States (Cedefop, 2015) – jobs are bundled according to their estimated risk of automation. The methodology builds on previous assessments of Frey and Osborne (2013) and Nedelkoska and Quintini (2018) and provides further insight by enabling estimation of the relationship between jobs’ task/skill content and automatability risk using individual-level data with highly disaggregated job title information. Overall, the analysis confirms well-reported estimates of automatability risk across different industries and occupational categories, with marked consequences for labour market outcomes. It is also found that the risk of automation is particularly stark among men and lower-skilled workers and is associated with jobs in which employee training is not provided, hence accentuating the vulnerability of at-risk workers.

Section 2 engages in a brief review of the enormous literature that examines the relationship between technological change, innovation and the impact of automation on labour market outcomes, such as employment or wages. Section 3 describes the data and discusses the key variables used in the analysis. Section 4 subsequently outlines in detail the methodological process employed in order to estimate the latent relationship between automation risk and skill requirements/tasks in jobs and, hence, infer the mean automation probability in EU job markets. Section 5 subsequently investigates the determinants of automation risk by engaging in multivariate regression analysis, while it also explores its correlation with various labour market outcomes, including earnings, job satisfaction, job insecurity and skills obsolescence. Section 6 provides a conclusion.

2. Literature Review

Concerns about changing technologies fostering technological unemployment and the substitution of machines for labour have featured prominently in all industrial revolutions and ages (Keynes, 1933; Mokyr et al., 2015; Autor, 2015).

Empirical studies of the impact of technological progress on economic and social outcomes therefore abound in the literature, including those that attribute rising wage inequality and returns to college education since the early 1980s to *skill-biased technological change (SBTC)* (Katz and Murphy, 1992; Berman et al., 1994; Katz and Autor, 1999), as evidenced by a positive association between computer use and other proxies of technology (e.g. R&D intensity) with skills upgrading (Krueger, 1993; Machin and van Reenen, 1998; Autor et al., 1998). Such an explanation, however, fails to take into account the non-linearities in growth of the employment structure observed across some advanced economies, most notably the widening polarisation of the occupational distribution, which gave rise to theories of *routine-biased technological change (RBTC)*. Starting with Autor et al. (2003), these theories emphasised the potentially disruptive effects of technical change on occupations heavily reliant on routine, non-complex tasks that can be easily codifiable by robotic or algorithmic processes (Autor et al., 2006; Autor and Dorn, 2013; Goos et al., 2009; Acemoglu and Autor, 2011; Handel, 2012).

Consistent with the RBTC hypothesis, recent studies have sought to estimate the susceptibility of occupations and jobs to automation. Such estimates are calculated on the basis that some professions are more frequently characterised by a set of ‘conductive’ task characteristics (e.g. routine or manual tasks, standardised job content, infrequent social interactions, precise physical or hand-arm movement) that can render them vulnerable to robotic processing or algorithmic coding/standardisation. These are in contrast to some tasks/skills that constitute ‘engineering bottlenecks’ to automation, including problem-solving or social intelligence, caring, perception and situational adaptability.

Applying this framework, Frey and Osborne (2013) estimated that 47% of occupational categories in the US labour market are at high risk of automation, mostly middle- and low-skilled professions (e.g. data entry clerks, telemarketers, transportation, librarians). Recent studies have also tended to demonstrate that increasing robotic adoption in advanced economies has exerted non-negligible effects on employment, wages (including a declining labour income share) and hours of work, though such negative impacts affect workers of different skill levels differently and are dependent on labour supply and demand elasticities and product market substitutability (including geographical proximity) (Graetz and Michaels, 2015; Acemoglu and Restrepo, 2016, 2017; Dauth et al. 2017).

Arntz et al. (2016) and more recently Nedelkoska and Quintini (2018) dismiss such high figures on the grounds that they potentially exaggerate the extent to which occupations as a whole can be automated. Accounting for the fact that workers who may be classified within the same occupational group may per-

form a different portfolio of tasks, about 9-14% of jobs are found to be at a high risk of being automated, defined as jobs where at least 70% of the tasks are automatable, though a large share (about one third) of all jobs face some smaller degree of automatability. Similar scepticism and reflection on ‘why so many jobs exist today’ have been expressed by Autor (2015), who notes that most of the pessimistic literature fails to adequately acknowledge the *Polanyi paradox* (*‘we can know more than we can tell’*) and since human judgement, adaptability and intuition (often beneath our conscious appreciation as they tend to be transmitted via culture, tradition and evolution) are features of jobs that cannot be easily automated.

Another strand of related literature, focussing on the relation between innovation and employment or skills bias (Vivarelli, 2014, 2015), further tends to argue that claims of negative consequences of technology are potentially exaggerated. Once one takes into account various compensatory price, scale or income effects arising from greater product (as opposed to process) innovation – such as lower prices of high-tech consumer goods and new product markets that stimulate higher aggregate demand – and other externalities and spillover effects across industries and occupations, technological innovation has been historically associated with a positive net employment premium (Van Reenen, 1997; Pantea et al., 2014; Vivarelli, 2015; Pellegrino et al., 2017; Piva and Vivarelli, 2017).

While historical evidence tends to dismiss widespread fears of robots and machines replacing human input, concerns about a jobless future of work are nevertheless sustained and have recently intensified (Hogarth, 2017). Part of the reason is that recent advancements in digital technology, such as machine and deep learning and mobile robotics, have raised the prospect of automation affecting a wider range of jobs dependent on cognitive/non-routine tasks (e.g. accountancy, logistics, legal works, transportation, translation, financial analysis, medical diagnostics, text writing), previously thought to be out of reach of computers (Frey and Osborne, 2017).

3. Data and descriptive statistics

3.1 The European skills and jobs survey

In this chapter we use data from the European Skills and Jobs Survey (ESJS) to identify the risk of automation across a sample of EU employees as well as how such risk varies across different socioeconomic determinants and affects labour market outcomes. The ESJS is a state-of-the-art survey of adult employees (aged 24-65) carried out in the 28 member states of the European Union, collecting

information on the match of their skills with the skill needs of their jobs². It was financed and developed by the European Centre for the Development of Vocational Training (Cedefop), in collaboration with a network of experts, the OECD, and Eurofound (Cedefop, 2015). The aim of the survey is to help inform the development of European policies on initial and continuing education and training and employment policies. To do so, it seeks to understand how individuals' qualifications and skills are matched (or not) to the changing skill demands and task complexities of their jobs. The survey also examines the extent to which employees' skills are developed and used in their workplaces over time. A mixed online-telephone methodology ensured that the data collected provided a representative sample of the adult working age population in each of the EU28 Member States³. The survey was carried out using quota sampling by the survey company Ipsos MORI and its network partners in each country between 7 March and 26 June 2014. In total, 48,676 respondents from different demographic groups took part either by telephone (9,154 employees) or online interviewing (39,522 employees). In most EU countries about 1,000-1,500 employees were effectively interviewed, although the sample varies between countries. The sample was augmented to 4,000 observations in the case of five large EU labour markets (Germany, France, Poland, UK, and Spain), 3,000 cases for Italy, and 2,000 cases in Greece and Finland, while 500 individuals were surveyed by telephone in each of the three smallest countries (Malta, Cyprus and Luxembourg)⁴.

3.2 Sample and key variables

To estimate the risk of automation affecting European workers' jobs, the analysis adopts a similar methodology to that of previous approaches that have moved

2. For full details of the survey and to download the microdata the reader is referred to: <http://www.cedefop.europa.eu/en/events-and-projects/projects/european-skills-and-jobs-esj-survey>

3. According to Forth, J. (2016) *Evaluation of Design Effects in the European Skills and Jobs Survey*, NIESR, UK, minimisation of design effects can be achieved in the ESJS by treating its sample design as akin to that of stratified cluster sampling. Furthermore, Cedefop (2015) demonstrates that the ESJS sample produces comparable survey estimates with those originating from other random probability surveys (ESWC, PIAAC) on similarly-defined survey items.

4. The questionnaire was translated into the national languages of the EU countries using a strict translation protocol, managed by Ipsos MORI. Prior to administering the survey, extensive cognitive and pilot tests took place to validate the content and validity of the survey instrument. For details, see Cedefop (2015).

beyond the occupational level of analysis used by Frey and Osborne (2013, 2017). In particular, Arntz et al. (2016) and Nedelkoska and Quintini (2018) exploit the unique data on tasks available in the OECD's Survey of Adult Skills (PIAAC), to estimate the micro relationship between workers' job tasks and the risk of automatability. As discussed above, such an approach accounts for the marked variation in tasks that exists within occupations.

The use of the ESJS data in this chapter enables the replication of the aforementioned approach, albeit it exploits a key value-added of the new survey, namely it contains information on a series of different skill sets needed in EU employees' jobs. Specifically, the survey asked respondents to assess the importance of a set of eleven different skills needed for their jobs⁵ It also collected information on the frequency of engaging in routine, autonomous or learning tasks at work. The ESJS also contains important contextual information, such as a standard set of control variables capturing demographic, socioeconomic and job characteristics of the EU employee workforce (age, gender, level of education, native status, firm size, type of contract, economic sector, occupation etc.).

Of specific relevance for the paper's analysis is the fact that information at the one- and two-digit international standard classification of occupations was collected for all ESJS respondents. Individuals in the online part of the survey were asked to identify their broad one- and two-digit occupation based on pre-existing drop-down lists, which contained detailed examples of four-digit occupations. For those who had difficulty identifying their broad occupational group, a follow-up question asked them to identify the name and title of their jobs. In the telephone interviews, all individuals were also asked to describe 'what kind of work they do most of the time' and this detailed job description was subsequently coded back to the broader one- and two-digit ISCO groupings by the survey company Ipsos MORI. Together, about 14,097 respondents (circa 29% of the total ESJS sample) provided detailed information about their job title/work description. In section 5 below we exploit this uniquely detailed level of occupational information to engage in estimation of the risk of automation in EU job markets.

5. The set of skills assessed in the ESJS included the level and importance of literacy, numeracy and ICT skills, as well as the degree of importance of technical, communication, team-working, foreign-language, customer-handling, problem-solving, learning and planning/organisational skills. Respondents were asked to assess '*On a scale from 0 to 10, where 0 means not at all important, 5 means moderately important and 10 means essential, how important are the following for doing your job?*'

4. Empirical methodology

4.1. *The skills/tasks-occupational approach*

In order to calculate the share of EU jobs susceptible to automation, namely those whose majority of tasks may be codified using state-of-the-art computer equipment and machine learning (ML) and artificial intelligence (AI) methods (conditional on the availability of big data), this paper adopts the standard methodology used in previous literature. In particular, information on the “true” likelihood of automation from a selected set of 70 detailed (4-digit) occupations is used (the so-called ‘training dataset’), as collected by Frey and Osborne (hereby FO) on the basis of expert opinions. FO subsequently relied on the views of ML specialists to identify three so-called ‘engineering bottlenecks’ (corresponding to nine O*NET variables), namely tasks which, given the current state of art of technology, are difficult to automate. By modelling the underlying latent probability of “true” automation as a function of the feature vector of nine bottleneck variables, FO extend their out-of-sample prediction of automation risk to about 702 occupations.

In this study, corresponding information on tasks and skill needs in the ESJS dataset is used that can be mapped or proxy for the engineering bottlenecks of FO, albeit in some cases imperfectly. The aim is to unearth the underlying latent empirical relationship between the variance in skill needs within occupations and the probability of automation, the latter inferred by the FO training dataset, in a similar manner to the task-based methodology employed by Arntz et al. (2016) and Nedelkoska and Quintini (2018).

Table 1 below illustrates the correspondence between ESJS-related variables and FO’s ‘engineering bottlenecks’. It is clear that while on most occasions there is reasonable connection between the two, for some, most notably those descriptive of work posture and the provision of care for others, there is a poor or absent link⁶. Nevertheless, it can be confirmed that the ESJS variables can be broadly mapped to the main matrix of descriptors identified in the task-based literature, namely routine-cognitive-interactive-manual tasks (Acemoglu and Autor, 2011; Autor, 2013).

6. The ESJS data also enables exploration of additional features conducive to job automation, not explicitly accounted for in the FO approach, namely the degree of ‘standardisation’ and ‘digitisation’ of job content. In particular, ESJS respondents were asked to assess the level of numeracy and ICT skills needed in their jobs. A priori, it is expected that jobs dependent on advanced numerical skills (defined in the ESJS as ‘*calculations using advanced mathematical or statistical procedures*’) or advanced digital skills (defined as ‘*developing software, applications or programming; use computer syntax or statistical analysis packages*’) will be more susceptible to automation, given that tasks in such jobs should be more easily specified to be performed by advanced machine learning techniques.

Table 1 - ESJS variables corresponding to FO identified engineering bottlenecks

Bottleneck	FO O*NET Variable	O*NET definition	ESJS variable definition	ESJS definition
Perception manipulation	Finger dexterity	<i>The ability to make precisely coordinated movements of the fingers of one or both hands to grasp, manipulate or assemble very small objects</i>	Technical skills	<i>Specialist knowledge needed to perform job duties; Knowledge of particular products or services; Ability of operating specialised technical equipment</i>
	Manual dexterity	<i>The ability to quickly move your hand, your hand together with your arm, or your two hands to grasp, manipulate or assemble objects</i>		
	Cramped work space, awkward positions	<i>How often does this job require working in cramped work spaces that requires getting into awkward positions?</i>	NA	
Creative intelligence	Originality	<i>The ability to come up with unusual or clever ideas about a given topic or situation, or to develop creative ways to solve a problem</i>	Problem solving skills	<i>Thinking of solutions to problems; Spotting and working out the cause of problems</i>
			Learning skills	<i>Learning and applying new methods and techniques in your job; adapting to new technology, equipment or materials; Engaging in own learning</i>
			Learning tasks	<i>How often, if at all, does your job involve 'learning new things'?</i>
			Non-routine tasks	<i>How often, if at all, does your job involve 'responding to non-routine situations during the course of your daily work'?</i>
			Autonomous tasks	<i>How often, if at all, does your job involve 'choosing yourself the way in which you do your work'?</i>
	Fine arts	<i>Knowledge of theory and techniques required to compose, produce and perform works of music, dance, visual arts, drama and sculpture.</i>	NA	
Social intelligence	Social perceptiveness	<i>Being aware of others' reaction and understanding why they react as they do.</i>	Team working skills	<i>Cooperating and interacting with co-workers; dealing and negotiating with people</i>
	Negotiation	<i>Bringing others together and trying to reconcile differences.</i>	Planning and organisation skills	<i>Setting up plans and managing duties according to plans; Planning the activities of others; Delegating tasks; Organising own or other's work time</i>
	Persuasion	<i>Persuading others to change their minds or behaviour.</i>	Foreign language skills	<i>Using a language other than your mother tongue to perform job duties</i>
			Communication skills	<i>Sharing information with co-workers/clients; Teaching and instructing people; Making speeches or presentations</i>
	Assisting and caring for others	<i>Providing personal assistance, medical attention, emotional support, or other personal care to others such as co-workers, customers or patients.</i>	Customer handling skills	<i>Selling a product/service; Dealing with people; Counselling, advising or caring for customers or clients</i>

4.2. *Estimating the latent automatability-skill needs relation*

A key challenge of the above exercise is to find a match between the 70 detailed occupations in the FO training dataset, derived from the US Bureau of Labor Statistics Standard Occupational Classification System, with corresponding occupational classes in the ESJS. Obtaining an exact identification is however difficult given that most micro datasets, including the ESJS, typically contain information at reasonable levels of sample accuracy for broader occupational levels. A similar assignment problem has been faced by Arntz et al. (2016), who use a multiple imputation approach to match the FO automatability indicator to the US PIAAC sample data based on available 2-digit ISCO codes. Nedelkoska and Quintini (2018), by contrast, achieve a closer correspondence between the 70 hand labelled occupations in FO's training data and a subset of 4-digit occupational classes. To do so, however, they have had to rely only on the Canadian sample of the PIAAC dataset, which has a substantially larger sample size than any other country in the international OECD survey.

This study exploits the uniquely detailed information on workers' job descriptions available in the ESJS to estimate automation risk in EU job markets. In particular, the analysis exploits the fact that the ESJS microdata contains detailed job titles and work descriptions for about 14,097 respondents⁷ from all EU28 Countries⁸ (circa 29% of the total ESJS sample) and has engaged in (quasi) text mining analysis, involving information and concept/entity extraction as well as text clustering. In particular, the detailed job descriptions have been matched, using a reasonable proximity of keywords, with the occupations in the FO training dataset. To achieve a good match, appropriate keywords, clues and recurrent grammatical and syntactical structures have been used that constitute 'close descriptors' of the minor FO training occupations, as described in the relevant US SOC and ISCO-08 taxonomies. As an additional quality control check, it has been ensured that the identified detailed job descriptions from the

7. The final number of cases with valid detailed job descriptions has been derived after a number of steps made to 'clean' the respective variable; in particular, all entries were first made upper case, multiple blank spaces were made visible and amended, while missing values (including anomalous entries such as '??', "...", "-") were made visible and dropped. Several redundant answers (such as 'NULL', 'NULL.', 'NO', 'NONE OF YOUR BUSINESS', 'NO COMMENT', 'I DON'T KNOW', 'NOTHING', 'I DON'T WANT TO DISCLOSE', 'NA', 'NOT APPLICABLE' etc.) were identified and deleted.

8. A notable feature of this detailed data capturing adult workers' job profiles is that the survey company Ipsos MORI used national linguists to translate the information from the respective national language of each respondent into English.

ESJS are loosely constrained to the broader 2-digit ISCO-08 group(s) containing the FO 4-digit training occupations⁹.

As an example of the abovementioned process, to match the ESJS job title string variable to a detailed FO occupational group, say ‘cashiers’, keywords such as ‘cashier’, ‘checkout assistant’ and ‘checkout attendant’ were used, together with clues (‘cash register’, ‘cash’) and relevant descriptive syntax (‘ticket issuing’). These keywords were derived from the descriptions of the respective occupation in either the US Bureau of Labor Statistics (BLS) SOC system or the International Labour Organisations’ (ILO) ISCO-08 group definitions¹⁰. A similar process has been employed for the remaining 67 occupations in the training dataset¹¹.

As an outcome of this analysis, approximately 3,471 matches were achieved with 68 of the original FO training occupations, corresponding to 7% of the total ESJS sample (and 25% of the subsample with non-missing job descriptions). As can be seen in Annex Figure A1, a majority of matches were realised for some common occupations (accountants, maids and housekeeping cleaners, cashiers, chefs/chief cooks, waiters, nurses, industrial truck and tractor operators), while other narrower or more specific occupations were characterised by weaker filtering outcomes (e.g. paralegals/legal assistants, physicists, technical writers, parking lot attendants, zoologists). Nevertheless, the fact that the ESJS data have allowed for such detailed matching of the FO occupational list with specific job titles of employees from different EU countries constitutes a value-added in the literature. In particular, it enables estimation of the underlying function between the “true” automatability risk and skill needs of jobs based on a pooled sample of all EU countries, as opposed to relying on only one country (which may be characterised by a specific industrial structure, global value chain position and labour market institutions) or inputting the match at a broader (e.g. two-digit) occupational level.

9. For instance, the identified matched job descriptions for ‘Civil engineers’ have been constrained to match only cases consistent with the group ISCO-08 21 ‘Science and engineering professionals’, whereas the cluster linked to ‘Civil engineering technicians’ was restricted only to cases within the broader group ISCO-08 31 ‘Science and engineering associate professionals’.

10. The BLS SOC system is available at the following link: https://www.bls.gov/soc/2018/major_groups.htm#13-0000; while the ILO ISCO-08 group definitions are available at: <http://www.ilo.org/public/english/bureau/stat/isco/isco08/index.htm>

11. Two occupations in the FO list, namely ‘credit and loan officers’ and ‘credit authorisers, checkers and clerks’, have been captured under one list, given their marked similarity in job descriptions. It has also not been possible to match any entries in the ESJS with the FO occupations ‘hunters and trappers’ and ‘farm labour contractors’.

More formally, a logistic regression can be used to estimate the latent function of the “true” automatability of occupations, as extracted from the FO training data, and individual-level information on skill needs at work, as follows:

$$P(y^* = 1|s) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 s + \beta_2 c_f)}} \quad [1]$$

where $y \in \{0,1\}$ is a (68 x 1) vector of the occupational automatability assessment and s is a matrix of ESJS skill-requirements variables (as shown in Table 1 above). The coefficients β are estimated on a pooled cross-section of employees from all EU28 countries after taking into account country fixed effects (C_f).

Having estimated the latent relationship between the risk of automation in the training occupational subsample and the ESJS skill needs variables, the coefficients of the model are subsequently applied to all other individuals in the 28 EU countries, to obtain an out-of-sample prediction of the individual risk of automation. The analysis also subsequently seeks to detect the underlying relationship between automation risk and various individual and job characteristics, and relates the former to several labour market outcomes (e.g. wages, job security, job satisfaction, skills obsolescence).

Despite the fact that estimation of automation risk using the detailed ESJS job descriptions is based on more precisely defined occupational matches with FO’s original training dataset, the approach has important methodological limitations. Most notably, while a non-trivial 29% of the total number of respondents provided a detailed job description, it is reasonable to expect some bias in the distribution of respondents who provided such information, especially among online respondents. This is because it was only requested in the survey conditional on individuals being unable to accurately identify their one- or two-digit occupational group in prior questions¹².

Furthermore, there is an imperfect correspondence between the US occupational classification used by FO and the ISCO classes and definitions used by the ESJS¹³. While it is also important to acknowledge that even though all efforts

12. Indeed, it is confirmed by the descriptive statistics that the subgroup of individuals providing detailed job descriptions, as well as those with matched cases, is more prone, on average, to be females, older-aged and less educated. A significantly lower incidence of workers undertaking clerical support and market and sales duties and more of those carrying out lower-skilled occupations were inclined to disclose their job title and kind of work.

13. This imperfect correspondence is more severe for some occupations than others; for instance, ‘Compliance Officers’ in the BLS SOC system are classified under the broad ISCO-08 title ‘Business and Financial Operations Occupations’, while in the ISCO-08 taxonomy the closest matched occupation is ‘Process control technicians, other’. See Table A.1. Annex A in

were made to exhaust the list of possible keywords used for matching the detailed ESJS job descriptions to the FO list, it is likely that several relevant entries may have not been identified. However, in order to ensure that the ESJS job descriptions mirror as closely as possible the respective FO occupations, the entity extraction process has been deliberately kept stringent¹⁴.

In addition, the underlying estimated model (1) connecting job tasks/skill needs to automatability risk is assumed to be fixed across countries in the EU job market, which is a generous assumption considering that EU economies are characterised by different industrial structures, development levels and position in global value chains, labour market institutions and incentives for capital-labour substitution.

5. Multivariate analysis

5.1. Risk of automation in EU job markets

Following implementation of the methodological steps outlined above, a “training dataset” denoted as $D = (s, y)$, comprising of the approximately 3,500 matched cases has been retained, containing information on whether an individual’s occupation is automatable or not, along with descriptions of his/her job tasks and required skills intensities for the job. In this dataset about 55% of employees (1,899 cases), labelled as $y=1$, belong to occupations whose tasks/skills, according to FO, can be automated, while the remaining 45% (1,572 cases), taking the value $y=0$, are employed in jobs that cannot (or can only partially) be replaced by machines.

For the purposes of estimation of equation (1) four distinct set of variables, descriptive of the skill needs of employees’ jobs, have been identified, as implied by factor analysis, as follows:

- *Transversal skills i.e.* the degree of importance of learning skills, problem-solving skills, communication skills, team working skills and planning/organisation skills for the job – indicative of a job’s reliance on the so-called “four C’s”, namely creativity (learning), critical-thinking, communication and collaboration;

Nedelkoska and Quintini (2018) for a suggested correspondence table between FO occupations and ISCO-08.

14. For example, including the keyword ‘chief’ to match the ESJS entries to the FO occupation ‘Chief executives’ would augment the number of matched cases, albeit at a cost of greater imprecision. This would be the case because it is not absolutely clear whether a person describing his/her job duties as ‘chief’ is actually a company director/executive, while a number of erroneous cases (such as ‘police chief officer’ or ‘political chief of staff’) would also be selected.

- *Foundation skills i.e.* the extent to which a job requires advanced literacy, numeracy or digital skills;
- *Selling or customer-serving skills i.e.* the importance of foreign language skills and customer-handling skills in the job – descriptive of a job’s need to cater to a domestic and/or international clientele;
- *Technical skills i.e.* the degree to which a job is reliant on specialised or job-specific skills.

To further facilitate efficiency in the estimation, given the potential collinearity in the repeated and similarly-measured skill intensity survey items of the ESJS, the variables included in the transversal and customer-serving skills sets have been reduced to two summative variables. These have been derived using Cronbach’s α statistic, and their internal consistency was verified¹⁵.

Estimation of the underlying latent ‘true’ probability of automation as a function of the aforementioned skill needs constructs and tasks characterising workers’ jobs reveals estimates in accordance with the task-based literature. The empirical logit coefficients¹⁶ shown in Table 2 indicate that there is a strong positive association between a job’s routinisation frequency and propensity towards automatability. Jobs that demand advanced numeracy and at least some digital skills and those that have greater reliance on specialised skills are also more likely to belong to FO’s list of automatable occupations. By contrast, the probability of automation is significantly lower for employees whose jobs facilitate their autonomy and which demand a higher degree of transversal¹⁷ as well as selling skills.

15. Details of the factor analysis and derivation of the Cronbach alpha scales are available in the Annex Table A1.

16. Estimation of equation (1) has also been carried out using a multilevel (mixed-effects) logistic model, which estimates the two moments of the country intercept and hence saves on degrees of freedom, relative to the inclusion of 28 country dummies in the logistic regression. The estimation confirms the statistically significant dispersion of automatability across EU countries – $\text{var}(\beta_0) = 0.11$ (robust s.e. = 0.054). Importantly, the estimated size and significance of the main skill needs coefficients are equivalent to those shown in Table 2. Results are available from the author upon request.

17. Although most skill needs variables are consistent with *a priori* expectations regarding their association with the risk of automation, a notable exception is learning skills, found to be positively related to automatable occupations. Nevertheless, it may be reasonably posited that jobs facing a higher degree of substitutability by technology may also entail a greater ‘*need for learning and applying new methods and techniques*’ and for ‘*adapting to new technology*’ by ‘*engaging in own learning*’.

Table 2 - Estimation of latent relationship between ‘true’ automatability and skill requirements/tasks of jobs, logistic regression estimates, EU28

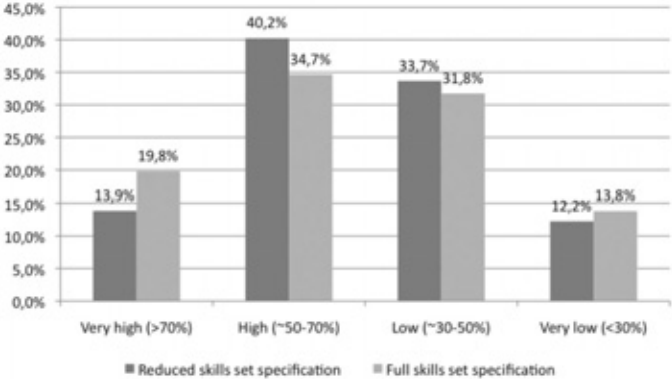
	(1) full skills set	(2) reduced skills set
High frequency of routine tasks	1.39*** (0.107)	1.37*** (0.103)
High frequency of autonomous tasks	0.78*** (0.064)	0.77*** (0.061)
Importance of technical skills	1.06*** (0.017)	1.08*** (0.016)
Importance of generic skills (summary variable)		0.71*** (0.042)
Importance of selling-customer service skills (summary variable)		0.90* (0.048)
Importance of communication skills	1.03 (0.022)	
Importance of team-working skills	0.88*** (0.018)	
Importance of problem solving skills	1.04 (0.023)	
Importance of learning skills	1.08*** (0.021)	
Importance of planning and organisation skills	0.88*** (0.016)	
Importance of foreign language skills	0.98 (0.013)	
Importance of customer handling skills	0.97** (0.013)	
Advanced literacy skills (level)	0.56*** (0.052)	0.56*** (0.051)
Advanced numeracy skills (level)	2.31*** (0.244)	2.28*** (0.238)
No ICT skills needed (level)	0.59*** (0.060)	0.56*** (0.054)
Country dummies (28)	√	√
Constant	2.53 (1.696)	0.74 (0.436)
Observations	3,385	3,441

Notes: Odds ratios of regression coefficients following logistic estimation of equation (1); Robust se in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Source: ESJS microdata <http://www.cedefop.europa.eu/en/events-and-projects/projects/european-skills-and-jobs-esj-survey>.

To obtain an out-of-sample prediction of the EU-wide individual risk of automation, the implied relationship between automatability and job tasks/skill needs as estimated above is extended to all other individuals in the ESJS sample. This analysis hence reveals that the median EU employee faces a 51% probability of being in a job that may be automated¹⁸. Following FO's approach, it is hence found that about 14% of EU adult employees are in jobs that face a very high risk of automation (i.e. the median automation probability exceeds 70%). Similarly, 40% have a non-trivial chance of automation (between 50 and 70%), while for 34% of workers the automation probability ranges between 30-50%. In the ESJS sample only 12% of adult employees are found to be facing a very low (less than 30%) chance of automation.

Figure 1 - Share of EU28 adult workers at risk of automation by degree of risk



Notes: The figure displays the estimated out-of-sample automation risk calculated for the whole ESJS sample of adult employees using two different specifications of equation (1), as shown in Table 2.

Source: ESJS microdata <http://www.cedefop.europa.eu/en/events-and-projects/projects/european-skills-and-jobs-esj-survey>

18. As in Nedelkoska and Quintini (2018), there is marked variance in the estimated automation risk across EU countries (a standard deviation in the mean risk of 0.16), ranging from a high of 68%, 65% and 63% for Bulgarian, Polish and Slovakian workers, respectively, to a low of 37% and 36% for Irish and German employees. With an estimated 18% median risk of automation, Finland appears to be an outlier. The paper does not overstate the country-specific estimates, given the small sample-sizes per country and since the ESJS did not adopt a random probabilistic design. Nevertheless, the results confirm previous literature indicating a higher risk of automation among Central and Eastern European countries, as well as the Baltics and some Southern EU states (notably Greece), and a low risk in Scandinavian and some Northern countries.

Overall, the inferred automatability distribution based on the ESJS data is more similar to that implied by Arntz et al. (2016) and Nedelkoska and Quintini (2018) as opposed to Frey and Osborne (2013, 2017), although it is more heavily skewed to the left¹⁹. This confirms the value of relying on rich individual-level data capturing the within-occupational variance of skill requirements/tasks for the purposes of estimating the latent automatability function (1).

5.2. Determinants of jobs at risk of automation

The rich ESJS contextual information on workers' sociodemographic and job characteristics permits further exploration of the factors associated with a greater risk of automation. In particular, Table 3 displays the estimated OLS coefficients of the predicted probability of automation, \widehat{y}_{os} , as well as those of the following logistic regression²⁰:

$$P(y_{hi}^* = 1) = \beta_{0i} + \beta_1 X_i + \beta_2 J_i + \beta_1 O_i + \beta_1 I_i + \beta_1 C_i \quad [2]$$

where y_h is defined as a dummy variable taking the value one if an individual i is employed in a job with a very high risk of automation and zero otherwise, X is a vector of individual sociodemographic characteristics (gender, age, education level, prior employment status), J is a vector of job-specific factors (private sector, training provision, contract type, employer tenure, multisite workplace, firm size, promotion prospects) and O , I and C are occupation, industry- and country-specific indicator variables, respectively. The estimation procedure is performed in steps, first including the set of variables in \mathbf{X} and subsequently \mathbf{J} and \mathbf{O}, \mathbf{I} , which enables careful scrutiny of the impact of individual and job level determinants, whilst avoiding the 'bad control' problem due to the simultaneous inclusion of occupational and industry variables (Angrist and Pischke, 2009).

19. The estimated percentages of adult EU workers at risk of automation are relatively sensitive to the specification of equation (1). For instance, using the detailed list of skill needs and tasks variables, without reducing them to a more limited control set, raises the estimated percentage of workers at very high and very low risk of automation to about 20% and 14%, respectively, compressing the shares of those in intermediate risk classes. However, an upper threshold of about 20-21% of very high risk of automation persists even when several specifications of equation (1) (such as dropping the level of foundation skills variables) are deployed.

20. For robustness purposes a multinomial logit model has also been estimated for a categorical dependent variable that contains four different degrees of automation risk, namely very high risk (>70% automation probability), high risk (between 50-70%), low risk (30-50%) and very low risk (<30%). The analysis confirms the overall robustness of the effects detected by estimation of equation (4). Results are available from the author upon request.

Table 3 - Determinants of risk of automation, OLS and logistic estimates, EU28

Specifications	(1) X	(2) X & J	(3) X & J & O&I	(4) X & J & skill mismatches	(5) Odds of very high risk (X & J)
Male	0.03*** (0.001)	0.03*** (0.001)	0.02*** (0.001)	0.03*** (0.001)	1.39*** (0.042)
Age band: 30-39	-0.01*** (0.002)	-0.01*** (0.002)	-0.01*** (0.002)	-0.01*** (0.002)	0.86*** (0.041)
Age band: 40-54	-0.01*** (0.002)	-0.01*** (0.002)	-0.01*** (0.002)	-0.01*** (0.002)	0.84*** (0.041)
Age band: 55-65	-0.01*** (0.002)	-0.01*** (0.002)	-0.01*** (0.002)	-0.01*** (0.002)	0.81*** (0.051)
(omitted: Age band: 24-29)					
Education: Medium	-0.01*** (0.002)	-0.00** (0.002)	-0.00 (0.002)	-0.00** (0.002)	1.04 (0.049)
Education: High	-0.02*** (0.002)	-0.02*** (0.002)	-0.01*** (0.002)	-0.02*** (0.002)	0.92 (0.045)
(omitted: Low education)					
Previous LM status: Unemployed	0.01*** (0.002)	0.01*** (0.002)	0.01*** (0.002)	0.01*** (0.002)	1.14*** (0.048)
Private sector		0.02*** (0.001)	0.00*** (0.001)	0.02*** (0.001)	1.24*** (0.040)
No training in last 12 months		0.01*** (0.001)	0.01*** (0.001)	0.01*** (0.001)	1.28*** (0.041)
Part time		0.00 (0.002)	0.01*** (0.002)	0.00 (0.002)	0.99 (0.045)
Permanent contract		0.00 (0.002)	0.00 (0.002)	0.00 (0.002)	0.99 (0.039)
Years in job		0.00*** (0.000)	0.00*** (0.000)	0.00*** (0.000)	1.00** (0.02)
Organisation with multiple sites		-0.00** (0.001)	-0.00*** (0.001)	-0.00 (0.001)	0.97 (0.030)
Small size firm (1-50 employees)		-0.01*** (0.001)	-0.01*** (0.001)	-0.01*** (0.001)	0.87*** (0.027)
Not promoted since start of job but changed tasks		0.01*** (0.001)	0.01*** (0.001)	0.01*** (0.001)	1.20*** (0.047)
No changes in job role since start of job		0.01*** (0.001)	0.01*** (0.002)	0.01*** (0.001)	1.21*** (0.048)
(omitted: Promoted)					

>>>

Table 3 >>>

Specifications	(1) X	(2) X & J	(3) X & J & O&I	(4) X & J & skill mismatches	(5) Odds of very high risk (X & J)
Occupation dummies (ISCO 1-digit)			√		
Industry dummies (NACE 16 categories)			√		
Country dummies (28)	√	√	√	√	√
Gap: ICT skills				0.02*** (0.002)	
Gap: literacy skills				-0.01*** (0.002)	
Gap: numeracy skills				-0.01*** (0.002)	
Gap: technical skills				-0.03*** (0.002)	
Gap: communication skills				0.02*** (0.002)	
Gap: team working skills				0.01*** (0.002)	
Gap: foreign language skills				-0.00*** (0.001)	
Gap: customer serving skills				0.01*** (0.002)	
Gap: problem-solving skills				0.01*** (0.002)	
Gap: learning skills				0.00 (0.002)	
Gap: planning skills				0.01*** (0.002)	
Constant	0.49*** (0.005)	0.46*** (0.005)	0.46*** (0.006)	0.45*** (0.005)	0.06*** (0.009)
Observations	47,913	47,575	47,575	47,575	48,258
R-squared	0.49	0.50	0.52	0.52	

Notes: Columns (1-4): OLS regression coefficients of equation (2) with \hat{y}_{OS} as dependent variable; Column (5) logistic regression coefficient of equation 2 with y_h as dependent variable. Robust se in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Source: ESJS microdata <http://www.cedefop.europa.eu/en/events-and-projects/projects/european-skills-and-jobs-esj-survey>.

It is evident from the table that, all other things equal, jobs characterised by a high risk of automation tend to be predominantly occupied by male employees²¹. This is an outcome of the fact that men are more likely to sort into occupations and sectors with a higher automation risk, but also perform jobs with more ‘automatable’ skills. Specifically, in the ESJS sample men are more likely to be performing jobs that require a higher level of technical and numerical skills, which are positively linked to automatability, in contrast to communication, team-working and planning/organisation skills, which are more likely to characterise the jobs of female workers and have lower automation risk.

Moreover, it is found that individuals who have a higher educational attainment level face statistically significant lower odds of being in an automatable job. It is therefore notable that, in contrast to job polarisation theory, automatability risk does not disproportionately impact only medium-qualified workers, but is instead greater for employees that, in general, have lower skill levels. Prior labour market status is also found to be a significant determinant of substitutability by machines, since the risk of being in a job facing high risk is markedly greater for employees who were unemployed before finding their current job.

The analysis also reveals a statistically significant U-shaped relationship between age and automatability, confirming Nedelkoska and Quintini (2018) and implying that middle- and older-aged workers tend to face lower automation risk than young workers. However, after taking into account age effects, individuals with longer spans of tenure with their current employer are characterised by higher chances of automation.

A number of job-related characteristics are found to be significantly related to the probability of automation. Jobs facing very high automatability risk tend to be predominantly in the private sector and in larger, single site, workplaces. Although in terms of raw descriptive statistics the probability of automation is higher for workers on fixed-term or temporary agency contracts (15.5% of adult employees on such temporary contracts face a very high risk of automation, as opposed to 13.5% of those on indefinite contracts), the effects are not statistically significant once other factors are taken into account. In automation-prone jobs, employees are also more likely to face limited pro-

21. This finding is in contrast to that of Nedelkoska and Quintini (2018), who find that females face a higher risk of automation and attribute this to the fact that their jobs have more automatable tasks than male peers (even if females tend to sort into occupations with lower automation risk).

motion prospects and their job role and tasks have remained stagnant over time. They are also significantly less likely to have undergone any type of training for their job (on- or off-the-job, non-formal or informal) over the course of the previous year. This is striking, considering that upskilling and reskilling are argued to be key ingredients for mitigating the difficult transitions required for workers affected by technological skills obsolescence (Cedefop, 2018; McGuinness et al., 2018).

The ESJS collected unique information on the degree of skill mismatches affecting EU workers. In particular, employees were asked to assess the correspondence between their own skills and those required by their jobs, both in terms of the total stock of skills and also for a set of eleven specific skills. Although such variables are likely to be endogenously related to the predicted risk of automation, given that both measures are confounded by the respondents' subjective assessment of skills needs in their job, inclusion of such uniquely detailed skill mismatch variables in the specification of equation (2) reveals some interesting findings. In particular, individuals who are employed in jobs at risk of displacement by machines are more likely to be affected by skill gaps in their digital skills, as well as in a variety of generic skills (communication, team working, customer-service, problem solving and planning). By contrast, they are less likely to experience gaps in their basic skills (literacy and numeracy) and in their level of required technical expertise (including knowledge of foreign languages).

Finally, the estimates further highlight a number of well-reported occupation and industry-specific impacts on the risk of automation (see Figures 2, 3). Individuals in crafts and elementary posts and those working as plant and machine operators face higher chances of being in highly automatable jobs, in contrast to those employed in high-skilled occupations (e.g. managers, professionals) and in services and market sales. Similarly, individuals employed in sectors providing social and personal services, education and health services and in the cultural industries face significantly lower automation chances, relative to those employed in the secondary and primary sector.

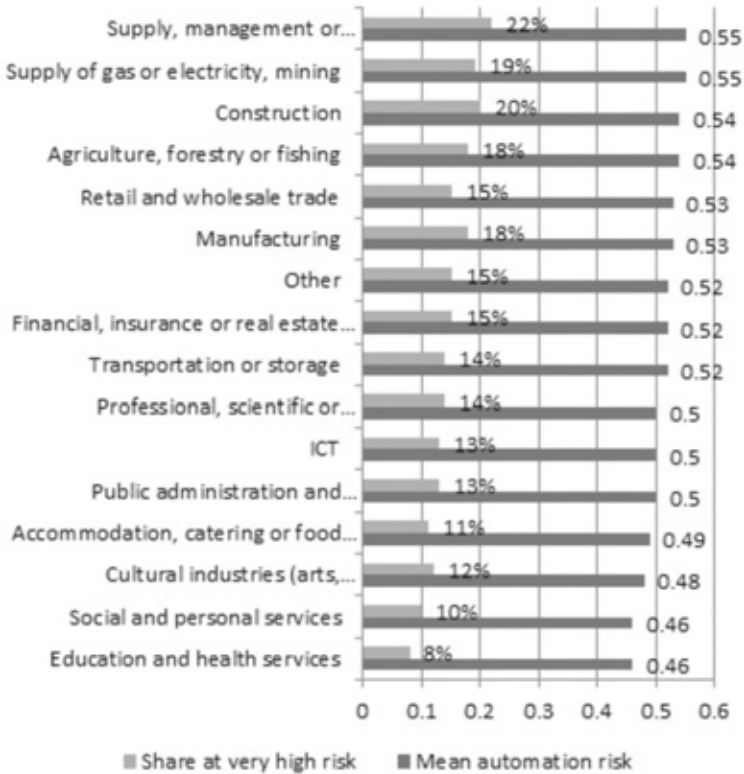
Figure 2 - Mean probability of automation by 2-digit occupation



Notes: Out-of-sample predicted probability of automation based on estimation of equation (1); share of workers at very high automation risk defined as those with probability of automation over 70%.

Source: ESJS microdata <http://www.cedefop.europa.eu/en/events-and-projects/projects/european-skills-and-jobs-esj-survey>

Figure 3 - Mean probability of automation by industry



Notes: Out-of-sample predicted probability of automation based on estimation of equation (1); share of workers at very high automation risk defined as those with probability of automation over 70%.

Source: ESJS microdata <http://www.cedefop.europa.eu/en/events-and-projects/projects/european-skills-and-jobs-esj-survey>.

Table 4 - Labour market impact of automation risk, OLS estimates, EU28

	(Log) hourly earnings	Job satisfaction	Job insecurity	Skills obsolescence
<i>Probability of automation</i>	-0.103*** (0.024)	-1.225*** (0.086)	0.627*** (0.117)	0.492*** (0.123)
<i>Very high risk of automation (dummy)</i>	-0.031*** (0.008)	-0.315*** (0.031)	0.099** (0.043)	0.088** (0.044)
<i>R2</i>	0.57	0.06	0.11	0.07
<i>N</i>	39,290	47,505	44,935	45,424

Notes: OLS regression coefficients with \hat{y}_{os} as independent variable in row (1) and y_h in row (2); Col 1 is based on estimation of a Mincer-type earnings function including age (and its quadratic), gender, education attainment level and years of employer tenure as additional control variables; Col. 2-4 include as control variables a standard set of individual and job characteristics as well as occupation and industry dummies as in column (3) of Table 3. Robust se in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Source: ESJS microdata <http://www.cedefop.europa.eu/en/events-and-projects/projects/european-skills-and-jobs-esj-survey>.

5.3. Labour market outcomes and the risk of automation

In addition to understanding factors associated with the risk of automation, this section focuses on testing how a job that is susceptible to being replaced by machines is associated with a variety of labour market outcomes. Table 4 demonstrates the estimated OLS relationship between the predicted (out of sample) probability of automation, \hat{y}_{os} , as well as the likelihood of being in a job that has a very high risk of automation, y_h , with individuals' (log) gross hourly earnings, their job satisfaction, and their anticipated job insecurity and skills obsolescence²².

22. In the ESJS adult workers were asked the following related questions; for earnings they were asked to declare 'On average, how much is your gross monthly earnings from your job (before deductions or credits of tax and national insurance)?' and, in case of non-response, to state their income band. See McGuinness and Pouliakas (2017) for further details on the construction of the continuous hourly wage variable.

For job security and skills obsolescence they were asked to state on a Likert scale from from 0 to 10, where 0 means very unlikely and 10 very likely 'How likely or unlikely do you think it is that each of the following may happen? (i) I will lose my job in the next year (ii) Several of my skills will become outdated in the next five years.'

Finally, a standard job satisfaction question was asked 'On a scale from 0 to 10, where 0 means very dissatisfied, 5 means neither satisfied nor dissatisfied and 10 means very satisfied, how satisfied are you with your job?'

As is clear from the table, a higher degree of automatability tends to be significantly associated with jobs in which workers have lower mean job satisfaction and a higher (perceived) likelihood of job insecurity. They are also more likely to believe that several of their skills will become outdated in the near future. It is also evident, based on estimation of a standard Mincer earnings function, which accounts for individuals' gender, a quadratic age term and years of employer tenure (to proxy for both general and specific human capital), that there is a strong negative relationship between the risk of automation and earnings. Employees in (highly) automatable jobs, for instance, receive about 3.5% lower hourly earnings, *ceteris paribus*, relative to comparable workers facing lower degrees of automation risk.

6. Conclusions

Much has been said and written recently on the threat posed by machines and robots to humans. Continuous advancements in artificial intelligence and advanced robotics, but also in a wide array of new technologies (e.g. nanotechnologies, 3D printing, bioengineering etc.) with potential to radically transform industries and occupations, have heightened concerns of employees, including this time high-skilled workers, becoming side-lined to machines. Despite such scaremongering, historical evidence as well as current estimates of the risk of automation, such as those presented in this paper, dispute claims of a future post-work society. It is important to always bear in mind that in dynamic economies that have set in place high quality, responsive and inclusive education and vocational training systems, as well as adequate social security safety nets that support career transitions, displaced or idle resources tend to be utilised in other value-creating industries and occupations over time. Moreover, in a standard Neo-Keynesian framework the translation of cost-saving technologies into cheaper goods and, hence, greater product demand, is also dependent on a high degree of demand elasticity as well as on a robust median wage level in an economy that can support greater consumption expenditure.

The deployment of more capital investment expenditure by firms, following the introduction of a new technology, is also not an automatic or irreversible process (DeCanio, 2016). While innovation cycles and their commercial application in industry, most notably via rapid prototyping, have become shorter, the diffusion of new technologies within firms in a manner that is labour-disruptive can be long and uncertain. In addition to taking into account the relative cost of human versus capital factor inputs, relative to their marginal productivities, to decide on the degree of substitutability of capital for labour, many organisations realise

that in a global economic environment their human capital constitutes a source of competitive advantage. Fast replacement of their workforce by machines may often come at a significant cost of lost organisation creativity, innovation and employee drive.

Moving from technical feasibility to actual market diffusion of capital investment also requires accounting for employers' incentives and commitment to their human resources. Assuming that jobs at high risk of automation must not only possess a specific skills/task mix that renders them susceptible to automation, but must also be characterised by employers disinclined to invest in their staff's human capital, it is hence possible to reassess the total stock of highly automatable jobs in the EU. Using the available ESJS data enables one to purge from the original estimate of very high risk jobs (14%) the share of employees employed in organisations consciously committed to their personnel's skills development. Doing so reduces the figure to 8.3% (accounting for firms that fully reimburse the cost of training) or to 7.6% (taking also into account employers who partly reimburse training expenditure).

While pinpointing the exact figure regarding the share of EU jobs at risk of displacement by machines can be imperfect science, the available evidence does however highlight the need for policies that can shield specific population groups most vulnerable to technological unemployment or skills obsolescence. The ESJS data identify that it is typically lower-educated males, suffering from skill gaps in digital and transversal skills, and those employed for larger-sized firms in the private sector, who are faced with greater automation risk. Overall, sectors and occupations requiring medium- or lower-level skills are more prone to automation, while professional and interpersonal services provision (such as health care or education) are relatively insulated.

A key challenge for policymakers is thus to ensure that individuals who will soon see their jobs transitioning from a 'semi-analogue to a digital world' can do so with as little disruption as possible (Goolsbee, 2018). This process will require that they acquire relevant skills, are offered an adequate welfare safety net and exhibit a high degree of adaptability that will allow them to remain employable in future job markets. Modernising education systems and lifelong learning so that training programmes focus more heavily on key competences and soft skills, including the four C's – communication, collaboration, creativity and critical thinking – is admittedly a critical parameter of the equation.

Ensuring that we converge to a future we want will also require that EU stakeholders build high quality skills anticipation systems so as to prepare for emerging jobs and in-demand skills. Harnessing the power of digitalisation for making better policy decisions, such as by extraction of real time data on emerging jobs

and in-demand skills, is another key input to the process. However, it is crucial that policymakers put in place safeguards so that there is adequate trust, transparency and governance in the interpretation and use of AI-generated intelligence in policy decisions.

With many advanced economies fundamentally struggling with low productivity, the advancement of digitalisation and AI holds significant promise for expanding efficiencies in a wide range of occupations and for new economic activities or markets emerging. But the move towards a new desirable 'future of work', such as a post-work or full employment society, instead of polarised labour markets, cannot rely only on more or better (re)skilling policies. A whole arsenal of innovation, competition and employment policies will have to be implemented together with forward-looking skills strategies to ensure equitable access for the majority of people to the profits and opportunities of digitalisation and automation.

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Annex

Figure A1 - Frequencies of matched ESJS job titles with FO occupations



Source: ESJS microdata <http://www.cedefop.europa.eu/en/events-and-projects/projects/european-skills-and-jobs-esj-survey>.

Table A1 - Factor analysis – reduction of skill requirements variables

Factor	Variance	Difference	Proportion	Cumulative
Factor 1	3.26247	2.37738	0.8641	0.8641
Factor 2	0.88509	0.60784	0.2344	1.0985
Factor 3	0.27726	0.12052	0.0734	1.1720
Factor 4	0.15674	.	0.0415	1.2135
<i>N</i>	46,322			
<i>Rotated factor loadings</i>				
Importance of technical skills	0.5544	0.0973	-0.0828	0.2048
Importance of communication skills	0.7336	0.1021	0.1997	-0.1568
Importance of team-working skills	0.6728	0.0187	0.0485	-0.1374
Importance of foreign language skills	0.3214	0.2699	0.2395	0.1173
Importance of customer service skills	0.4532	0.0565	0.3457	-0.0536
Importance of problem-solving skills	0.7462	0.1133	0.0699	0.0946
Importance of learning skills	0.7271	0.1487	-0.0058	0.177
Importance of planning skills	0.6782	0.2189	0.071	0.062
Advanced literacy skills (level)	0.1794	0.5667	0.0665	-0.017
Advanced numeracy skills (level)	0.1155	0.5219	-0.0299	0.0444
No ICT skills (level)	-0.2541	-0.3352	-0.1897	-0.0913

Notes: Principal factors method; orthogonal varimax rotation; Rotated factor loadings (pattern matrix) and unique variances.

Source: ESJS microdata <http://www.cedefop.europa.eu/en/events-and-projects/projects/european-skills-and-jobs-esj-survey>.

Defining industry 4.0 professional archetypes: a data-driven approach

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1. Introduction

Worldwide industrial systems are evolving by leveraging internet connected technologies to generate new added values for organisations and society. Researchers, policy makers and entrepreneurs refer to such phenomenon as Industry 4.0. An increasing number of experts from different fields are focusing on this topic and bringing their contributions in terms of new technologies and methods. As a consequence of this process, companies that are embracing the new paradigm need to manage new technologies and the relations between them with a multidisciplinary approach. The result is an emerging need for personnel with the capabilities to bridge different fields. Accordingly, Industry 4.0 presents a wide range of skill issues that need to be addressed. While the scientific interest in the technological aspects of Industry 4.0 is constantly growing, an understanding of the implications for the future of work and new professional roles it is likely to give rise to prove to more difficult to get to grips with. In many respects this stems from the heterogeneity, complexity and static nature of job description systems. As a result, the issue is addressed in a qualitative manner which results in findings being uncertain and partial. To rectify this data gap, a method for identifying the skills associated with Industry 4.0 has been developed which is explained in greater detail below. The first step in developing data driven mapping of Industry 4.0 competencies is to develop a method which benefits – rather than suffers – from the heterogeneity of the entities to map. As will be demonstrated below, this allows for the classification of the groups of competencies that can be used to identify and define archetypes of Industry 4.0 workers. Before proceeding to the analysis and results, consideration is given to the literature to allow the reader to contextualise the work and its contribution to scientific discourse.

2. Literature Review

2.1 *The Fourth Industrial Revolution*

Formulated initially in Germany in 2011, Industry 4.0 is defined as a trend related to automation and data exchanges based on the use of new technologies and their interconnectivity. Because of its innovative power, the phenomenon is frequently called “the Fourth Industrial Revolution”. The differences between this new production paradigm and the previous ones are its exponential growth, the global scope, and the certain - and still not clearly defined - impact on social, economic and political structures (Caddel Last, 2016). According to the Industry 4.0 paradigm, technologies allow devices, machines, and systems to communicate with each other directly (Lasi et al., 2014). Even if it is often presented as a new paradigm, Industry 4.0 is strongly linked to technologies and frameworks that have existed for many years¹. It can be interpreted as: (i) a re-combination of existing technologies with new ones; and (ii) the application of such technologies to the manufacturing environment (Trappey et al., 2016). Most importantly, the relationship between technology and business is now stronger than ever: Industry 4.0 technologies allow the creation of new business models and increased revenues by providing scope for the delivery of a wider range of products and services than hitherto (Geissbauer et al., 2016). The successful implementation of Industry 4.0 is dependent upon its take-up and integration into the systems already extant in organisations (small, medium, and large alike), and the capability of the workforce to adapt to the changes it potentially affords organisations. Developing skills and competencies is necessary for the development, diffusion and implementation of Industry 4.0 into society.

2.2 *Digital Competency Development*

The radical technological change will affect the whole industrial environment and will transform the world we live in (Potstada and Zybur, 2013). Consequently, the fourth industrial revolution does not just concern the development and diffusion of sophisticated machines, but that of the world of work, the skills that will be required from workers. On the one hand the implementation of Industry 4.0 may have a negative impact on some jobs which could be substituted by robots. In support of this theory, Frey and Osborne (2016) estimated the

1. The technologies adopted and the idea of a “new paradigm” were already analysed in the past: e.g. “Computer Integrated Manufacturing” in the 1970s contained many of the principles now referred to as Industry 4.0.

probability of job being replaced by computerisation. The results are pessimistic: jobs were defined as being at high, medium or low risk of computerisation with around 47 per cent of jobs in the high-risk category being at risk of substitution. In other words, around a half of jobs in the high risk category could disappear. On the other hand, a possible impact is a significant increase in the skill and competences of the workforce possibly linked with the emergence of new occupations. This is the primary focus here – that of understanding the way in which technological change leads to the emergence of new jobs which are sometimes difficult to detect because, for instance, occupational classifications are updated only every ten years or so. In many respects, real-time information is needed which identifies in a timely fashion the new types of jobs emerging in the economy. In this way, those responsible for skills supply in a country have ready access to up to date information.

2.3 Data mining and graph analysis

The proposed mapping methodology is realised through graph analysis and clustering tools and uses Wikipedia as a data source. Wikipedia is a free, unrestricted encyclopaedia, consisting of 600,000 English articles and a total of 1,5 million articles. The Wikipedia database structure is a source of interconnected knowledge, whose corpus is frequently updated and modified by its users. This free source of information is an ideal opportunity for implementing clustering techniques with the aim of realising several different tasks (Moro, 2013).

Wikipedia's database is composed of pages or articles that define events or entities. Internal links between the pages allow the reader to move from one page to another easily. All the pages are featured with:

1. Anchor text: it is the clickable text in a hyperlink (webpage). The number of anchor texts is an important indicator of the “importance” of the page;
2. Redirect page or hyperlink redirection: it directs the reader of a specific topic to the more generic concept which contains the first page;
3. Disambiguation: this function is aimed at avoiding the wrong interpretation of terms that have several meanings.

The correlation and interconnection of keywords contained within the database is explained through network analysis. This is set of methodologies designed to describe the characteristics of a graph and the existing connections between the nodes through mathematical tools. The hyperlinked structure of Wikipedia makes it a particularly interesting domain for this application (Bellomi, R. Bonato, 2005). One of the major objectives of the mining techniques application to Wikipedia is finding a significant correlation between different pages (Milne,

2012). The measurement of the relationship between different pages has several purposes:

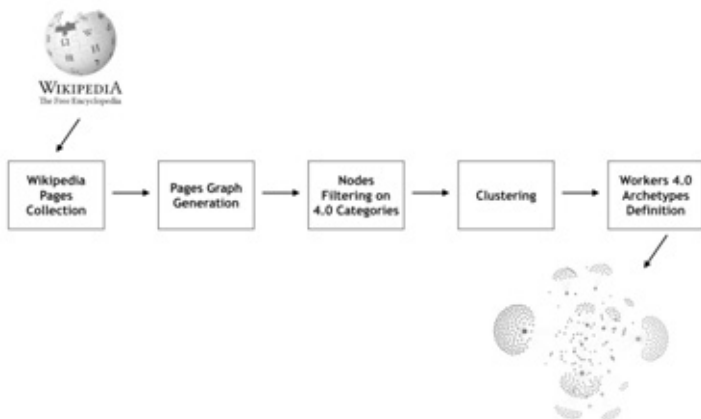
- Entity disambiguation;
- Topic recognition;
- Clustering and document categorisation.

For example, analysing the similarity between different words through the application of specific algorithms can show the degree of interrelation amongst different pages.

3. Data analysis methodology and results

Outlined below is process used to build the graph of Wikipedia pages related to Industry 4.0. This graph will then be used by experts to define 4.0 worker's archetypes. Figure 1 shows the process. It takes as input a set of linked entities (e.g. Wikipedia pages) and produces a clustered graph. The activities and the intermediate outputs are shown in detail in sections 3.1 to 3.5 below.

Figure 1 - Flow diagram of the process for mapping Wikipedia pages related to Industry 4.0



3.1 Wikipedia Pages Collection

The process takes as input a set of entities linked between them. A link between two entities represents a relation between them. Here the concept of relation is defined as the sharing of a topic. In other words, two entities must be connected if they belong to the same topic. Any entities-links structure that meets this re-

quirement can be used as input for the proposed process. For the present work, it was decided to use Wikipedia².

Wikipedia is structured so that each page contains links to other Wikipedia pages. The links from page to page are manually assigned by the contributors, meaning the structure of the links evolves dynamically. Furthermore, each page is categorised by the contributors with the intent of grouping together pages on similar subjects. To collect industry 4.0 related Wikipedia pages, this information and structure is exploited. On the date of 23 November 2017 three levels of pages typologies were collected as shown in Table 1, for a total of 4,739 pages. For each page, **page name**, the **links**, and **categories** were collected.

Table 1 - Number of pages and definitions for the three levels of extraction

Levels	Definition	Number of pages
L1	The Wikipedia page of industry 4.0 ³	1
L2	All the pages linked to L1	39
L3	All the pages linked to L2	4,699

3.2 Pages Graph Generation

Once all the pages and the links between them are collected, the structure is presented as a directed graph (S). It is composed of:

- A set of nodes (N): the Wikipedia pages;
- A set of edges (E): the links between the pages (considering also the direction of the edge).

S has 4,739 nodes and 194,299 edges.

3.3 Nodes filtering on 4.0 Categories

Considering the content of Wikipedia and the process followed in section 3.1 and 3.2, it is reasonable to assume that not all 4,739 pages are related to Industry 4.0. To sanitise the set of nodes N, a series of filtering rules based on the categories of the pages were used. The steps of the process were as follows.

2. en.wikipedia.org.

3. https://en.wikipedia.org/wiki/Industry_4.0.

1. The count the occurrence of each category was extracted. At this step there were 14,711 categories.
2. Filtering the categories occurring less than or equal to three times. This threshold level was chosen by looking at the distribution of the occurrences (the number of pages per category). A change in the central node could affect the selection of this threshold level. At this step there were 1,605 categories.
3. Manually screen the categories and select those related to industry 4.0, taking in to consideration the definition of Industry 4.0 given in Lasi et al. (2014). At this step there were 337 categories.
4. Select the nodes that contain at least one of the 337 categories.

As an example, the top 10 categories in terms of occurrence and relative occurrences are: production and manufacturing (51), parallel computing (42), manufacturing (37), business terms (33), management (31), process management (29), engineering disciplines (28), Internet of Things (28), technology in society (26), and cloud computing (25). This list shows how the process can find categories correlated to Industry 4.0. As a result, a new graph S' that is a sub graph of S (all the nodes N' and the edges E' are a subset of N and E respectively) is obtained. S' has 645 nodes and 703 edges. Of these nodes 75 are disconnected from the graph (both in-degree and out-degree equals to zero) and are thus not useful for the analysis presented in Section 3.4 below. These nodes are filtered, obtaining a definitive S' that has 570 nodes.

3.4 Clustering

It can be assumed that S' provides a reasonable representation of Industry 4.0 related Wikipedia pages in terms of precision and recall. It is thus possible to analyse whether the pages are arranged in clusters or, in other words, if there exist groups of similar pages. To understand the concept of similarity, the nodes N_1 and N_2 , and the sets of all nodes connected to N_1 and N_2 , respectively L_1 and L_2 , must be considered. The similarity of N_1 and N_2 is proportional to the module of the intersection between L_1 and L_2 . To investigate this similarity and find clusters of similar pages, similar nodes were grouped via short random walks. This algorithm is described in Durrett (2007). The approach finds ways to compute an intimacy relation between the nodes incident to each of the graph's edges. This process is not supervised and so makes an optimal decision on the number of clusters. The output was nine different communities. The resulting graph is shown in Figure 2. The figure shows the nodes, their labels, and

the edges. The dimension of the nodes is proportional to the out-degree of each one (the number of tail edges adjacent to the vertex) and the colour represents the community it belongs to. The labels of the nodes (at the centre of the clusters) are shown for those with an out-degree greater than 4. The table shows the correspondence between the community, the colours, and the percentage of nodes per community. These clusters were analysed by the experts to define the archetypes described in Section 3.5.

Figure 2 - Representation of the graph *S*. The nodes show the Wikipedia pages related to Industry 4.0.



Note: The arch between two nodes demonstrates a link between the pages. The labels of the nodes are shown only for nodes with an out-degree (number of tail edges adjacent to the vertex) greater than 4. The colour of each node represents the community the node belongs to. The table in the low-left quadrant of the chart shows the percentages of nodes for each community.

3.5 Definition of worker 4.0 archetypes

The results obtained in the previous section 3.4 were then used by the authors to draw up the list of archetypes shown in the first column of Table 2. The authors generated a list representing the “Industry 4.0 workers archetypes” based on Wikipedia. Possible bias due to the profile of people writing these Wikipedia pages does not reduce the importance of the exercise, but it is fundamental to understand why the reader will find such a great emphasis on technologies, methodologies and tools as pages describing the archetypes in Section 4. The skills, competences and professional profiles are, then, behind and beyond the archetypes, which represent just the attitudinal profiles of the workers that will soon be sought by companies adopting the Industry 4.0 paradigm.

Table 2 shows the relation between the archetypes and the communities (created by the text-mining procedure presented above). It also shows the total number of nodes per archetypes and per community.

Table 2 - Table to show the accordance between the archetypes and communities

		Community Number									Total
		1	2	3	4	5	6	7	8	9	
Archetypes Names	the Architect	44	1	3	6	0	4	0	0	5	63
	the Prophet	21	0	4	0	0	0	0	0	7	32
	the Perfectionist	0	36	1	2	0	0	0	0	3	42
	the Geek	5	1	65	152	0	10	0	0	43	276
	the Investigator	0	0	0	0	0	2	26	0	2	30
	the Strategist	0	0	2	4	0	6	0	30	9	51
	Null	5	6	4	14	2	4	0	0	41	76
	Total	75	44	79	178	2	26	26	30	110	570

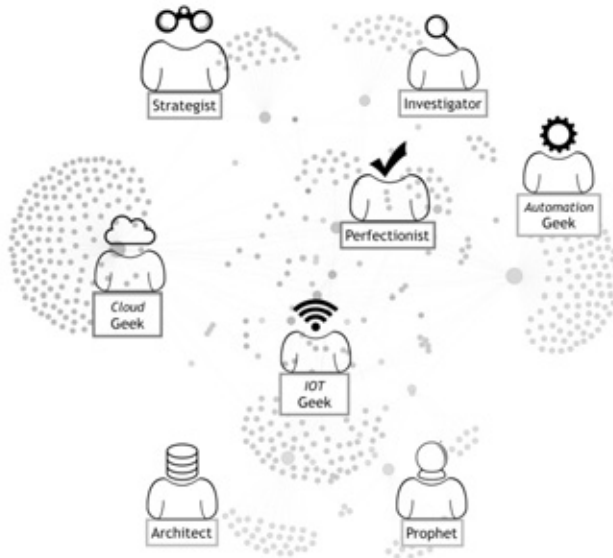
Note: The total number of pages for each archetype is shown in the last column, the total number of pages for each community is shown in the last row.

From Table 2 it can be seen that:

- Group 1 (75 pages) has two nodes/centre: the page “Big Data” and the page “Analytics”. Therefore in Group 1 there are two different archetypes: “the Architect” (44 pages, centred in Big Data) and “the Prophet” (21, centred in Analytics). This is evidence of the fact that these two archetypes are strongly related between them, since they belong differently from all the other groups.
- More than 80% of the pages referring to Group 2 (centred in the page “SCADA” and “Industrial Control system) were used to create the archetype of “the Perfectionist”. It is important to underline that the page SCADA - acronym for Supervisory control and data acquisition - being a specific control system architecture - was not assigned to a specific archetype. The focus for designing “the Perfectionist” was the generic page “Industrial Control System”.
- Group 3, Group 4 and Group 9 are composed of pages linked to the same archetype: “The Geek”. With respect to Group 1, a different choice was made: the majority these three groups’ pages were referred to just one archetype, “nuanced” based on the closest technologies on the graph: “Cloud Computing”, “Automation” and “Internet of Things”. As “the Geek” was created from three different groups, it has three different declinations as shown in Figure 3. “The geek”, as will be explained in section 4, must be the expert of a specific family of similar technologies strongly related to Industry 4.0.
- Group 6 is composed of 26 pages that refer to almost all the archetypes. These pages are general purpose as they are centrally positioned in Figure 2 (they are related to every community). The predominance of pages referring to one archetype (the Geek) meant that the group centred on the page “Computer Integrated Manufacturing” could not be considered as another nuance of “the Geek”. Moreover, Group 6 is strictly related to Group 9, as demonstrated by the proximity of the clusters on the graph.
- In group 7, centred on the “Root Cause Analysis” page, it was found that 100% of pages were referable to the archetype called “the Investigator”.
- As in the previous group, and also in Group 8 (centred in “Value Chain” page), it was found that 100% of pages were referable to one archetype: “the Strategist”.

Figure 3 shows the same graph of Figure 2 with the archetypes superimposed on it (described in detail in section 4). In this new version of the graph it is possible to identify the centres of each cluster, the position of the clusters (and the related archetype) with respect to other clusters, and the interrelation among the clusters/archetypes. In section 5, after having analysed each single archetype, an interpretation of such relations is provided.

Figure 3 - The different professional archetypes associated with each technological cluster



4. The archetypes

The term “archetype” has its origins in the Greek word “*archein*”, meaning “original or old” and “*typos*”, meaning “pattern, model or type”. It thus etymologically refers to the “original pattern” from which all other similar persons are derived, modelled, or emulated. In this work the etymological definition is considered, discarding any philosophical or psychoanalytic references which would mislead the research.

Concerning the archetypal personalities, many theories have been proposed over the years (D. Schultz and S. Schultz, 2012, Yan et al., 2015), but with no common vision reached at the academic level. Both Jung’s theory of personality types

(Jung, 2014), and the Myers-Briggs indicator (MBTI) in the field of work psychology (Myers and Myers, 1995), produce several psychological types defined through descriptions and traits. Some of them (e.g. the 16 psychological types of MBTI) are standards for Human Resource managers and are largely used for human resource classification and selection.

It is important to underline that in the present work that: (i) technologies and skills have been extracted in a scientific and repeatable manner; and (ii) they have been clustered following a well-known and accepted algorithm. Conversely, archetypes' names have been chosen with the intent to better communicate the research outcomes. The archetype descriptive sections are built following a common structure as set out below.

1. **The name of the archetype.** The choice of the name was made by the authors to have an evocative impact on the reader and there has a communication goal. In some cases, the names are deliberately imaginative with the aim of engaging the reader.
2. **The list of the Wikipedia pages selected.** The pages represent the elements considered by the authors for defining the archetypes. The selection of the pages was undertaken by referring to the clusters identified by data-mining as shown in Section 3. All the archetypes are referenced at least to one group, with the exception of group 1, from which two different archetypes were created, and groups 3, 4 and 9, which all together participated in the creation of another archetype. In many cases the pages reported in the box are related to technologies, methodologies, tools: evidently the authors of Wikipedia pages related to Industry 4.0 are more interested in “hard” rather than “soft” topics, such as competencies or cultural aspects of the new paradigm.
3. **Industry 4.0 Emerging needs.** The authors presented briefly the needs that companies face when introducing Industry 4.0 applications. The needs are mainly based upon the interpretation given by the ACATECH study (Schuh, et al., 2017), which represents one of the most effective ways of understanding the new paradigm (Fantoni, et al., 2017).
4. **The archetype.** An explanation has already been provided for what is meant by “archetype” and the rationale behind the choice of the specific names. The explanation of the archetype given in this section is based upon the interpretation of the Wikipedia pages selected and on the semantic fields they refer to. An attempt was made to describe the inner nature of the individuals referable to each specific archetype, defining the peculiar traits of their mind-sets and their most marked features. The aim was also to make them recognisable in daily experience.

5. **Keywords.** The keywords are taken from the column “categories” of the clustered list of selected Wikipedia pages as shown in Section 3.2. Strikethrough in the body of the text indicates where the authors decided to delete misleading words: they were kept in to make the procedure behind this cleaning activity clear and transparent. The reasons for deleting some words were:
- They were too generic and did not characterise the archetype;
 - They were too specific, reducing the archetype’s scope;
 - Even if they survived the “cleaning” after the data-mining, they were referred to another semantic field (disambiguation).

The Architect

The Wikipedia pages selected: Big data; Data blending; Data quality; Cognitive computing; Data fusion; Data science; Unstructured data; Data lake; Data set; Data; Data lineage; Data transmission; Radio-frequency identification; Data philanthropy; Datafication.

Industry 4.0 Emerging needs

When making a decision in the Industry 4.0 paradigm it is important that the individuals can access, collect and process data and information. Data can be gathered from machinery, equipment and tools using sensors, actuators and information processing systems, linked to a communication layer. Big data is a buzzword usually linked to Industry 4.0. It describes mass data that cannot be analysed through common procedures instead requiring advanced applications and technologies. Thus, in the new paradigm, it is important to collect and process data in an innovative way and shape them into a form that makes them usable for the company decision-makers and other employees.

The archetype: the Architect

Architects are the individuals that are at ease in managing, transforming and processing data. They have a clear idea of the importance of the data and understand which data are useful, in which context and for whom. The Architect likes formalised information and the possibility of shaping it, has an innate capacity to breakdown problems and finds the best solutions to them: this capacity is fundamental when having to deal with different sources of information and numerous data and inputs. They are precise and reliable and have a great aptitude for visualisation and problem solving.

Key words: big data; data management; transaction processing, artificial intelligence; cognitive science; data; information technology management, computer data, automatic identification and data capture; ubiquitous computing; big data, types of analytics, online analytical processing.

The Prophet

The Wikipedia pages selected: Analytics; User behaviour analytics; Business analytics; Data mining; Data analysis; Continuous analytics; Machine learning; Data visualization; Cultural analytics; Predictive analytics; Natural language processing; Customer analytics; Business intelligence; Analytic applications; News analytics; Statistics; Behavioural analytics; Predictive engineering analytics.

Industry 4.0 Emerging needs

The implementation process of the Industry 4.0 paradigm involves different stages. At one advanced stage of this process the company should be able, starting from the data collected, to simulate future scenarios and select the one most likely to occur (Schuh et al., 2017). To do so the company needs to have analysed and assessed several data and projected the “digital shadow” of its assets into the future. Forecasting and the recommendations based on it become the key elements when developing the company. Analysis of the different scenarios is the basis for building business success. To reach these targets it is necessary to have constructed proper “digital shadows” of the assets and have understood the interactions between them.

The archetype: The Prophet

The Prophet is an individual with strong analytical thinking skills, who is able to critically examine specific situations in detail. A Prophet will have a future-oriented mind-set. They are at ease when thinking about the next steps or possible future scenarios with medium-to-long-term vision.

Starting from the analysis of data and adoption of statistical methods, the Prophet investigates the problems (creative thinking) and identifies possible solutions (complex problem solving) in order to reach the best case scenario.

Key words: analytics; business intelligence; business terms; financial data analysis; actuarial science; prediction; statistical analysis; types of analytics; financial technology; mathematical and quantitative methods (economics); research methods; statistical charts and diagrams; visualization (graphic); applied data mining; business analytics; market research; marketing performance measurement.

The Perfectionist

The Wikipedia pages selected: Industrial control system; Instrumentation; Control valve; Overall equipment effectiveness; Enterprise resource planning; Distributed control system; Control system; Lean manufacturing; Total productive maintenance; Programmable logic controller; Risk; Control System Security; Control loop.

Industry 4.0 Emerging needs

Since the First Industrial Revolution, improvements in quality have been one of the critical aspects for developing any business. In the current age of high competition and mass production, this has become, along with price strategies, the main element in expanding a company's market. Thus, quality control has become a central issue to consider before establishing any industrial undertaking and the best way to ensure good allocation of resources and highest level of production. In the Industry 4.0 paradigm quality has become even more important. This is mainly because machinery, processes and procedures have become increasingly more flexible. This allows businesses to intervene continuously to analyse the parameters and identify in advance machine faults or quality issues with a high degree of confidence. Flexibility and agility (which denotes the ability to implement changes in real-time, including changes to the company's business model) are two key factors that allow for a constant improvement.

The archetype: the Perfectionist

The Perfectionist is the individual who is never satisfied with actual conditions: it could be his/her current personal situation, their preparation for an exam, or the functioning of a process or machinery. They think that things could always be done better in a shorter time, with less resources, involving different teams, and by collaborating more (or less). Perfectionists like tests: they will test, monitor, and check the results, think about it (possibly analysing data and empirical results) and then suggest - or decide - how to make things work right.

Key words: control engineering; telemetry; lean manufacturing; automation; control theory; systems engineering; systems theory; programmable logic controllers; measuring instruments; sensors; ERP software; enterprise resource planning terminology; information technology management; management; production and manufacturing; management terms; management; process management; production and manufacturing; control devices; business terms; commercial item transport and distribution.

The Geek

The Wikipedia pages selected: Cloud computing; Smart grid; Productivity; Cyber manufacturing; Artificial intelligence; Embedded system; Cyber-physical system; Cybernetics; system; Manufacturing; Computer network; Cloud manufacturing; Computer security; Internet of things; Information technology; Distributed computing; Service-oriented architecture; Automation; Adaptable robotics; Automation Technician; Developmental robotics; Industrial Engineering.

Industry 4.0 Emerging needs

Besides the aspects related to a new organisational structure and a different work culture, Industry 4.0 is strongly determined by new technologies, both hardware and software. It is impossible to implement the Industry 4.0 applications without considering the technical aspects. The company must know of the enabling technologies (Clouds, Augmented reality, Simulation, IoT, etc.) in order to make the new paradigm real. There are so many specific technologies that it is important to have some knowledge of all of them (even if not deep) and be able to integrate them when trying to find the most effective custom-made solution for a specific problem.

The archetype: the Geek

The Geek is the archetype of an individual extremely passionate about new technologies and their applications. They are interested in everything new and innovative, and in thinking outside-the-box: how technological applications work, why and to what extent their capacities can be used. Integration is always an important aspect: the Geek enjoys taking things apart and recombining them to produce something new and improved. They have a kinaesthetic learning style (or tactile learning style) and approach to their work. They test (rather than think or plan), pilot solutions (rather than have someone else do the job) and works in the field. The geek is always up-to-date on the newest technology and willing to be the first to create something new. As there were numerous pages referable to the Geek, the authors decided to create three different nuances represented by three different logos, one for each field of expertise of “the Geeks”.

Key words: emerging technologies; internet of things; computers; information-theoretically secure algorithms; information technology; media technology decentralisation; distributed computing; enterprise application integration; service-oriented (business computing); software design patterns; web services; cloud computing; cloud infrastructure; big data; industrial revolution; industrial automation; industrial computing; technology forecasting; computer systems; industrial computing; industry; manufacturing; computer systems;

physical systems industry; manufacturing ambient intelligence; emerging technologies; smart grid; artificial intelligence; computational fields of study; computational neuroscience; cybernetics; formal sciences; technology in society; unsolved problems in computer science; cybernetics computer networking; computer networks; telecommunications engineering; computer network security; cybercrime; e-commerce; information governance; secure communication; security technology; economic growth; industry; production economics; electrical engineering; embedded systems; cloud computing; automation; engineering disciplines; adaptable robotics; robot kits; robotics stubs; industrial automation; technicians; machine learning; robot control; engineering disciplines; industrial engineering; operations research; production and manufacturing.

The Investigator

The Wikipedia pages selected: Root cause analysis; A3 problem solving; Failure mode and effects analysis; Quality control; Business process mapping; Forensic engineering; Business process; DMAIC; Incident management; Value stream mapping; Design of experiments; Pareto chart; 5S (methodology).

Industry 4.0 Emerging needs

The Industry 4.0 paradigm enables a constant check on procedures, processes and systems. This is because they are all integrated and all the information is transferred to the same repository (the communication layer). All these aspects can then be monitored in a totally new way: it is possible, for example, to have data in real time. This means decisions can be made according to information which can be transferred almost at the same time, they are created by one or more devices or tools. As a result of the high amount of information than can be analysed, mistakes can be treated differently. In Industry 4.0 it will be easier to focus on and investigate the cause of a failure and solve them, rather than finding out who is to blame.

The archetype: The Investigator

The Investigator is naturally curious: as a proper scout they want to understand what is working and what is not. They are never satisfied with the explanation they receive and are always searching for a mistake, a bug or another way of reaching the same conclusion. The Investigator is eager to analyse what is already known and what is new. They like going into detail, understanding how things work and how they could work in a different way. When identifying a problem Investigators are not necessarily interested in finding the fix. Instead they prefer to find another problem to break whilst someone else searches for the solution (that they can analyse).

Key words: business terms; problem solving; production and manufacturing; quality; quality management; six sigma; design for x; management; quality control; statistical process control; business process; enterprise modelling; process management; lean manufacturing; commercial item transport and distribution; inventory; Japanese business terms; lean manufacturing; methodology; process management; quality control tools; business process; data management; design of experiments; experiments; industrial engineering; quantitative research; statistical theory; systems engineering; reliability analysis; reliability engineering; systems analysis; engineering disciplines; engineering failures; materials science; disaster preparedness; enterprise modelling; categorical data; statistical charts and diagrams.

The Strategist

The Wikipedia pages selected: Value chain; Core competency; SWOT analysis; Business model; Delta Model; Strategic management; Balanced scorecard; Game theory; Strategic planning; Control (management); Porter's five forces analysis; Strategic thinking.

Industry 4.0 Emerging needs

If Industry 4.0 allows companies to foresee different scenarios based on data and information, it does not guarantee that the entrepreneurs will select the right one or make the correct decision. Data should be read correctly, but the strategy for reaching the preferred scenario should also be decided in the proper way. In particular, one of the largest risks is not being able to redefine the company business model properly, which should be constantly monitored, assessed and, according to the most updated information, modified.

The archetype: the Strategist

The Strategist is the individual who has an open mind: they consider the outcomes of each activity and reflect on the different ways for reaching the target. Strategic thinking, strategic management and planning are their most marked qualities: they like thinking about all the possible outputs in a comparative way. They are also pragmatic given that starting from the analysis of the current situation they do not like to consider different scenarios (as the Prophet does) but rather reach the result established in the most effective way. Even if Strategists are not entrepreneurs, they have some of their qualities and therefore this archetype can be referred to the entrepreneurial mind-set. The Strategist is a visionary, a risk-taker, creative, has a strong willingness to challenge the *status quo* and has diplomatic and leadership skills.

Key words: distribution (business); process management; supply chain management; value proposition; business models; management; strategic management; types of

marketing; business planning; business software; business terms; management; control theory; artificial intelligence; game theory; mathematical economics; business terms; strategic management; business intelligence; strategy; systems thinking.

5. Conclusions

The present work can be considered the first step in a long journey. As stated in the introduction, the archetypes use the etymological definition - as original models - and assume that they are emerging in the digital economy. As a result of the data-mining exercise clusters of Wikipedia pages were able to be placed in a graph, and analysed according to their contents. The archetypes were then positioned on the graph.

Recurrence of the same pages in almost all of the clusters led to the conclusion that some topics are common to all the archetypes, and independent of the cluster they originated from. For example, being able to read and exploit data is a transversal issue and all the archetypes (and all the workers referable to them) should be able to work around this. Another constant in all clusters is the reference to technologies. Technologies are central to the new paradigm and understanding them is unavoidable for a worker. Even if the Fourth Industrial Revolution does not end with a bunch of IT tools, they are central to the new paradigm and workers must be able to use them (Cerveli et al., 2017).

To conclude and anticipate further developments, an interpretation of the position of the archetypes on the graph is provided in Figure 4. The Archetypes can be clustered according to the general company functional areas they might be found in. The areas are as follows.

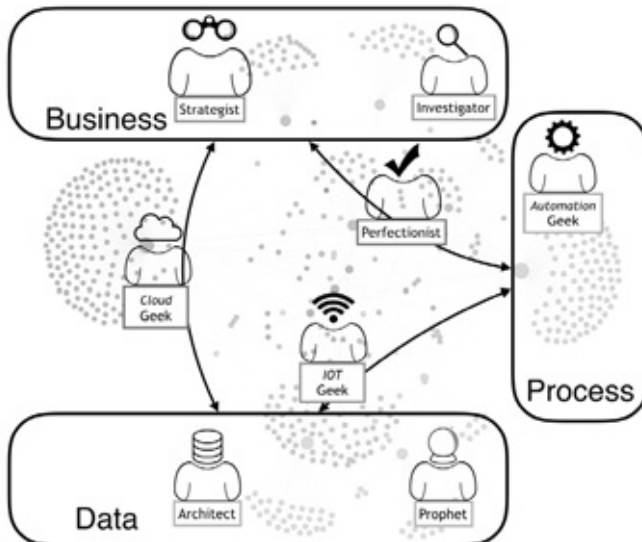
- **Business.** The Strategist and the Investigator are the main actors. In this area the decision regarding the future and strategy of the company is taken. It is important to have people who understand the bigger picture. (the Strategists) and are good at analysing the situation for what it is (the Investigator).
- **Data.** The Architect and the Prophet fit well here. This area is referred to as the acquisition, collection and management of data. This area is perfectly suitable for someone who is comfortable in analysing and structuring data (the Architect) and for someone who has a future-oriented mind-set, always based on the actual inputs coming from the company functions (the Prophet).
- **Process.** The Geek (automation) is the only major player in this area. The process area is where the core activities of a company are performed.

The connection between the three areas is ensured by three archetypes:

1. The Perfectionist is the bridge between the process area and the business area: in both areas it is useful to have someone who is comfortable with solving problems and making things work better;
2. The Geek (cloud) is the bridge between the data area, where they will contribute their knowledge of technologies, and the business area, where archetypes benefit from these technologies for new business development;
3. Finally, the Geek (IoT) is the connection between the process area and the data area, representing the bridge between the core activities and the usage of information generated by them.

A possible next step of the study will be identifying which function of the Porter value chain model each archetype suits better. Having placed the Archetypes in their most suitable function, it will then be possible to allocate the most appropriate 4.0 professional/job profiles to each archetype, to follow their attitudes and exploit their skills further. As noted in the introduction, this is very much a first step.

Figure 4 - the archetypes grouped by business areas



Note: The image also shows the strategic roles of the perfectionist, cloud geek and IOT geek, who represent the bridges between different functions

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Workers 4.0: skills, profiles and jobs in different business functions

Silvia Fareri, Filippo Chiarello, Elena Coli, Diego Teloni, Giancarlo Dente, Gualtiero Fantoni

Introduction

The term “Industry 4.0” refers to a new production paradigm, radically different from the previous ones because of its global scope and its certain (if not clearly defined) impact on social, economic and political structures. The key characteristics of the Industry 4.0 includes the integration of electronics and computer science observed in machine to machine communication (nowadays known as the Industrial Internet of Things), the possibilities opened up by cloud computing, the opportunities to explore big data, and augmented and/or virtual reality made possible by the past investments in computer games. The need to manage the use of these new technologies is likely to bring about a radical change in the design of products, how they are produced and, concomitantly, the organisation of work. This suggests that consideration needs to be given to the skills needs that are likely to arise. While predicting emerging skills needs from Industry 4.0 is still in its infancy, it is vitally important that steps are made to identifying those skills which people will need in the future.

This chapter builds upon the previous one by Fantoni and his colleagues to:

- (i) Identify where, according to the Porter value-chain model, the effects of Industry 4.0 will take place; and
- (ii) Building on (i) identify the basic competences associated with the emerging job profiles resulting from Industry 4.0.

After having identified and clustered competences by using text mining techniques, the chapter analyses how competences are distributed among company functions (i.e. marketing, sales, production, design, R&D, maintenance, etc.).

Data are drawn from Scopus – the abstract and citation database – and O*NET. These provide information on emerging job/professional profiles and associated skill profiles respectively. Porter’s value-chain describes the structure of an organisation as a limited set of processes; it is divided into nine main processes, five

primary and four supports. The primary processes are those which directly contribute to the creation of output, while the supporting ones are necessary for the latter to be produced. Using this model it is possible to identify the functions within organisations most affected by Industry 4.0. The result is a matrix that cross-classifies workers' Industry 4.0 job profiles by business functions. From the analysis it is possible to notice not only where the new skills will have a particular impact, but also which are the professional profiles associated with them and in which business area they will contribute most.

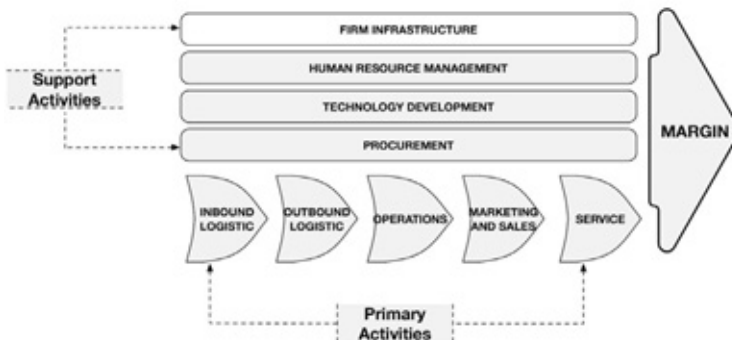
2. Industry 4.0, business functions, and skills

2.1 The Value Chain

The epochal phenomenon “Industry 4.0” is radically changing the existing social and economic structures that characterise the global market (Last, 2017). Indubitably, the future demand for skills will be conditioned by industrial innovation and the increasingly radical integration of new technologies. The earlier chapters in this book by Pouliakas and Suta et al., respectively, indicate the scale of change resulting from rapid technological change. What is of particular interest here is not only the capacity of new technology to substitute for existing jobs but, importantly, create new jobs the profiles of which are only just beginning to emerge (Rainie and Anderson, 2017). These new emerging job profiles are referred to as 4.0 Professional Archetypes. But where do they exist in the value-chain?

In the economics literature, a “value chain” indicates the set of activities that a firm performs in order to create a profitable product or service for the market (see Figure 1). In particular, Porter’s value-chain represents an universally recognised model that identifies and measures where firm’s add value (Porter, 1985).

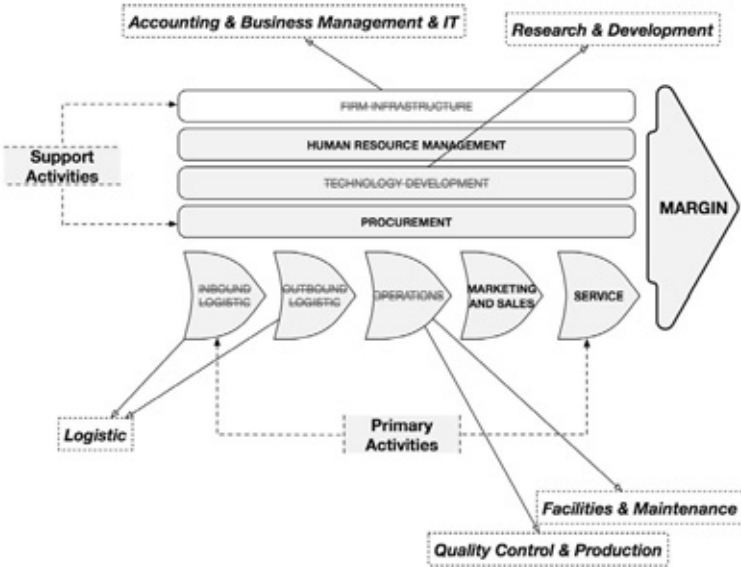
Figure 1 - Porter’s Value Chain



The primary activities are the ones that directly contribute to create firm's value; whereas the support activities are necessary to create a product or to develop a service. Finally, the margin is given by the difference between the value created and the sustained costs of creating that value (mindtools.com, 2015).

Assuming that not all the value-chains are designed the same way, but need to be adapted in respect of a particular case (Olhager, Selldin and Wikner, 2006), the starting point of our research was that of finding a way to rethink the Porter's value-chain and find a way to homogenise functions¹. For this reason similar activities (i.e. logistics) were unified into one, while the biggest ones (i.e. operations and firm infrastructure) were been divided into multiple functions (see Figure 2). In the end, the function "technology development" was renamed as "research & development".

Figure 2 - Rethinking Porter's Value chain - 1

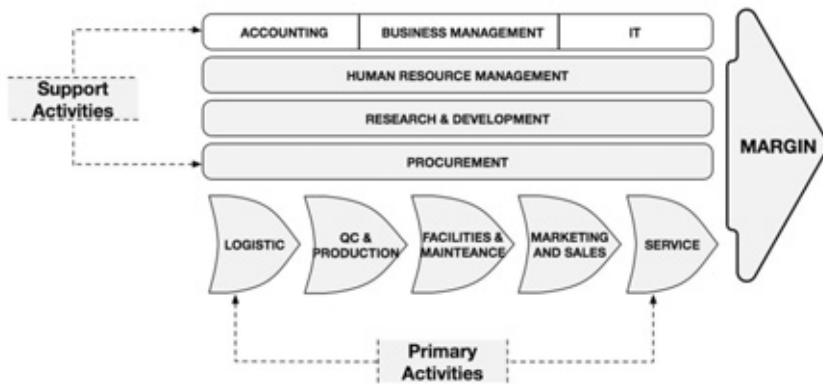


The new concept of Porter's value-chain - see Figure 3 - shows a greater number of business functions, with a finer declination of both "Operations" (divided

1. Thereby making them searchable by our search engines and useful for our NLP algorithms (please, refer to the next paragraphs).

between “Quality control & Production” and “Facilities & Maintenance”) and “**Infrastructure**” (divided on “Accounting”, “Business Management” and “IT”). “**Quality Control & Production**” represents the convergence between the productive processes and all the activities which ensure customers receive products free from defects and meet their needs. On the other hand, “**Facilities & Maintenance**” represents all the industrial machineries and the procedures for their optimal maintenance. The “**Inbound Logistic**” and “**Outbound Logistic**” functions have been collapsed into one, in order to optimise the analysis results.

Figure 3 - Rethinking Porter's Value chain - 2



2.2 Text mining process and tools

Text mining is the semi-automatic process of extracting knowledge from text. The automatic analysis of text is called Natural Language Processing (NLP). The NLP approach usually involves the execution of a software pipeline composed of steps with the aim of extracting information from text. A standard NLP tool includes the following steps:

1. Sentence Splitting and Tokenisation: these steps split the raw text into sentences and then segments each sentence in orthographic units called tokens;
2. Part Of Speech Tagging: is the step in which unambiguous grammatical categories are assigned to tokens;
3. Syntactic Parsing: is the step which computes the parse tree of sentences and the syntactic relations between tokens in a sentence;

4. By exploiting the information obtained by these steps, several information extraction tasks can be solved by other NLP tools such as:
 - i. Term extraction: the task of automatically extract relevant terms from a given corpus. Part of Speech Tags are typically used by term extractors to narrow the terms search to a predefined term structure;
 - ii. Relation extraction: the task of automatically build relations among entities in the analysed text. In this context entities can be named entities or extracted terms. In addition, the syntactic role of the entities can be exploited to better categorise the relation type (e.g. subject, object).

The main problem of NLP approaches is that technical domain language, as with other linguistic domains, suffers from linguistic ambiguities. For instance the word “support” can have two totally different meanings when used as a noun or as a verb. By using part of speech taggers which are able to disambiguate the morphological role of each word in a sentence, more precise information extractions are possible and can be used in several applications (e.g. paper search engines).

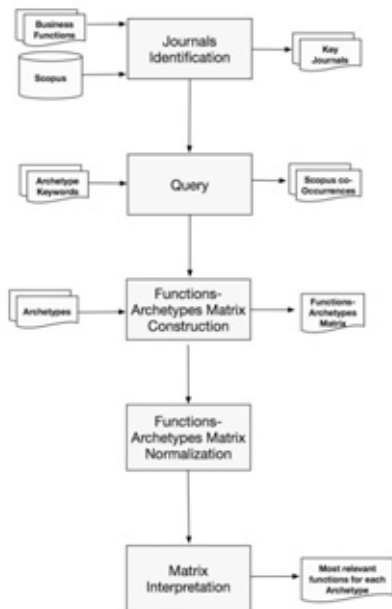
These approaches have shown great success in different fields of research such as mining and summarising customer reviews (Hu and Liu, 2004), the study of social media (Hong and Davison, 2010) and patent analysis (Tseng, Lin, and Lin, 2007). Also the literature on automatic information extraction from papers is growing and aims to solve multiple issues such as systematic reviews (Lefebvre, et al, 2013), duplicate publication detection ((Labbe and Labbe, 2013), and bibliometrics (Garousi, and Mäntylä, 2016). In the previous chapter by Fantoni et al., the authors extracted and categorised business intelligence and big data skills using text mining techniques and using job offers as a source. This chapter is an evidence of the fact that text mining tools are suitable for the extraction and classification of skill related information. In the current chapter we will use similar techniques but applied to paper documents.

3. Methodology

The workflow we developed is shown in Figure.4. The Porter value-chain provides a series of terms. The analysis of their distribution among journals (indexed in Scopus) allowed us to select the journal most specific for each company function/business area. After such a choice a query was built on the basis of the terms characterising each 4.0 archetype/4.0 worker’s profile. The analysis of the distribution of such terms among business areas allowed us to measure the impact of each profile on a specific business area. The result is a matrix that con-

tains profiles versus business function. Further operations such as normalisations allowed us to better interpret the results.

Figure 4 - Workers 4.0 research workflow



We define a “**lexicon**” as a “list of notable terms in relation to a specific topic, frequently used as a tool to support data mining and word recognition processes”. In the present chapter, the lexicon terms used to characterise and to unequivocally identify the proposed six professional archetypes. Such archetypes derive from a previous work performed by Fantoni et al. as revealed in the previous chapter (see in particular Figure 2 and Table 2 in the previous chapter).

In the previous chapter by Fantoni et al, the following professional archetypes were constructed to illustrate the types of roles individuals play within an organisation and their associated skill sets. To recap these were:

1. Data Architect;
2. IT Architect;
3. Prophet;
4. Perfectionist;

5. Geek;
6. Investigator;
7. Strategist.

In the next section evidence is provided of the extent to which these are distributed across different functions of the firm.

4. Analysis

4.1 Correspondence between Business Functions and Journals

The present paragraph concerns the identification of a correspondence (if any) between the revisited Porter's Business Functions and the Journal categories on Scopus. In this regard, we exploited the "ASJC Code"² which allowed us to perform advanced searches, focusing on a particular search field. The chosen ASJC Codes could be found in Table 1.

Table 1 - Correspondence between Journal categories and Business Functions

Business Function	ASJC Code	ASJC Definition
Accounting	1402	Accounting
Business Management	1408	Strategy and Management
IT	1710	Information Systems
Quality Control & Production	2213	Safety, Risk, Reliability and Quality
Facilities & Maintenance	2209	Industrial and Manufacturing Engineering
Logistic	1404	Management Information Systems
Marketing	1406	Marketing
Service	1802	Information Systems and Management
Procurement	1401	Business, Management and Accounting
Human Resource Management	1407	Organizational Behavior and HRM
Research & Development	1405	Management of Technology and Innovation

After that, two key processes were automated: 1) the query construction and 2) the search construction.

2. i.e. All Science Journal Classification.

3.2 The Function-Archetype matrix

The standard query structure was the following one:

("keyword_1" OR "keyword_2" OR "keyword_3" OR ... OR "keyword_n") AND SUBJTERMS(ASJC_CODE)

Each lexicon had been cross classified with each business function; the searches produced occurrence values automatically collected by machine. In the end, the process output was a 7x11 Function-Archetype Matrix (FAM), represented in Table 2.

Table 2 - The Function-Archetype Matrix

BUSINESS FUNCTION	ACCOUNTING	BUSINESS MANAGEMENT	IT	QC & PRODUCTION	FACILITIES & MAINTENANCE	LOGISTIC	MARKETING	SERVICE	PROCUREMENT	HRM	R&D
ARCHETYPE											
DATA ARCHITECT	12722	56820	202735	53524	156359	23068	21152	49585	9308	19132	40473
IT ARCHITECT	776	12893	68712	12649	39021	11739	2574	20421	1320	1509	12164
GEEK	4064	32302	85862	31473	135785	10533	5365	26411	4161	5076	21284
INVESTIGATOR	1694	26002	25782	24012	49949	7258	2486	14023	2290	1685	9629
PERFECTIONIST	14405	32251	55584	77307	97651	10129	7219	20581	5064	6117	18746
PROPHET	1383	10714	49385	19292	24671	6385	2876	12877	1680	2081	8572
STRATEGIST	4707	45053	28802	14902	61194	15373	18390	20536	4994	4939	32809

To facilitate the FAM interpretation, first **columns** and then **rows** have been normalised.

$$X_{i\text{norm}} = \frac{X_i - \min(X_1 \dots X_n)}{\max(X_1 \dots X_n) - \min(X_1 \dots X_n)}$$

Considering business functions one by one, each archetype value varies between 0 (minimum significance) and 1 (maximum significance) – see Table 3.

Table 3 - The normalised Function-Archetype Matrix

BUSINESS FUNCTION	ACCOUNTING	BUSINESS MANAGEMENT	IT	QC & PRODUCTION	FACILITIES & MAINTENANCE	LOGISTIC	MARKETING	SERVICE	PROCUREMENT	HRM	R&D
ARCHETYPE											
DATA ARCHITECT	0,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
IT ARCHITECT	0,00	0,15	0,76	0,00	0,34	1,00	0,01	0,64	0,00	0,00	0,35
GEEK	0,13	0,45	0,27	0,11	1,00	0,14	0,00	0,31	0,29	0,07	0,35
INVESTIGATOR	0,35	0,60	0,00	0,73	1,00	0,27	0,00	0,16	0,63	0,05	0,17
PERFECTIONIST	1,00	0,36	0,00	0,76	0,46	0,07	0,10	0,05	0,36	0,11	0,18
PROPHET	0,33	0,00	1,00	0,62	0,00	0,00	0,16	0,00	0,34	0,24	0,00
STRATEGIST	0,32	0,87	0,00	0,01	0,31	0,64	1,00	0,23	0,53	0,21	0,89

For each row, the **significance threshold** was **set over 0.6**. With the exception of the “Data Architect”, we did not select more than three relevant business functions for each archetype. Table 4 shows the most relevant archetypes by business function (i.e. the figures in bold type).

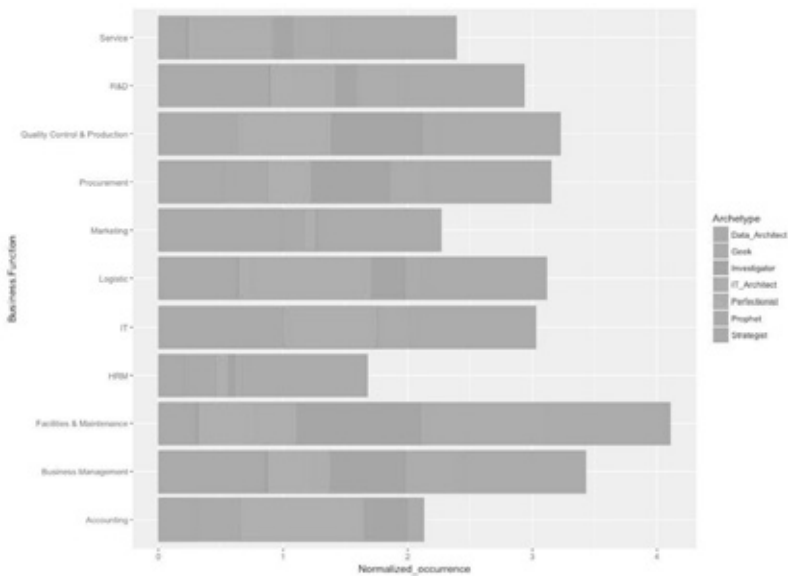
Table 4 - Selection of the most relevant values on the Function-Archetype Matrix

BUSINESS FUNCTION \ ARCHETYPE	BUSINESS FUNCTION										
	ACCOUNTING	BUSINESS MANAGEMENT	IT	QC & PRODUCTION	FACILITIES & MAINTENANCE	LOGISTIC	MARKETING	SERVICE	PROCUREMENT	HRM	R&D
DATA ARCHITECT	0,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
IT ARCHITECT	0,00	0,15	0,78	0,00	0,34	1,00	0,01	0,64	0,00	0,00	0,35
GEEK	0,13	0,45	0,27	0,11	1,00	0,34	0,00	0,31	0,29	0,07	0,35
INVESTIGATOR	0,35	0,60	0,00	0,73	1,00	0,27	0,00	0,16	0,63	0,05	0,17
PERFECTIONIST	1,00	0,36	0,00	0,78	0,46	0,07	0,10	0,05	0,36	0,11	0,18
PROPHET	0,33	0,00	1,00	0,62	0,00	0,00	0,16	0,00	0,34	0,24	0,00
STRATEGIST	0,32	0,82	0,00	0,01	0,31	0,64	1,00	0,23	0,53	0,21	0,88

5. Workers 4.0 roles in different Porter’s business areas

When the professional archetypes are cross-classified by the different business functions, the predominant presence of the “Data Architect” is clear. The other figures/profiles tend to be equally distributed among the business functions, with at least one and a maximum of three peaks on their most representative areas. Figure 5 also shows how the professional archetypes are distributed across business functions.

Figure 5 - Archetypes cumulative occurrences on business functions



The Data Architect

Surprisingly, the first architect is probably the **most relevant** archetype: it strongly impacts upon every business function with the same strength. It may be defined as the “**Architect of Change**”, the one who plans, acts and manages the 4th Industrial Revolution implementation across the whole organisation. However another possible explanation is that such behaviour could represent a signal of too many competences assigned to a single profile, therefore future work could be oriented to disentangle the two or more profiles hidden behind the Data Architect.

The IT Architect

The IT architect has a particularly strong impact on logistics and IT, and he or she in all likelihood is used as support on the management of information and materials. For this reason, the “IT architect” may be also defined as the “**Supply-chain Architect**”, the one who has the entire responsibility of the logistic/information chain.

The Geek

The Geek has two peaks: in “Business Management” and “Facilities”. The last one, in particular, categorises the archetype as the “**Technology and Communication Archetype**”; the person who has responsibility over automation and who is strongly connected to machines and communication technologies.

The Investigator

The Investigator markedly impacts on “Facilities” and “Quality Control”. For this reason, the person filling this role is probably in charge of detecting, recognising and solving failures. Moreover, it could be considered as a bridge between “Quality Control” and “Facilities”. Thus, it could be categorised as “**Non-conformity Detection Archetype**” or “**Quality Control & Machines Archetype**”.

The Perfectionist

The Perfectionist is, of course, inseparable from The Investigator. He or she has, in the same way, a strong impact on “Facilities” and “Quality Control” but has the most relevant occurrence in “Accounting” (actually bigger than that of the “Data Architect”). Moreover, this role could be defined as a bridge between “Methods” and “Money”, the person who has to continuously improve business and operative processes. Thus, it easily becomes the “**Improvement Archetype**”.

The Prophet

The Prophet is particularly relevant in “IT” and “Production”; thus, this role most likely represents the bridge between “Machines” and “Materials”. He/she is the fine master of predictive analysis and IT technologies and is the one who

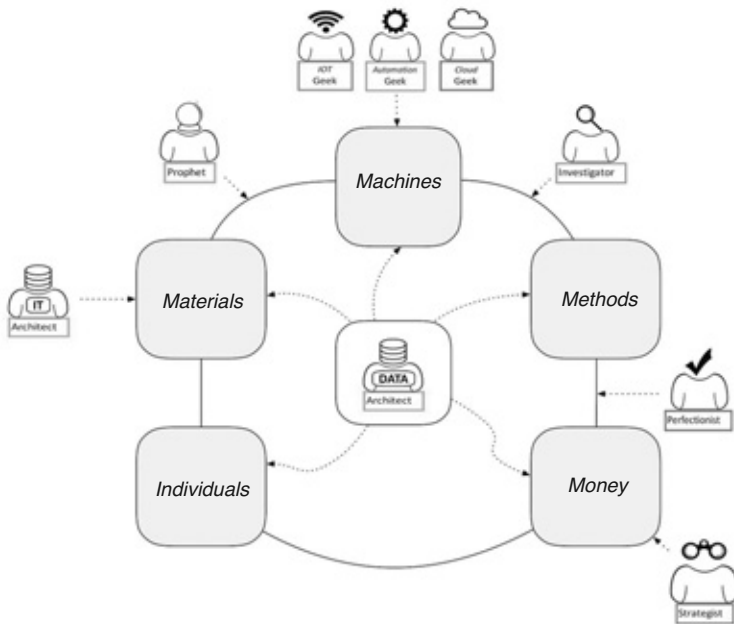
provides for production needs. For all of these reasons, he/she could be called the “**Production Data Miner Archetype**”.

The Strategist

The Strategist has a strong impact on three business functions: “Marketing”, “Business Management” and “R&D”. The person fulfilling this role is clearly the “business manager”, the one who has the objective of increasing sales through a continuous “Research & Development” process and thorough and intensive market analysis. Thus, it requires someone who can combine the roles of businessman, data analyst, and researcher at the same time. In the end, the role could be considered the “**Digital Businessman Archetype**”.

In a simple way such archetypes could be represented according also to the 5M model as shown in Figure 6. Perhaps it does not supply any new relevant information: profiles are close to the machines, use methods to improve the opera-

Figure 6 - “Proposal Archetype’s positions on 5M model”. The image summarizes the remarks made for each archetype, linking them to the correspondent “M” class



tions and the business, exploits data to better manage the flows of materials, energy and information. However such a big revolution seems to miss a key profile: the one able to understand the human resources in the new 4.0 era. Is this something we have missed in our work? Is the dataset under-representing such problem? Future work will be oriented to discover the reasons and which new skills such profile should have.

6. Conclusion and Future Developments

The present work should be seen as the second step of a long journey. As stated in introduction, the need to identify the professional/job profiles emerging as a consequence of Industry 4.0 is increasing. The data mining exercise presented in this chapter has sought to identify the skills and job profiles that will increasingly come to the fore as Industry 4.0 technologies become more commonplace. The analysis here, based on Porter's value-chain model, has been able to demonstrate the extent to which professional job profiles are associated with certain functional areas of a business. The analysis identified the "Data Architect" as the "Architect of Change", a role which will have a central and strategic role during the transition to the digital era. As noted above this is just the start of the research process. The next stage of the research will be to increase the level of detail with respect to professional profiles.

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Just-in-time? Meeting employer STEM skill needs through apprenticeship training in England

Lynn Gambin and Terence Hogarth

1. Introduction

The Government has indicated that the future of the UK economy rests in large measure on the performance of its advanced manufacturing sector (BIS, 2013). The future success of the sector is dependent upon many factors, not least of which is its capacity to capture the skills needed to develop the new products and processes which will secure UK producers an increasing share of high value segments of the global market (BIS, 2013). Achieving this will depend upon higher level skills typically supplied through higher education but, as will be discussed below, will also depend upon meeting a substantial demand for intermediate level skills typically supplied through apprenticeships.

While task-based technical change has seen many intermediate level jobs disappear – the disappearing middle of the occupational hierarchy – this is not so much the case in manufacturing where the demand for intermediate level skills, as a share of the overall demand for all skills, has remained more or less constant over the past twenty to thirty years (McIntosh, 2013). The pace of technical change in the manufacturing sector, along with an ageing workforce in which many skilled craft workers and technicians are set to retire over the next decade or so, suggests that meeting even short-term skill requirements may prove difficult (Wilson and Hogarth, 2013). Or so it would seem. Other evidence indicates that the supply of STEM (science, technology, engineering and mathematics) skills overall, at both graduate and intermediate/apprenticeship levels, is keeping pace with current employer demand (Bosworth et al., 2013; McCaig et al., 2014). These two perspectives are not necessarily inconsistent. If the UK's advanced manufacturing sector were to develop along the lines advocated by policymakers by shifting increasingly to higher value sectors of production, then skills supply may well prove to be a formidable barrier to achieving this. On the other hand, if the manufacturing sector simply continues along current lines, then skill demand may well be readily satisfied, albeit at what might be considered a socially sub-optimal level.

In this chapter, the factors that guide employers' decisions to invest in engineering apprenticeships are considered, along with the implications of this for the future supply of intermediate level skilled employees in the manufacturing sector. In this exposition, intermediate level skilled employees are defined as those working in associate professional or skilled trades jobs – as defined by the Standard Occupational Classification (SOC) – and who are working in an engineering or related discipline. Alongside this overarching aim, the chapter explores:

1. Whether the current supply of engineering apprentices is sub-optimal in some way;
2. The way in which manufacturing employers are able to balance the risk of investing in Apprenticeships and obtain a return from that investment;
3. The implications of the above for ensuring that there is an appropriate level of skills supply to meet the needs of the sector.

In exploring these issues, one can observe the extent to which the supply of intermediate level through STEM apprenticeship programmes tends to achieve a 'just-in-time' equilibrium – fulfilling employer present skill requirements with relatively little longer forward planning. This 'just-in-time' approach to skills supply might eventually prove a constraint on future growth.

2. The demand for STEM skills

Skill shortages, however defined, have acted as a drag on economic growth in the UK economy over recent decades. During the 1980s and 1990s, skill shortages contributed to downturns in the economy – by pushing up wage rates and constraining output growth – and dampened growth in the recovery period following economic recession (Blake et al., 2001). Many of these skill shortages were for skilled labour in the manufacturing sector and were likely to have inhibited the pace of technical and organisational change in the workplace (IFF Research, 1998; Daniel and Hogarth, 1992; Hogarth, 1994). Skill shortages at this time were driven, at least in part, by a vocational education and training (VET) system characterised by under-investment in the types of skills which would allow employers to meet their current needs and, importantly, move into higher value segments of the market. Before the introduction of publicly funded Modern Apprenticeships in 1994, the apprenticeship system was considered to be especially weak insofar as employer demand for this type of training was low (Haxby and Parkes, 1989).

More than two decades later, it is immediately apparent that there are concerns that not much has changed. The press commonly reports on the shortages of skilled labour, at both graduate and intermediate levels, damaging the economic

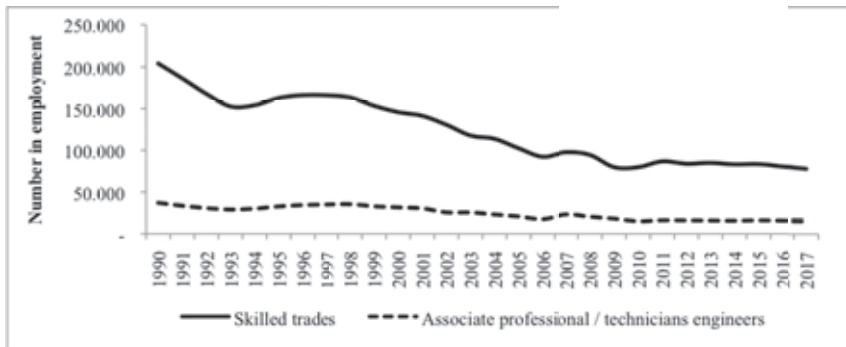
prospects of the UK's hi-tech companies. A headline in the Guardian newspaper was not uncommon in this respect. In 2010, when the economy was still in the doldrums following the 2007/8 recession, it ran the following headline "Skills shortage is getting worse, bosses warn: It's tough finding staff with science and technology skills, and as the recovery sets in, it's going to get even harder..." drawing attention to the emerging shortage of people qualified in STEM subjects (The Guardian, 2010).

Arguably the stakes are now higher than they were twenty-five years ago. The latest recession (2007/8) refocused policy and, as noted above, the Government has indicated that the performance of the advanced manufacturing sector is central in the future of the UK economy (BIS, 2013). This future success depends upon many factors, crucially the capacity of employers in this sector to capture the skills needed to develop the new products and production processes which will enable them to secure an increasing share of high value segments of the global market (BIS, 2013). The skills supplied through higher education will affect the UK's capability to achieve this but it is equally important that substantial demand for intermediate level skills typically supplied through apprenticeships also be met.

The evidence suggests that over recent decades the number of people working in science, engineering and technology occupations who would have completed an apprenticeship has declined in both percentage and absolute terms (Jagger et al., 2010; Mason, 2012). There are a variety of reasons why the number of apprenticeships in STEM subjects is low, including: the relatively high costs of training such apprentices; companies' product market strategies not requiring such skills; and the increasing availability of alternative sources of skills (e.g. overqualified graduates) (Lewis, 2014). Changes on the supply side have meant that employers have been able to increasingly recruit graduates from higher education but these do not necessarily substitute directly for the skills provided through apprenticeships. There is some indicative evidence that employers which are dependent upon STEM skills generally, and engineering ones specifically, have increasingly sought to expand the number of apprenticeships they provide with the intention of reinvigorating the role of technician within the firm (Lewis 2012a, 2012b). For some occupational groups, employers prefer the combination of theoretical education and practical application of knowledge within apprenticeships to the more theoretical education provided by a bachelor's degree. Hogarth et al. (1996) drew attention to the way in which employers in the engineering sector have traditionally segmented their apprenticeship in-take each year between: (a) the cadre from which future technicians and managers would be selected; and (b) those destined to remain as skilled workers on the shop floor. The former group tended to comprise of those considered to be most able at the end of the first year of the apprenticeship.

One way of gauging the extent to which there is a demand for apprenticeships typically associated with engineering subjects is to examine trends in employment for those occupations where entry typically requires completion of an apprenticeship. If one looks at employment in skilled trades and technicians jobs in the engineering sector one can see, from Figure 1, the long run decline in the number of people employed in these occupations. Despite the long-run decline there is still evidence of skill shortages. According to the Employers Skills Survey 2015, 8 per cent of employers in manufacturing reported that they had unfilled vacancies because of shortages of applicants with the skills, experience and qualifications they are looking for (Vivian et al., 2016). This amounts to around 13,000 skill shortage vacancies, at a single point in time, of which around 7,000 were for technicians and skilled trades workers.

Figure 1 - Number of people employed in skilled trades and technician jobs in the engineering sector, 1990-2017



Source: Authors' calculations from Working Futures data (Wilson et al., 2014).

The key issue is whether apprenticeships can satisfy employers STEM skill needs. Before providing empirical evidence it is worth considering how employers make decisions about investments in apprenticeships.

3. The employer's investment decision with respect to apprenticeships

The human capital model (Becker, 1962, 1964; Mincer, 1958; Shultz, 1961) provides a useful starting point for considering employers' decisions to train workers through apprenticeships. Apprenticeship training is seen an investment

which is expected to provide positive future returns to apprentices and their employers. The skills obtained over the training period are expected to increase the productivity, and the marginal product, of the individual.

According to Becker, in a perfectly competitive labour market, the employer will not invest in apprenticeships where the skills being accrued during training are general and transferrable to another employer. In the presence of market imperfections however, the employer may be motivated to meet at least some of the costs of training as they can, at some time in the future, realise a positive return on their investment. At the end of the training period, an apprentice's productivity is expected to be higher (however, not necessarily equal to that of a fully experienced worker) though their wage level also typically increases¹. Under imperfect market conditions, the employer can increase the former apprentice's wage but to a level lower than their post-training marginal product (Acemoglu and Pischke, 1999) thereby obtaining a net gain (though this is likely realised only sometime after completion of the Apprenticeship). The costs of recruiting a fully experienced worker from the external labour market are also foregone when an employer retains their former apprentice, again increasing the benefit of apprenticeships to the employer (Stevens, 1994).

As noted, obtaining the net benefit from an apprenticeship depends on the employer's ability to retain the former apprentice after the training period. The length of time required for the employer to achieve the net benefit post-apprenticeship is not negligible in sectors such as engineering – around three years (Hogarth et al., 2012) – thus retaining ex-apprentices is an important issue. The human resource management (HRM) perspective provides a number of reasons why employers could expect the poaching problem to be less prevalent than initially thought and further reasons why employers choose to train through apprenticeships. As noted by Lewis (2014), employer provided training is often accompanied by a range of other HR practices which are designed to maximise the employee's attachment to the employer. Nevertheless, there is still potential for other employers to poach former apprentices, thus there is a risk attached to the employer recouping their investment in the apprenticeship. Employers have an incentive to provide apprenticeships, but there is a danger that the level of investment will be lower than the socially optimal level due to the level of risk perceived by the employer.

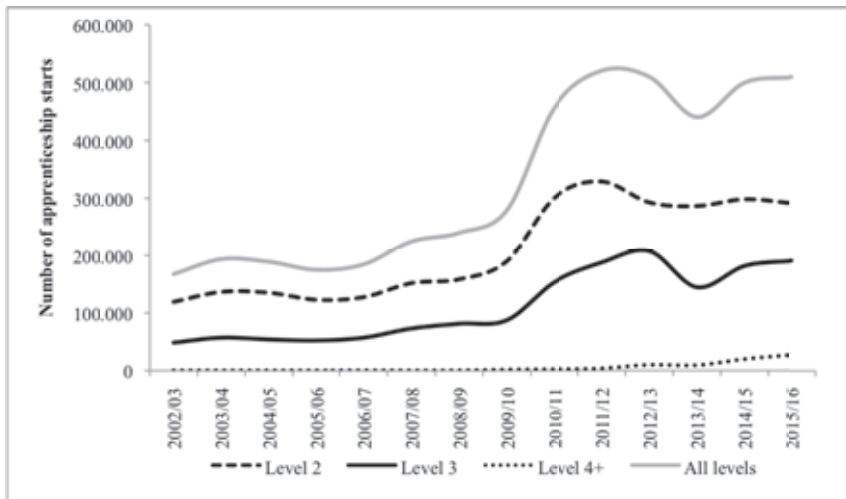
1. This can be considered the norm in the apprenticeships under consideration here, that is, advanced apprenticeships in engineering.

4. Apprenticeships and STEM skill demand and supply

The apprenticeship system following the Richard Review in 2012 has undergone a period of substantial overhaul to bring about a more demand led system. This has seen employers be given more say over the content and structure of an apprenticeship (cf. trailblazer standards) in return for which government expects them to bear an increased share of the overall cost of delivering an apprenticeship. One of the problems the apprenticeship system has faced in England has been that of increasing the number of apprentices. By making it more demand led and increasing employer influence over the content of apprenticeships, there was an expectation that this would boost participation in apprenticeships. Employers would be attracted to it because it delivered the skills they needed, and individuals would be attracted to taking up the apprenticeships on offer because of the opportunity to earn whilst learning.

Figure 2 shows the number of apprenticeship starts by level over time. At the start of the 2010s there was a substantial increase in the number of starts at Level 2 (broadly equivalent to ISCED level 2) and Level 3 (broadly equivalent to ISCED level 3). From a policy perspective, however, this was not seen as sufficient and in April 2017 the apprenticeship levy was introduced. With the introduction of the levy, employers pay 0.5 per cent of their payroll above £3m

Figure 2 - Apprenticeship starts in England, 2002/3 to 2015/16



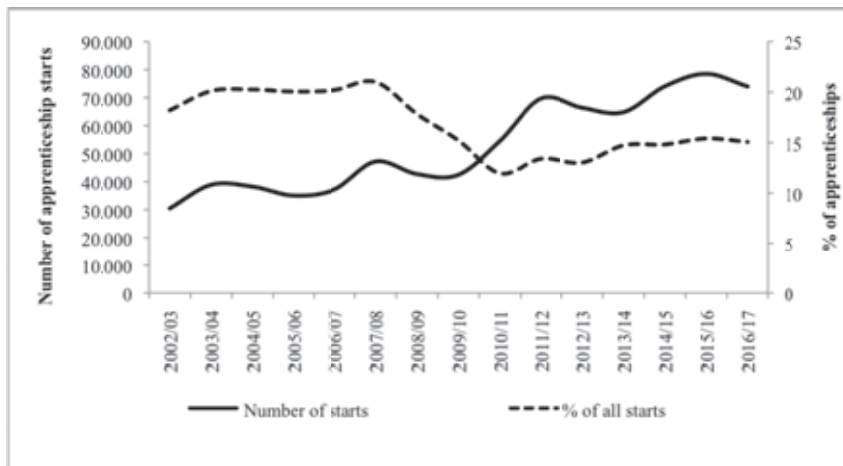
Source: DfE Apprenticeship Programme Starts by Age, Gender and Level

which can be reclaimed – at least in part – by agreeing to train apprentices. Initial evidence suggests that the levy has not brought about the expected boost to apprenticeship starts. Evidence reveals that in quarter four of 2015/16, before the introduction of the apprenticeship levy, there were 117,000 apprenticeship starts, compared with 48,000 in quarter four of 2016/17, after the introduction of the levy. The general picture as of mid-2018 is of much fewer apprenticeship starts in the period following the introduction of the levy (DfE, 2018).

One plausible reason behind the observed trend following the levy's introduction is that the return obtained from investing in the levy is insufficient to cover the costs of investing in the levy in the first instance. In other words, this has altered the cost-benefit investment decision of employers. The amount of funding which will be returned by employers which decide to train apprentices is, for many employers paying the levy, insufficient to cover the costs of training an apprentice (Gambin, et al., 2016). This is particularly so for those employers offering apprenticeships at Level 2 in sectors such as retailing, hospitality, and such like, where there is no guarantee that the apprentices will remain in the employer's employment for long after completion of the apprenticeship. So unless the employer is able to fully recover the costs of training the apprentice over the formal training period, they will be unlikely to take on apprentices. In relation to STEM apprenticeships which are typically delivered at Level 3 and above, this is much less the case. Here employers see investments in apprenticeships as a long-term investment. Accordingly, the apprenticeship levy has had much less impact on the number of starts as the share of the overall costs of delivering the apprenticeships met through the levy payment is relatively small (Gambin, et al., 2016; Gambin and Hogarth, 2016).

Figure 3 shows the number of apprenticeship starts in engineering and manufacturing technologies which provides a reasonable proxy for STEM apprenticeships. It shows that starts have grown steadily over recent years, but accounted for a gradually declining share of all apprenticeships in the pre-levy period. This reflects the fact that starts in relatively costly apprenticeships such as those in engineering and manufacturing technologies are less sensitive to government initiatives to increase the number of apprenticeship starts. The relatively high net cost to the employer of training an apprentice at level 3 in this subject – approximately £40,000 over the formal training period – means that the decision to train an apprentice is driven more by a long-term skill need (Hogarth et al., 2012).

Figure 3 - Number of apprenticeship starts in engineering and manufacturing technologies 2002/3 to 2016/17



Source: *Apprenticeship Programme Starts by Sector Subject Area*

Drawing on qualitative evidence collected in a series of employer case studies, evidence is provided about the factors which determine the employer’s investment in STEM apprenticeships. This demonstrates the way in which the net cost of training apprentices makes employers risk averse and begins to shed light on why the introduction of the levy might have relatively little impact on the number of starts in relatively high net costs apprenticeships of a kind associated with STEM.

5. Employer investment in STEM apprenticeships: case study evidence

The employer case studies drawn on here were undertaken in the manufacturing sector between 2010 and 2013, when employers were only just beginning to recover from the financial crisis in 2007/8. The case studies formed parts of larger studies commissioned by the Department for Business, Innovation and Skills and the source data can be found in Hogarth et al. (2012 and 2013). Insights are also drawn from McCaig et al. (2014)². Details of the case study employers, given pseudonyms to ensure confidentiality, are provided in Table 1.

2. The Department for Business Innovation and Skills (BIS) no longer exists with its responsibilities for skills transferred to the Department for Education.

Table 1 - Overview of employer case studies

Engineering Employer	Description	Number of employees	Type / Ownership
No. 1	Specialist vehicle manufacturer	200 (in UK)	Part of multinational
No. 2	Maintenance services to power stations	50	Independent company
No. 3	Manufacture of safety equipment	250 (in UK)	Part of foreign-owned multinational
No. 4	Maintenance and restoration of aircraft	25	Independent company
No. 5	Maintenance and manufacture of locomotives and railway equipment	500+	Part of multinational
No. 6	Manufacture of electrical control panels for heating industry	500+	Part of multinational
No. 7	Manufacture of refrigeration equipment	250	Independent company
No. 8	Design and manufacture of electrical control panels	500+	Multi-site, UK company
No. 9	Instrument engineers (electrical sensors)	500+	Part of multinational
No. 10	Vehicle manufacturer	500+	Part of multinational
No. 11	Automotive supplier of air pumps and pneumatic equipment	150	Independent company
No. 12	Specialist vehicle manufacturer for construction industry	500+	Part of multinational
No. 13	Aerospace company – repair and maintenance of aircraft	500+	Part of multinational

All of the case study establishments employed young people training towards completion of an apprenticeship in engineering at the time the research was undertaken. Each year a business case was made to senior management by the person responsible for training indicating the number of apprentices that needed to be trained in order to meet demands resulting from: (a) people about to retire (replacement demand); and (b) meeting anticipated future (expansion) demand on the shop floor. In practice employers saw little alternative to training apprentices. The external labour market was considered to be a relatively weak source of skills given recruitment costs, the wage levels experienced engineering workers could command, and the preference for employers to train their own employees such that they were steeped in the company's values. University graduates were also considered to be a relatively poor substitute for apprentices given that their skills were more theoretical and their interests were not in carrying out work on the shop floor (or at least not for a prolonged period). At Engineering Employer No. 1, for instance, the HR manager commented that compared with the university graduate the apprentice '... is actually working on the machine we

need him to work on. If he didn't know how to do it he would ask "how does it work" or "can you show me". Apprentices learn 'from scratch' and gain practical experience with the machinery and techniques the establishment uses. In contrast, the HR manager commented, a recruit with an engineering degree would be on a higher salary and would lack the specific practical experience required to operate the machinery from the outset.

Employers also reported a long tradition of taking on apprentices and that this had served them well despite various changes over the years to the delivery of publicly funded apprenticeships. Accordingly there was reluctance to break with a tradition which had worked well. Engineering Employer No. 2 was typical in outlining the benefits it derived from training apprentices in engineering (see box).

Engineering Employer No. 2

The company had offered apprenticeships since the mid 1960s, though they used to take on a much higher number in the early years when the company was much larger. It now had 60 employees, one third of whom had been apprentices at the company. The company usually takes on one apprentice a year leading to completion of an Advanced Apprenticeship (Level 3). Asked to identify the most valuable elements of apprenticeships to the business, the respondent mentioned that the apprenticeship provided:

- An ability to attract high quality people to the business;
- The skills the business needs;
- Rigorous and structured training;
- A good springboard from which to develop further skills – apprentices were seen as future team leaders and, potentially, future management given that the employer did not recruit graduates;
- Training which facilitates the introduction of technical change because apprentices are trained in the use of the latest technologies. The skills they acquire in their formal training can be passed on to other employees;
- A flexible programme of training allowing work and training to be readily accommodated;
- Reduction in labour turnover because the employees it trained tended to stay with the company;
- A cost-effective form of training compared with recruiting from the external labour market.

Although the rationale for recurrently training apprentices was more or less constant across the case study, employers said that there were differences in the way employers utilised their apprentices within the workplace which was likely to affect how they recruited in the future. Employers in this regard could be categorised as follows:

1. Where the apprentice was expected to fill a particular tier of technical and engineering jobs in the establishment. These skilled trades jobs included being an electro-mechanical fitter, electrician, etc. There was an expectation that most apprentices would fill jobs at this level with only a few going on to higher level jobs with the employer;
2. Those which were looking to develop, or strengthen the role of technician in the workplace such that some apprentices would take on more technically demanding and supervisory roles within the workplace. The jobs were typically at the boundary between skilled trades / associate professional occupations. Their roles, however, would still be distinguishable from those filled by university graduates with the latter expected to go on to fill more senior management jobs.

The former approach is exemplified by Engineering Employer No.3 (see box).

Engineering Employer No. 3

There were 250 employees at the workplace which was situated in an area of relatively high unemployment with few local competitors for skilled engineering workers. As such the employer was regarded locally as a prestigious one to work for which accounted for the high number of applications it received each year for the three apprentices it was looking to hire.

As part of a multi-national organisation more senior management jobs at the workplace were filled from its graduate recruitment scheme. What the employer wanted from its apprenticeship intake was individuals to fill a variety of jobs related to maintenance and equipment testing, and who would be willing to undertake additional training as and when required by the introduction of a new product or production process. In return, the employer paid a wage which was reported as being relatively high compared with the average in the local labour market, along with a number of fringe benefits.

In general, the company found that this model worked for them. Labour turnover was relatively low, the site met its production targets and other performance measures, and there was a strong demand each year from young people wanting to become apprentices. If an apprentice was considered to be particularly gifted then there was flexibility in the system for them to be promoted to more senior positions in the organisation.

The approach outlined above can be contrasted with that at Engineering Employer No.4. Here there was a sorting process whereby the apprentice intake each year would be split at around about the end of year one with those apprentices considered to be more able earmarked for the technician apprenticeship (see box).

Engineering Employer No. 4

The employer was a large multinational manufacturing employer with a long history of recruiting graduates and apprentices. It had around 6,000 employees in the UK with around 500 based at the case study establishment. In general graduates tended to be recruited into “the indirect areas” whereas apprentices were working in the direct areas (i.e. making things on the shop floor) or in maintenance. In order to fill a number of skilled manual jobs the company took on 80 Apprentices in the past three years (all in STEM-related roles). They were planning to take on around 20 apprentices in the forthcoming recruitment round and had already received a large number of applications. As the company’s product market strategies changed and the company’s operations in the UK were increasingly moving away from large-scale production, they were increasingly looking to fill technician roles from their apprenticeship intake.

Overall there was no shortfall in the number of applicants for STEM apprenticeships. The STEM apprentices trained to be technicians and obtained a qualification up to an HNC. In total they trained for five years, which included the formal apprenticeship and a period afterwards where they are still considered to be ‘trainees’ even though they had completed their formal apprenticeship.

Employers also recognised that in order to retain the services of their former apprentices there was a need to offer career progression. Engineering Employer No.5, for example, used Foundation Degrees to develop their employees to fill para-professional roles in the firm’s occupational hierarchy (see box). These, the employer was keen to point out, were different from the management roles that would be filled through their graduate recruitment programme. So there was a sense in which career progression for apprentices was constrained in a number of ways.

Engineering Employer No. 5

The employer, which manufactures a range of specialist vehicles for use in the engineering construction industry, recruits around 25 apprentices every year into mechanical, engineering, advanced materials, and IT sections of its workplace. It also has a well-developed graduate recruitment scheme which takes on trainees in the same areas of the business. The destinations of each group are distinct. Graduates are trained to take on management level positions, whereas the apprentices will remain in manual jobs on the shopfloor.

The employer realised a long time ago that if it wanted to retain its former apprentices then it needed to develop roles which would allow those employees to obtain a degree of professional satisfaction from doing so. To this end, the employer provided a range of continuing training courses to further develop the skills of its workforce and some former apprentices were enrolled on a Foundation Degree at a local FE college. This would allow former apprentices to develop the skills which would allow them to take on para-professional technical roles in the organisation.

The employer had found this to be an effective means of developing the additional skills they required on the shop floor while, at same time, strengthening the bond between employer and employee.

What was apparent from all of the employer case study interviews was that an apprenticeship under any given framework was sufficiently flexible to meet a wide range of needs. In some cases this was simply to satisfy the skill needs associated with skilled manual jobs on the shop floor, in other cases it was to provide a base upon which additional skills obtained through technician training and Foundation Degrees could be built. Early studies of the Modern Apprenticeship programme demonstrated the way in which employers had become adept at shoe-horning their existing training programmes into the publicly funded one such that the latter delivered exactly what the employer wanted (Hogarth et al., 1996).

6. Managing the financial risk associated with Apprenticeship investment: employer case study evidence

Employers, in general, will train only if marginal benefits exceed or equal marginal costs meaning that the cost of training is a central determinant of training participation and volumes. In some of the case studies, employers provided information about how much it cost to train an apprentice to completion of an

Advanced Apprenticeship. Table 2 indicates the overall cost of training an apprentice to completion of a typical three-year advanced apprenticeship in engineering on the basis of this collected information and information on the levels of state funding. The figure in column (a) refers to the net cost which the employer bears at the end of the training period. The estimate incorporates all of the employers' benefits obtained from training during the apprenticeship (i.e. the value of the productive contribution of the apprentice) and all of the costs of the apprenticeship (including labour costs, cost of foregone output whilst the apprentice is training, training materials and courses, etc.). Gambin et al. (2010) provides the details of how the estimates are derived.

Table 2: Estimate of the total cost of training met by the employer for an Advanced Apprenticeship in engineering (2011 prices).

(a)	(b)	(c)	(d)	(e)
Employer Costs	Costs of Apprenticeship met by State	Total cost of Apprenticeship (a + b)	% costs met directly by employer (%)	% of costs met directly by the State (%)
£39,582	£23,240*	£62,822	63	37

Notes: based on the costs of training an individual aged between 16 and 24 years of age at the commencement of their Apprenticeships. All data in 2011 prices

* comprising £14,403 for a Level 3 Apprenticeship and £8,837 for a Level 2.

Source: estimates derived from Hogarth et al. (2011)

The costs borne by the employer in delivering an engineering apprenticeship are much higher than in other industries and, as Table 2 also demonstrates, a large share of the overall cost is met by the State through meeting the costs of the training provider which provides the off-the-job training. Over time the State has met an increasing share of the costs of the apprenticeship. The situation has evolved from one where the cost of the apprenticeships was largely met by industry via a grant-levy scheme in the 1960s and 1970s to one where the State meets a significant share of the overall cost. In the case study establishments, employers had become accustomed to a system where the costs for the services delivered by their training provider were met by the State. In the realm of engineering apprenticeships, proposed changes to State financing could, plausibly, result in the overall cost to the employer increasing further unless they can find the means to reduce or absorb particular cost elements.

An employer being able to retain former apprentices, and thereby recoup the

costs of the apprenticeship investment and realise its benefits, was heavily dependent upon creating strong internal labour markets. This may be regarded as a form of an imperfect labour market. The employers were able to pay a wage that is below the employee's marginal product. They could therefore obtain an economic rent from the investment in the apprenticeship and were also able to avoid losing the services of their former apprentices. Employers, it was apparent, expended considerable effort in developing their internal labour markets to their employees. Lazear (2005) suggests that nearly all of the skills employers require are, in fact general, transferable ones but they are bundled together in such a way that they become company-specific ones. There was some evidence of this in the employer case studies in the emphasis employers placed on 'their way of doing things', which the apprenticeship sought to inculcate in the apprentice. In this way general skills became more company-specific. This had, however, the capacity to work in the reverse direction to that suggested by Lazear. Completing an apprenticeship with an employer that others considered to be prestigious, even if the apprentice was schooled in that particular company's way of doing things, could prove attractive to other employers. Hence the need for these companies to reinforce the strength of their internal labour markets in retaining their former apprentices through, for example, offering a variety of career progression opportunities.

The development of the internal labour market however is not without a cost to the employer which further inhibits their capacity to invest in apprenticeships.

7. The Just-in-Time STEM Apprenticeship model

In the majority of case study establishments the demand for their goods and services had been, at best, more or less stable, and at worst they had been experiencing a modest tail off in demand. Moreover, at the time of the fieldwork, they saw little prospect of demand side conditions improving over the short- to medium-term. Employers were therefore recruiting in conditions where skills supply was exceeding demand, though there were exceptions. Two manufacturing plants, for instance, had begun to experience relatively rapid growth in output. Engineering Employer No. 7 illustrates this situation (see box).

Engineering Employer No. 7

After a period of uncertainty regarding its position in its parent company's plans, the establishment was beginning to experience a period of employment expansion following the go-ahead from the parent company to become the central manufacturing point for a major new product. This resulted in the company needing to recruit a substantial number of skilled electro-mechanical engineers who had typically completed an apprenticeship. They were also looking to recruit professional / managerial staff, too.

The company had experienced a degree of difficulty in finding the skilled employees required. They had tapped into new sources of skills, including ex-service personnel or local employers who were making their staff redundant. Whilst this was considered a successful approach, the company had also had to persuade employees to work overtime and introduced an extra night shift, which proved unpopular with employees.

The company needed to be cautious about the extent to which it could resort to unpopular measures such as overtime because it faced competition from other employers for its skilled employees. These employees, as a consequence of being trained by the company, are attractive to other employers. The company had resorted also to increasing its apprentice numbers but this approach would only produce the skills it needed in three to four years. It was proving difficult to attract employees from other local employers, even by offering a wage premium due to the bond between employees and employers in the area.

The example above exemplifies the nature of the problem here. The relatively high overall cost of delivering an engineering apprenticeship means that employers cannot afford to train in excess of their own immediate needs. Their own training horizons tend to be relatively short-term. This is because the business case for taking on an apprentice needs to be made with a relatively high level of certainty that the apprentice's skills will be in demand by the business once the apprentice has completed their training. Accordingly, the fully trained apprentice is delivered 'just-in-time' to meet the skill needs of the workplace. Should demand unexpectedly increase in the workplace there would appear to be relatively little excess capacity either within the workplace or within the local labour market to meet that demand.

8. Conclusion

The Government in the UK has clearly signalled its intention to rebalance the economy in favour of high value, export-led sectors of the economy. The advanced manufacturing sector, defined loosely with reference to those parts of the manufacturing industry which are engaged in the production of relatively high value, technically advanced goods, is seen as being of central importance to that rebalancing. Attempting to move quickly in this direction will likely reveal skill shortages given the just-in-time nature of skills supply in engineering. It is essential then to identify effective means of increasing the engineering skill supply through, amongst other things, apprenticeships.

Over time apprenticeship policy in England shifted markedly. In the mid-1990s, policy was very much intent on boosting the numbers of apprentices and training employers. Policy at that time was very much led by the activities of training providers. There was then expansion in relatively short-duration apprenticeships and these were most often delivered to existing employees such that existing rather than new skills were being accredited. This approach was seen as a major failing of the VET system in England (Leitch, 2006). Moving to create a more demand-led, employer-driven system, employers were increasingly expected to make greater contributions to the overall costs of apprenticeship training. The emphasis shifted to requiring employers to meet some of the costs of the training provider previously met by the state with this being rationalised on an expectation that if they were paying, employers would be motivated to ensure that the training met their business needs (Banks, 2010). This swing to demand-led policy is the core of the relatively recent decision to route funding for apprenticeships through employers rather than the State paying money directly to training providers (Hogarth et al., 2014). The evidence indeed points to employers increasingly paying more for the training they consume, as the Net Costs studies demonstrate.

The evidence suggests that cost is one important barrier to increasing skills supply. Employers are unwilling to engage in training which is likely to result in over-supply (in the more traditional sense of training a surplus of apprentices and releasing some of them after the training period) because they face high costs in doing so. In practice, they would be assuming the training costs of their competitors. This contrasts with other sectors of the economy where the employer breaks even on their investment in an apprenticeship more or less at the point of completion, such as in retailing. In contrast, it can take three years for engineering employers to recoup their costs in training someone to be a trained engineer (Hogarth et al., 2012). The introduction of the apprenticeship

levy is unlikely, other things being equal, to have a substantial impact on the volume of engineering and STEM apprenticeships because the amount of funding the employer can claim back from the levy for training an apprentice is relatively modest compared with the overall cost faced in delivering that apprenticeship (as indicated in Table 2 above).

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The Economics of Germanic Apprenticeship Systems

Samuel Muehleman

1. Introduction

A distinctive feature of Germanic apprenticeship systems is that firms provide and finance part of the formal education that would otherwise take place in a classroom as part of the upper secondary education system. Recent empirical studies find that the transition to work is more favourable for apprenticeship graduates when compared with graduates from more general and school-based educational tracks (Brunello and Rocco 2017, Hanushek et al. 2017), a finding that may be attributed to the substantial labour market experience that apprentices gain during their training program. Studies exploiting quasi-experiments for countries where the educational system underwent significant education reforms (Malamud and Pop-Elches 2010, Zilic 2018) found no differences with regard to long-term labour market outcomes based on the type of education that individuals received. Thus, while there appears to be advantages of apprenticeship training that can be identified in terms of individual labour market outcomes in countries with established apprenticeship systems, it is important from a policy perspective to better understand how apprenticeship markets work. In particular, what the determinants of demand and supply in apprenticeship markets are, and how such knowledge can help design effective and efficient policies.

A potentially important factor explaining labour market outcomes that is particularly difficult to measure in cross-national comparisons, but also within a country, is the quality of apprenticeship training. In Austria, Germany and Switzerland, external monitoring ensures that firms provide sufficient training at the workplace, and standardized exams at the end of the training ensure that skills are transferable to other employers, at least within the trained occupation. Thus, an important aspect of policies aimed at increasing a firm's investment in formal apprenticeship training is not necessarily the increase in productivity of the workforce *per se*, but the relationship between any training-related increase in productivity and higher wages and mobility of the workforce (Alfonsi et al. 2017, Dostie 2015). In Germany, for example, work councils also have the legal

rights to enforce training quality, and if necessary call for the training instructors to be replaced (Koch et al. 2018). Clearly, higher quality training is desirable from an individual's perspective, as it increases productivity and thus improves post-training employment outcomes¹. From a firm's perspective, high-quality training may result in increased costs, but can potentially also attract more qualified applicants and thus increase training benefits.

As higher apprentice wages may be associated with an increased apprentice supply, it is a popular argument used by policy makers to increase the number of apprenticeship positions, as recently proposed in Germany². However, an important aspect to consider is the heterogeneity within an apprenticeship system, which is particularly relevant in countries like Germany and Switzerland where more than half of a cohort enrolls in apprenticeship training. Thus, by definition, there is a large variation in cognitive and non-cognitive skills when compared with a country where only a small number and a possibly very homogenous group of school leavers enrolls in apprenticeship training. To the extent that minimum wages are set too high in order to attract high-qualified applicants, a likely consequence is that individuals from the bottom of the skill distribution find it difficult to obtain a training position because expected (net) training costs are too high from a firm's perspective.

The remainder of this chapter discusses how an apprenticeship market can be analysed in terms of demand for and supply of apprentices, how the costs and benefits of apprenticeship training are associated with the outcomes on the apprenticeship market, and to what extent the training quality at the workplace and the quality of applicants determines the equilibrium outcomes. The chapter concludes with a brief analysis of how the introduction of a national minimum wage for apprentices affects an apprenticeship market.

2. The market for apprentices: demand and supply considerations

An apprenticeship market can be described as similar to a regular labour market. However, rather than solely considering individual wage costs, apprenticeship training also involves the wage costs for instructors, training material and infrastructure (cf. Muehlemann 2016 for a summary).

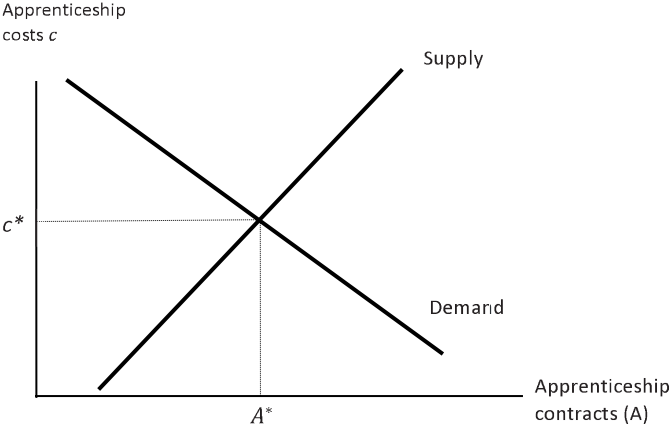
1. E.g., Dietrich et al. (2016) find for Germany that doubling the amount of workplace training during an apprenticeship increases individual post-training wages by 2.8%.

2. <https://www.reuters.com/article/us-germany-politics-pact-factbox/factbox-key-points-agreed-in-german-coalition-pact-idUSKBN1FR2NO>.

Conversely, as opposed to regular workers, apprentices are not always productive during the entire work week. Instead, depending on the apprenticeship regulations of a particular country and training occupation, apprentices spend 1-2 days a week away from the workplace to attend vocational school (which may also place in block courses). Moreover, firms in the Germanic apprenticeship systems have the obligation to provide training at the workplace that goes beyond informal learning.

Figure 1 illustrates that a firm's demand curve is downward sloping due to the law of diminishing marginal returns. A firm's demand curve corresponds to the marginal benefit of training an apprentice, which in turn depends on a number of other factors, including the time spent at the workplace with productive tasks (both skilled and unskilled), a firm's production process, and also on an apprentice's cognitive skills, innate ability, and motivation (cf. Muehleemann 2016).

Figure 1 - The market for apprenticeships



The supply of interested candidates for apprenticeship positions depends on a variety of factors that influence the benefits of obtaining a VET qualification compared to other education pathways. From an economic perspective, the main determinants of apprentice supply are apprentice wages and subsequent skilled worker wages (in comparison to other education pathways). The latter, however, depends on the amount of skills that individuals acquire during an apprenticeship program in vocational school and at the workplace, and therefore also on training costs. Thus, both the quantity and quality of training are im-

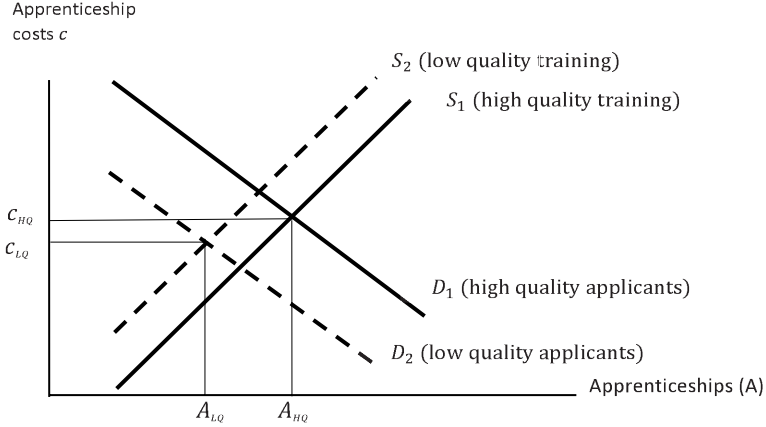
portant determinants of the post-training productivity of apprentices, and consequently their expected labour market outcomes over the life cycle.

As a result, both the supply of and demand for apprentices depend on a variety of factors that may be summarized in terms of the quality of training and the quality of applicants. To the extent that high quality training yields favourable employment outcomes over the life cycle, high quality individuals will find it attractive to apply for apprenticeship positions. Conversely, firms will only be willing to offer high quality (and thus high cost) training to the extent that high quality applicants seek apprenticeship positions. Figure 1 clearly shows that given a demand and supply schedule for a particular type of apprenticeship, the market will clear at training cost c^* .

3. What happens if the quality of apprentice supply decreases?

Figure 2 illustrates what happens if the quality of apprentice supply decreases because of, for example, an expansion of the academic school track at the upper secondary level. Starting from an initial high-quality training and applicant equilibrium (A_{HQ} apprenticeship contracts at costs c_{QH}), a decrease in the quality of interested applicants leads to a shift in the demand for apprentices (from D_1 to D_2). This is because a firm's expected benefit from training decreases accordingly at any level of training costs. As a result, a firm offers less training positions, and at a lower cost, either by reducing apprentice wages or training quality (e.g., by offering fewer hours of instruction at the workplace, or by allocating a higher share of unskilled tasks to apprentices and thereby reducing their opportunities to practice skilled tasks). Some individuals who were initially interested in apprenticeship training will no longer apply for a training position in a low-quality training regime, thereby causing a shift to the left in the supply curve. Thus, the apprentice market eventually reaches a "low-quality" equilibrium (A_{LQ} c_{LQ}), with neither excess supply of, nor excess demand for apprentices. The overall number of apprentices, however, decreases compared to the high-quality equilibrium ($A_{LQ} < c_{LQ}$). Clearly, there is a continuum of possible equilibrium outcomes, ranging from very few apprenticeships at a low training quality to many apprenticeships at a high training quality. An important implication, however, is that as long as training costs (and apprentice wages in particular) can adjust freely and in the absence of large subsidies to training firms or individuals, it is unlikely that low quality apprenticeship training and a high number of apprenticeship contracts will be observed.

Figure 2 - High and low-quality equilibrium



In the Germanic countries, apprentices need to pass standardized exams at the end of the apprenticeship, and a firm’s failure to provide an adequate training quality would result in poor performance of their apprentices at the final exams. As a consequence, such firms would likely find it difficult to recruit (qualified) apprentices in subsequent periods. Therefore, as a response to decrease in the quality of apprentice supply, firms would need to be able to adjust (real) wages accordingly. Otherwise, they would hire even fewer apprentices (i.e., up to the point where $c_{LQ} = D_2$). In some apprenticeship systems (e.g. in the United Kingdom) however, there are no standardized exams, and as a result training quality may indeed suffer in response to a decline in the quality of applicants for training positions (c.f. Kuczera and Field, 2018).

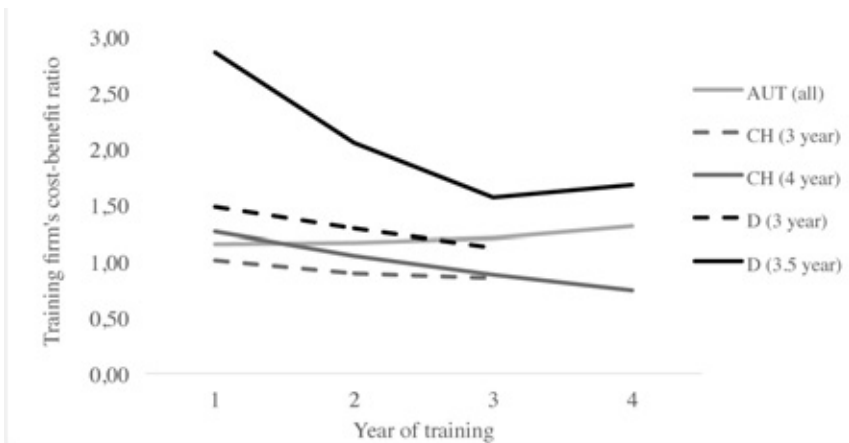
4. A firm’s costs and benefits of apprenticeship training

A firm will be willing to train apprentices up to the point where the marginal benefit of the last apprentice is equal to the marginal training costs, as outlined in Figure 1. Empirical estimates on the average costs and benefits of apprenticeship training are readily available for the Germanic countries and have been documented at length elsewhere (for a recent review, see Muehlemann et al. 2016). Basically, such studies calculate the training costs, which consist of apprentice wages, wages for training personnel, as well as other cost (such as training materials and infrastructure that is needed explicitly for apprentices). The

training benefit is calculated by estimating the productive contribution of apprentices during the training program, either through unskilled work, or skilled work. The time that apprentices spend with unskilled tasks is valued at the wage of unskilled workers, while skilled work is valued at the wage of a skilled worker in the training firm – but adjusted for the apprentice’s relative productivity (particularly in the beginning of training, the productivity of an apprentice is considerably lower compared to an experienced skilled worker). Interestingly, even though the apprenticeship systems in Austria, Germany, and Switzerland are similar in terms of the trained occupations, and important as a large share of young enrol in such apprenticeships; the outcomes in terms of a firm’s cost-benefit ratio differ substantially.

Figure 3 shows that in Austria and Germany, firms make an investment in apprenticeship training in training year, as average training costs are higher than average training benefits. Particularly in 3.5 year apprenticeships, a firm’s costs are almost three times higher than the benefit in the first year of training, and the total net costs average at 35,300 € – 11,400 € in three-year apprenticeships (Jansen et al., 2015). Conversely, in Switzerland, training firms break even in three-year programmes in each training year (7,900 € net benefit in total), and in four-year programmes the net benefits in the second half of training outweigh the net costs in the first two years of training, yielding a total average net bene-

Figure 3 - Share of total training costs borne by apprentices, by year of training



Source: Jansen et al. (2015) for Germany, Mayerl and Schlögl (2016) for Austria, and Strupler and Wolter (2012) for Switzerland.

fit of 7,600 € per apprentice³. Austria constitutes as an intermediate case between Germany and Switzerland. While apprenticeship training results in net costs in each year of training, total net costs average 13,300 €⁴.

From an economic perspective, it is of interest to know why German and Austrian firms are willing to make a substantial net investment in apprenticeship training, while the Swiss firms do not. A first necessary condition is that a firm can retain an apprentice for some time after graduation, because otherwise there is no possibility to generate any type of post-training benefit (Soskice, 1994). Indeed, empirical studies show that German and Austrian firms retain a much higher share of apprentices compared to Swiss firms, and that firms can thereby save on future hiring costs because they do not need to hire skilled workers from the external labour market (Blatter et al., 2016, Jansen et al., 2015, Moretti et al., 2017, Schlögl and Mayerl, 2017). Moreover, training firms may be able to use their informational advantage, in terms of retaining the most able apprentices after graduation. However, as apprentices in Germanic training systems obtain a vocational qualification that contains information on their performance, they could credibly signal their skills to outside firms. Nonetheless, to the extent that apprentices already sort into training firms that constitute a good match for them, they might have little incentives to leave the firm after training. Empirical evidence for Germany shows that particularly large firms and firms with works councils invest more in the recruitment process for hiring suitable apprentices, and subsequently retain a higher fraction of apprentices after training (Kriechel et al., 2014, Wenzelmann et al., 2017).

A final important consideration is whether or not firms who are able to offer training profitably will have a higher willingness to hire and train individuals from the bottom of the (cognitive) ability distribution, compared to a situation where training constitutes a net investment. Empirical evidence for Switzerland suggests that firms who train apprentices in occupations where training can be offered profitably offer on average more workplace training to apprentices with below-average school grades than ones with above-average grades (Muehleemann, Brändli and Wolter, 2013). Conversely, firms who train in occupations where training on average results in net costs are investment-oriented, such that they provide more of their resources to individuals with above-average grades in

3. Based on a CHF/EUR exchange rate of 1.10 on 11 September 2015 (cf. Muehleemann 2016)

4. The results for Austria are not reported separately by training duration (Schlögl and Mayerl 2016).

school. Thus, from a policy perspective, allowing firms to offer training profitably may prevent a substantial fraction of school-leavers from not finding an apprenticeship position. To the extent that apprentice wages are subject to bilateral negotiations between firms and individuals, a situation with low apprentice wages but high training quality may increase welfare for both firms and individuals. Thus, the focus of the next section is to briefly summarize the empirical literature on the returns to apprenticeship training in Austria, Germany and Switzerland.

5. Apprenticeships: is it worth it for individuals?

In Switzerland, the observed wage premium of a vocational qualification is roughly comparable to other types of education, as post-training wage premia are about 6% for each year of apprenticeship training (SKBF 2011). Similarly, apprenticeship training yields a wage return of about 5% in Germany (Piopiniuk et al., 2017) and Austria (Festerer et al., 2008). Thus, apprenticeship training appears to be a favourable investment for individuals in monetary terms. A vocational qualification also reduces the unemployment risk compared to not having any post-compulsory education.

Much of the recent political debate centred around the question of whether or not apprenticeships are a better option than full-time schooling options at the upper secondary level in countries where apprenticeships are part of the formal education system, and whether or not apprenticeships are superior compared to non-formal or informal workplace training in countries where apprenticeships are not part of the formal education system (such as the United States or Canada).

A potential issue for individuals is that much of the human capital that they acquire during an apprenticeship could be firm-specific, meaning that even though apprentices may reap some of these returns in the form of higher wages, mobility between firms and across industries could be limited. Empirical evidence for Switzerland suggests that apprenticeship graduates do not suffer statistically significant wage losses when leaving the training firm but remain in the same occupation (Müller and Schweri, 2015), indicating that there are no disadvantages due to a possibly too narrow and firm-specific skill set that was acquired during apprenticeship training. Other studies also find a substantial advantage of apprenticeship training in terms of employability early on in the career compared to individuals who graduated from more general educational programs (Hanushek et al., 2017, Brunello and Rocco, 2017). Over time, that advantage diminishes. In some countries, it can even turn into a

disadvantage, although that clearly depends on the quality and the curricula of the particular apprenticeship occupations. As shown by Jansen et al. (2017), changing the content of a training curriculum in terms of general versus specific skills directly affects the demand for and the supply of apprentices in a particular apprenticeship occupation in Germany. They found that introducing choice-options that allowed for more heterogeneity in the training curriculum (so that firms find it easier to align training with their production process) not only increase a firm's demand for apprentices, but was even associated with an increase in the supply of apprentices. Thus, at least to the extent that occupations are large enough, training curricula can include some choice options that increase a firm's willingness to train apprentices without adversely affecting apprentice supply. Finally, quasi-experimental evidence from Romania (Malamud and Pop-Elches, 2010) and Croatia (Zilic, 2018) shows that much of the observed differences in labour market outcomes between apprenticeship graduates and graduates from general education are due to an initial negative selection into apprenticeship programmes. In both Romania and Croatia, no clear and significant differences in labour market outcomes could be observed between individuals who were – due to a change in the education system – exogenously restriction in their educational choice. Thus, these results indicate that while apprenticeship training may facilitate the transition in the labour market early in the career, there are unlikely to be strong negative effects for older workers.

Thus, summing up the empirical evidence, it appears that apprenticeship training yields labour market outcomes comparable to general education in terms of future wages, and better employment outcomes early on in a worker's career – to the extent that the quality of apprenticeship training is sufficiently high and the training curriculum includes a sufficiently high share of general or transferable skills – which is the case in Germanic apprenticeship systems, but not necessarily true in other countries that are currently in the process of setting up or expanding apprenticeship systems.

6. Does minimum apprentice pay lead to a disequilibrium on the apprenticeship market?

In a number of countries, including Germany and Austria, apprentice wages are determined by collective bargaining agreements. Clearly, to the extent that the supply of apprentices (within an occupation, or an industry) is homogenous, the efficient equilibrium outcome may by still be achieved if the bargained wage in addition to training costs is equal to c^* , as outlined in Figure 1. In Germany, the agreements are binding at the sector-level and, depending on the agreement, they

are binding for all firms operating in a particular sector, or only for firms that are part of an employer association and with unionized employees, respectively. For firms that are not subject to collective bargaining agreements, apprentice wages must be no lower than 20% of the corresponding sectoral minimum wage. In Austria, almost all apprenticeships are subject to mandated minimum wages. Recently, the newly elected German government considered the introduction of a national minimum wage for apprentices with the goal to increase apprentice supply, because firms (particularly in the South of Germany) report that they often have problems with filling apprenticeship vacancies⁵. Clearly, higher training wages are appealing for apprentices and would therefore increase the apprentice supply – however, it is unclear how elastic the supply curve really is (i.e. by how many percent apprentice supply increases when apprentices wages increase by 1%).

Moreover, even within occupations, the qualifications of apprenticeship applicants differ substantially. In Germany, for example, 28% of all newly enrolled apprentices held a university access diploma in 2015 (BIBB 2016), while other applicants were younger and held lower-level school qualifications. To the extent that mandated minimum wages do not allow for different pay for more or less qualified applicants, firms may not be willing to hire applicants with below-average educational qualifications.

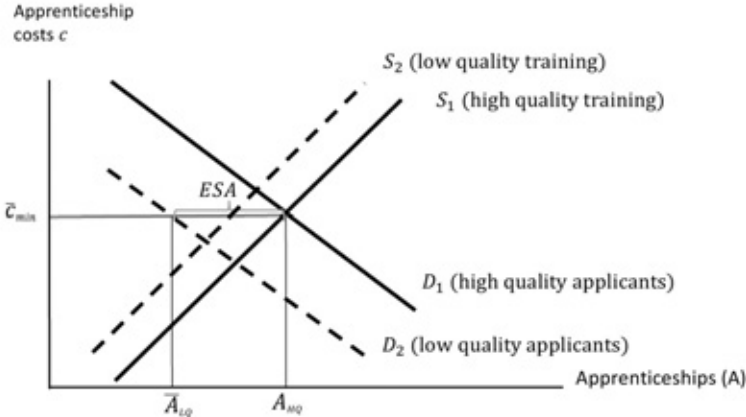
While few individuals with a university access diploma apply for an apprenticeship in the handicraft sector, and few individuals with lower-level educational qualification may want to obtain a training position in a bank, there are many apprenticeship occupations that are appealing to individuals with a variety of credentials in education. Muehlemann et al. (2018) recently showed that an exogenous supply shock of high-qualified applicants in Germany was fully absorbed by training firms, despite the fact that there was an overall increase in apprenticeship wages. This observation suggests that there was an excess demand for high-educated apprentices prior to the positive supply shock. Such an outcome can be explained by sticky wages due to the influence of semi-formal institutions such as works councils, unions or employer associations that prevent wage competition for apprentices (i.e., paying a higher wages to apprentices with a high school qualification compared to apprentices with lower qualification levels).

From a firm's perspective, the main effect of minimum apprentice wages is that training costs may increase accordingly. Consequently, a firm's demand for apprentices decreases, unless training firms can reduce training costs by lowering the quality of training. For small firms who typically only train one apprentice

5. Conversely, in other parts of the country, such as North Rhine-Westfalia, there is an excess supply of apprentices.

at the time, a substantial increase in the apprentices wages (due to mandated minimum wages) may imply that they withdraw from offering apprenticeships altogether. Thus, while minimum wages are supposed to protect apprentices from exploitation as cheap labour and serve as a way to make apprenticeship training more attractive, they can also be harmful with regard to the outcomes on the apprenticeship market, as illustrated in Figure 4.

Figure 4 - Excess supply due a change in the quality of applicants under mandated apprentice wages

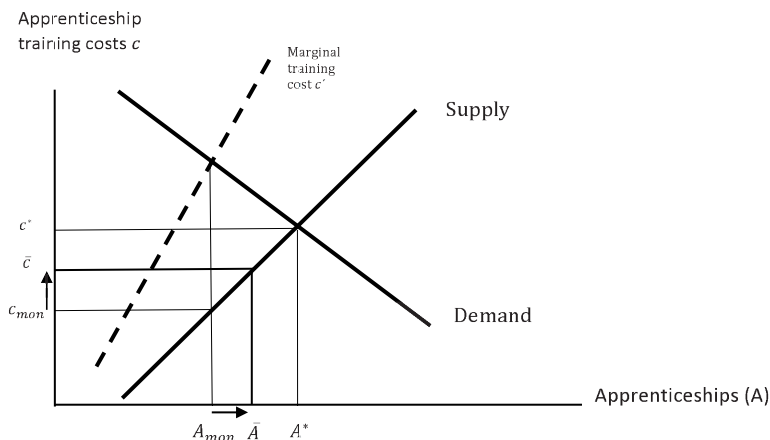


Consider the case where the minimum wage is initially set at the optimal level, i.e., such that there is no excess supply or demand, given the supply curve S_1 and demand curve D_1 in Figure 4. Here, there is an exogenous change in the quality (cognitive skills) of applicants because of, for example, an expansion of the academic track. Such a change was observed in Germany in recent years (i.e., a higher fraction of pupils per cohort now enrol in *Gymnasium* rather than in apprenticeship training). As a result, the firm's demand shifts to the left. Consequently, at training costs \bar{c}_{min} , firms only demand \bar{A}_{LQ} apprentices. To the extent that firms are not able to reduce their training quality by offering fewer hours of workplace training, there will be an excess supply of apprentices (ESA), as shown in Figure 4, because downward adjustment of apprentice wages is not possible. In the case where firms are able to lower their quality, the ESA would be smaller because the training supply also shifts to the left. Thus, if the quality of apprenticeship training is monitored and enforced, and minimum apprentice wages are binding, then an excess supply of apprentices will be observed.

7. Is there monopsony power in the apprenticeship market?

It is important to consider whether current apprentice wages are close to the market outcome, or if firms possess and exercise substantial monopsony power over apprentices. Only the latter case would justify government intervention from a welfare perspective. Monopsony power, due to frictions in the training market (such as low mobility of apprentices who often still live at home with their parents), would allow firms to lower apprentice wages below the competitive level, and therefore hire fewer apprentices than in competitive markets in order to maximize profits (Muehleemann, Ryan and Wolter, 2013). In a monopsonistic training market, the marginal training costs are increasing in the number of apprentices (as indicated by the dotted line in Figure 5 below), but constant and equal to c^* in competitive markets. Put differently, if markets are indeed competitive, then an individual firm can hire and train as many apprentices as it wants at constant training costs c^* because the firm is too small to influence wages⁶. In monopsonistic training markets, however, an individual firm faces an upward sloping supply curve, which means that it has to increase apprentice wages (or the training quality) in order to attract additional applicants.

Figure 5 - Minimum apprentice wages in monopsonistic apprenticeship market



6. Large firms may also be able to exploit economies of scale in the provision of training, which would lead to decreasing marginal training costs. To keep the illustration of minimum wage effects simple, the exposition in Figure 5 assumes that there are no diseconomies of scale in the provision of training.

Figure 5 shows that the introduction of a minimum apprentice wage that leads to training costs \bar{c} could in fact increase the number of apprenticeship contracts from A_{mon} to \bar{A} , as long as the minimum wage is set above the current wage (leading to training costs c_{mon}) but still below the competitive outcome (at training costs c^*)⁷. The reason for this outcome is that marginal training costs remain constant at \bar{c} up to \bar{A} apprentices, and only above that level of training positions jump up to the marginal training cost of c' , where hiring additional apprentices is no longer profitable for the training firm. Thus, while mandated minimum apprentice wages in theory could increase the number of training positions, it remains an empirical issue to determine whether training firms in fact have substantial monopsony power in the first place. Empirical estimates for Switzerland suggest that firms in general have relatively little monopsony power, except for firms operating in local labour markets with few competitors in the same sector (Muehleemann, Ryan and Wolter, 2013).

For Germany and Austria, no empirical evidence exists for the apprenticeship market. However, mandated minimum apprentice wages (*tarifliche Ausbildungsvergütungen*) in Germany increased substantially from 2011 to 2016 (between 3.2% and 4.5% each year⁸), a development that coincided with a significant reduction in the training participation of very small German firms (BIBB 2016). Thus, it appears that, at least for small firms, it was not the case that they made excessive use of monopsony power. Instead, the net costs of apprenticeship training likely became too high – particularly because small firms did not primarily train apprentices with the motive to retain them later as skilled workers, and as a result these firms no longer continued to offer apprenticeship training. Large firms in Germany often have internal labour markets and train apprentices largely with the goal to retain those who turn out to be a good match as skilled workers. Thus, for these firms, not only are training costs lower than for small firms in relation to revenue, but they can also generate post-training benefits in the form of saved future hiring costs (Blatter et al. 2016, Jansen et al. 2015, Moretti et al. 2017). Therefore, large firms are less likely to be affected by increases in the minimum apprentice wage.

Nonetheless, in all Germanic countries, many apprentices receive their training in small and medium-sized firms, and therefore it is important to keep in mind

7. In section 2 it is assumed that firms pay market wages to their apprentices and training costs are constant. In monopsonistic markets, firms that want to hire many apprentices need to pay higher wages (which is observed in empirical studies). Thus, a profit-maximizing firm would hire apprentices up to the point where the marginal training cost c' is equal to the marginal benefit (the demand curve). For a more detailed discussion see Muehleemann (2016).

8. <https://www.bibb.de/de/73539.php>.

that small and large firms may have different training motivations (Mohrenweiser and Backes-Gellner, 2010). While large firms are typically successful in retaining apprentices (Mohrenweiser, Zwick and Backes-Gellner, 2018), the threat of poaching may deter small firms with an investment-oriented training motive from offering apprenticeship positions in the first place (Muehlemann and Wolter, 2011). In Germany, more than 500,000 apprentices enrol in the system each year – but over 250,000 individuals who were initially interested in apprenticeship training end up in the transitory system each year (BIBB 2016). These high numbers are particularly striking as they have not decreased substantially in recent years, while the overall number of school leavers declined in most German states, and many firms continue to report problems with filling apprenticeship vacancies. Unfortunately, no direct empirical evidence is available yet with regard to how changes in the quality of applicants are associated with a firm's demand for apprentices (at a given wage level). Muehlemann et al. (2007), however, showed that a firm's demand for apprentices has a strong and negative association with net training costs in Switzerland. However, the above analysis clearly shows that an increase in training costs has a negative effect on the demand for apprentices, meaning that setting a minimum apprentice wage above the market-clearing level will lead to an excess supply of apprentices. Therefore, increasing minimum wages with the goal of increasing the number of apprenticeship contracts may not have the intended effect.

8. Conclusions

This chapter provided a short overview of the economics of Germanic apprenticeship systems. Changes in the costs and benefits of apprenticeship training result in corresponding changes on the demand for and supply of apprentices, as both a firm's and an individual's willingness to participate in apprenticeship training depends on the expected payoffs, i.e., the return on their training investment.

Changes in a firm's expected training benefit, e.g. due to a change in the quality of applicants, leads to a shift in a firm's demand for apprentices, and consequently in the equilibrium number of training positions. However, to the extent that apprentice wages can adjust freely, markets clear (i.e., there is no excess demand for, nor excess supply of apprentices).

The analysis showed that mandated minimum apprentice wages can lead to an excess supply of apprentices. Thus, implementing or maintaining minimum apprentice wages that exceed the market-clearing level will cause a disequilibrium in the apprenticeship market and decrease the demand for apprentices. Recent

evidence from Germany reveals that the fraction of very small firms no longer offering apprenticeship positions increased in recent years. During this period, sector-level minimum apprentice wages increased rather strongly. Moreover, as minimum apprentice wages are often binding at the national level, they can lead to regional imbalances where some firms find it difficult to recruit apprentices while in other regions many applicants are not successful in finding an apprenticeship position. Finally, in the absence of external agencies that monitor apprenticeship training standards, minimum wages that are set too high will give incentives to firms to reduce the quality of training.

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Productivity, Human Capital and New Technology in Latin America and the Caribbean¹

Rafael Novella and David Rosas-Shady

1. Introduction

In the last decades, the Latin American and Caribbean (LAC) region has experienced important improvements in terms of economic growth and development. Despite these improvements, the region still faces important challenges related to productivity, inequality and the quality of human capital. In a context of imminent technological change, these challenges are likely to be aggravated if corrections are not implemented.

This chapter has two main objectives. First, it aims at describing, from a comparative perspective, the evolution, current situation and challenges of LAC in terms of economic growth and development, labour markets and human capital development. Secondly, it discusses policy recommendations to improve productivity through the quality of human capital.

The rest of the document is organised into four sections. Section 2 describes the main challenges that LAC faces in terms of productivity, inequality, labour markets and skills formation. Section 3 discusses how these challenges might be aggravated by the imminent arrival of new technologies. Section 4 summarises the evidence of the main policies in LAC aimed at improving workers job opportunities. Finally, the last section briefly offers some policy recommendations for increasing productivity and wellbeing through improvements in human capital.

1. We would like to thank Carolina González-Velosa and Terence Hogarth for their helpful comments and Alfredo Alvarado for research assistance. The authors are responsible for all results and views, which do not necessarily represent the view of the Inter-American Development Bank or the University of Oxford.

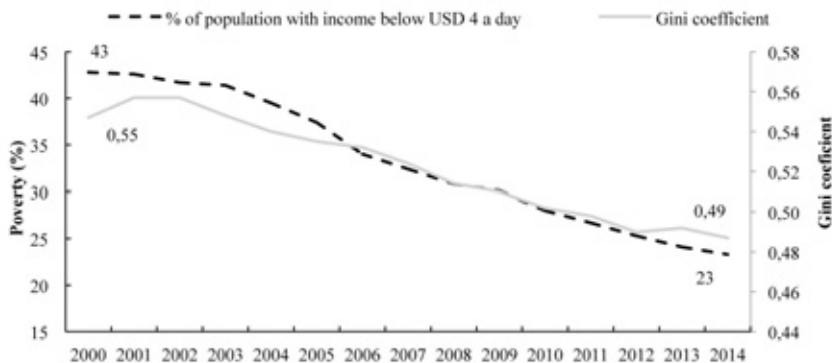
2. Productivity, employment and skills development in Latin America and the Caribbean

This section discusses the advances and main challenges that the region faces in terms of productivity and labour markets outcomes. It also discusses how education and more broadly skills development are key determinants of these challenges, and therefore hinder the continual improvement of economic growth and wellbeing. Comparisons with other relevant countries or regions are presented.

2.1 Productivity and the Labour Market

During the decade 2000-2010, or at least until the global crisis of 2008, most LAC countries showed high economic growth rates. The average growth rate of the real Gross Domestic Product (GDP) per capita in the region was 3.5% per year. This economic growth was mainly caused by favourable external conditions (Cavallo & Powell, 2018) and was accompanied by a significant reduction in poverty and inequality (Levy & Schady, 2013). As a result of this, poverty has halved since the beginning of 2000 as Figure 1 shows. Along with this, income inequality has decreased steadily over time.

Figure 1 -Poverty and income inequality in LAC, 2000-2014



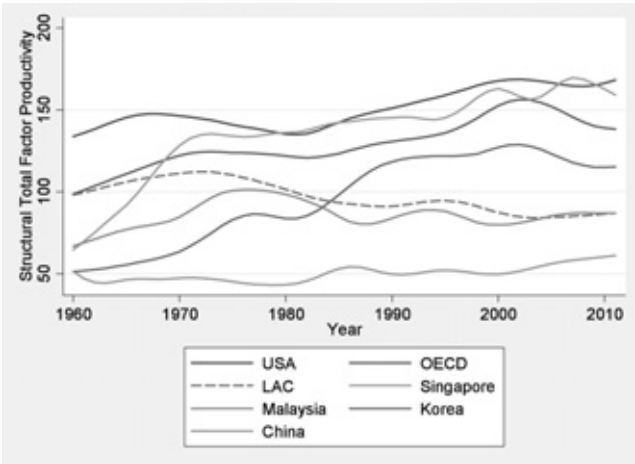
Source: Inter-American Development Bank (2018) and OCDE, CEPAL and CAF (2016).

Note: The Gini coefficient is a number between 0 and 1, where 0 corresponds with perfect equality and 1 corresponds with absolute inequality.

Despite these improvements in welfare, the region still faces an important challenge related to its low productivity. Figure 2 shows the poor performance, in ab-

solite and relative terms, of productivity in LAC, particularly in the last three decades (Fernández-Arias, 2014). In the period between 1960 and 2011, OECD countries, which started at a similar level in 1960, experienced a steady increase in productivity. Other countries at a considerably disadvantaged position in 1960, such as Singapore and South Korea, experienced a dramatic growth in productivity.

Figure 2 - Total Factor Productivity, 1960-2011

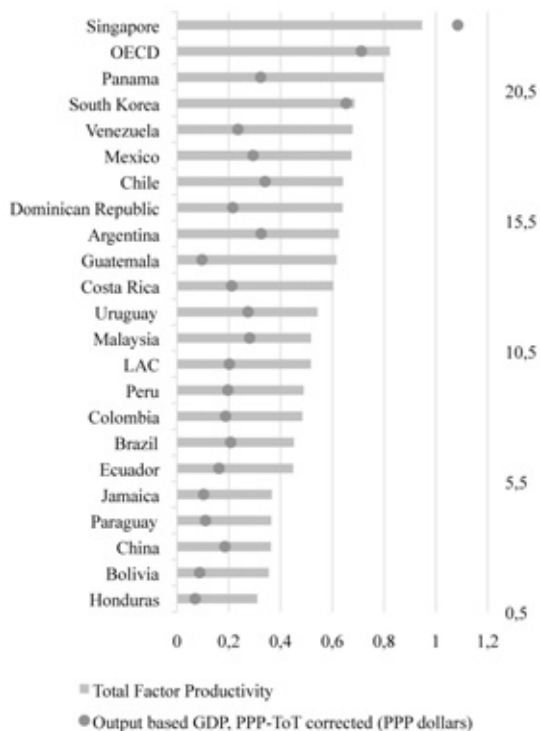


Source: Fernández-Arias (2014)

The poor performance of LAC in productivity is not homogenous across the countries. On the one hand, Figure 3 shows that in 2011, Panama’s TFP was 0.8 times the USA’s, above the average of LAC (about 0.5) and similar to the value for the OECD countries. In fact, the country’s TFP average annual growth (0.47%), over the period 1960-2011, was the highest in the region (Fernández-Arias, 2014). On the other side, Honduras’ TFP was less than a third of the USA’s and its TFP average annual growth was -1.44%. Despite the relative good performances of some LAC countries, the regional average is still well below Asian and OECD countries. Low productivity has direct implications on economic growth. The GDP is positively associated with TFP (see Figure 3). For instance, Panama (among the top) and Honduras (among the bottom) hold similar positions in the distribution of TFP and GDP. Moreover, following Fernández-Arias and Rodríguez-Apolinar (2016), it is estimated that closing the TFP gap with the USA would double the

GDP of the average LAC country. In sum, low levels of productivity in LAC explain its low economic growth (Pagés, 2010; Fernández-Arias, 2014).

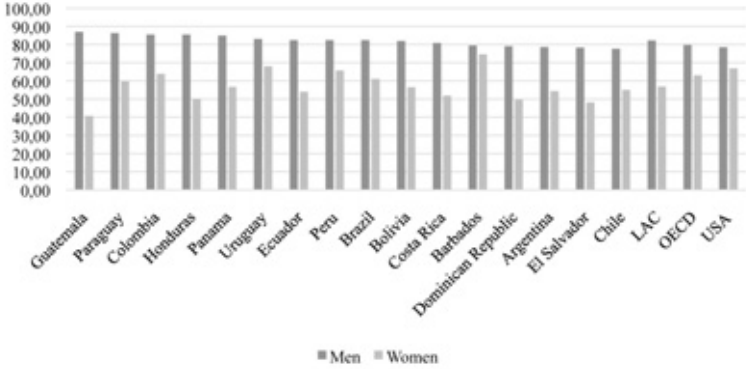
Figure 3 - GDP and TFP relative to USA, 2011 (USA=1)



Source: Fernández-Arias (2014)

LAC also faces important challenges concerning its labour market outcomes, mainly those related to low participation, high unemployment rates, and low-quality jobs, particularly among certain groups of population. First, labour force participation has been increasing but the region still presents large differences between men and women (see Figure 4). While male labour participation in LAC is, on average, 82% and slightly larger than the ones in OECD and USA, female labour participation is 25 percentage points smaller and below that of the OECD and USA. A gender gap is also present in earnings. Nopo (2012) finds that, on average, women in the region earn 20 per cent less than men with the same characteristics.

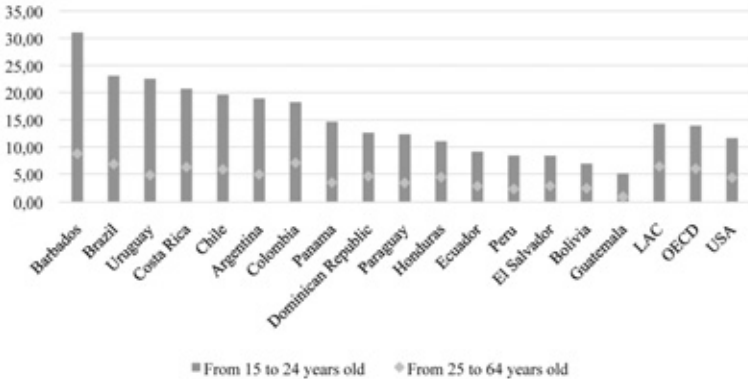
Figure 4 - Labour participation by gender and age, 2015 (%)



Source: Inter-American Development Bank (2018).

Secondly, the unemployment rate in LAC is, on average, similar to the OECD’s but with important differences across countries and age groups (see Figure 5). The unemployment rate of young people in the region is, on average, more than twice that of adult workers aged 25 to 64. Although young people are more affected by unemployment than adults, they stay in unemployment for a shorter period of time.. According to OCDE/CEPAL/CAF (2016), while the average unemployment duration of young workers is three months, the one for adult workers is eight months.

Figure 5 - Unemployment rate by age, 2015 (%)



Source: Inter-American Development Bank (2018).

Moreover, around 20 million or 20% of young people (aged 15-24) in LAC are neither working nor in education (Hoyos, Rogers, & Székely, 2016). As the authors mention, most of them (two thirds) are women, who are mainly affected by early marriage and teenage pregnancy.

Third, the quality of employment in LAC is very low and generates a vicious cycle of informal jobs and instability (Alaimo, Bosch, Kaplan, Pagés, & Ripani, 2015). On the one hand, LAC countries suffer from high levels of labour informality². Table 1, from Charmes (2012), compares the informal employment share of LAC with other developing and transitioning countries. According to the author, the informality rate in LAC has been above 50% for the last two decades, which is 2.5 times the one in transition economies³. While informality has constantly increased in LAC over the last 20 years, it decreased in other regions such as South and Southeast Asia and Sub-Saharan Africa.

Table 1 - Share of informal employment in total non-agricultural employment by 5-year period and by region (%)

Regions	1990-94	1995-99	2000-04	2005-10
North Africa	-	47.5	47.3	58.4
Sub-Saharan Africa	76.0	86.9	-	65.9
Latin America and Caribbean	52.5	54.2	55.9	57.7
South and Southeast Asia	65.2	69.9	-	69.7
West Asia	-	-	43.2	-
Transition countries	-	-	20.7	22.6

Source: Charmes (2012)

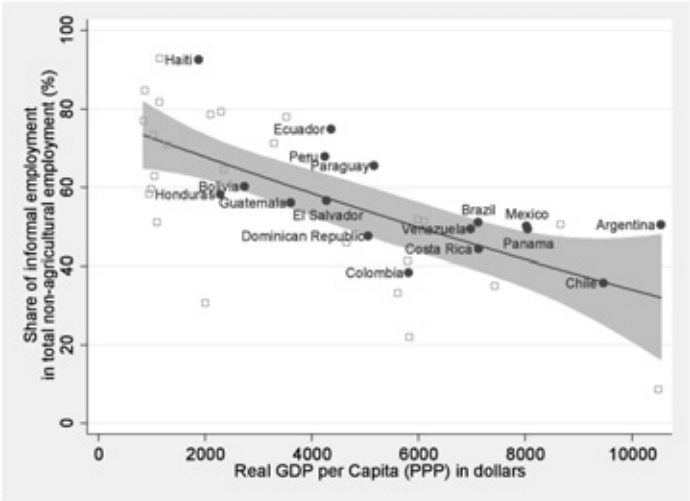
A clear negative association between labour informality and GDP per capita is observed in LAC. As can be seen from Figure 6, poorer countries, such as Haiti, Honduras and Bolivia, show high shares of informal employment. In contrast, richer countries in the region, such as Argentina and Chile, show lower informality rates. It is worth noting, however, that countries of similar GDP per capita level show substantially different informality rates, which re-

2. In Charmes (2012) informality comprises all persons working in unregistered enterprises or workers without social protection.

3. Transition economies included are: Armenia, Azerbaijan, Kyrgyzstan, Macedonia, Moldova, Romania, Russia, Serbia, Slovakia and Ukraine.

flects the role that other factors, such as education or corruption, play in explaining informality in LAC (Loayza, Servén, & Sugawara, 2009; La Porta & Shleifer, 2014).

Figure 6 - Informal employment and GDP per capita

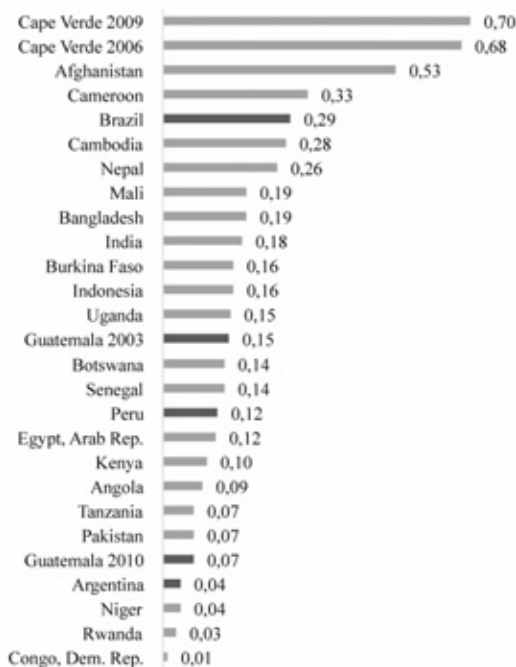


Source: Charmes (2009)

A negative relationship between productivity and informality is also observed within countries. La Porta and Shleifer (2014) shows (Figure 7) that there is a productivity gap between formal and informal firms in developing countries. Labour productivity in the informal firms of LAC countries included in their study represents less than 30% of labour productivity in formal firms.

Informality affects individuals heterogeneously. Young people (15-24 years old) and the elderly (65 or older) are more likely to work informally than middle-aged workers. Informality also affects men more than women in LAC, except for some countries where the overall informality rate is relatively low (Chile, Colombia and the Dominican Republic). Maloney (2004) argues that the informal sector (or self-employment) offers women in LAC the chance of balancing their work and home responsibilities in a context of rigid work arrangements. Informality is also closely related to the lack of human capital. Workers with lower levels of education and skills have considerably lower chances of accessing better quality formal jobs.

Figure 7 - Ratio of labour productivity by informal firms to formal firms



Source: *La Porta and Shleifer (2014)*

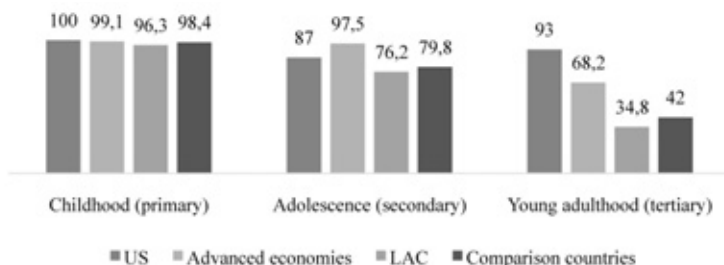
Note: Labour productivity is measured by the value added per employee.

On the other hand, the low level of job quality in LAC is related to job instability. Labour instability is high in LAC: 25% of workers aged 25-54 have one year or less in their current job, compared to 17% in the USA and 13% in OECD, and most of the turnovers are to poorer-quality jobs. Workers in unstable jobs are less likely to get training, which affects their productivity and increase their chances of staying in informality. In turn, informality results in a lack of unemployment protection and inefficient job searches, which again leads to bad matches in the labour market and therefore to labour instability.

2.2 Education and Skills Development

In recent years, LAC has achieved considerable progress in increasing access to education, particularly at a basic level. However, the region still faces significant challenges in the quality of education and more broadly in skills development. First, despite the fact that the net primary school enrolment rate in LAC is almost universal, and similar to the one of the US or other advanced economies (see Figure 8), the enrolment in secondary and tertiary educational levels are much lower. On average, attendance rates in these levels in LAC are substantially below the ones in developed countries. The main reason behind this is the high dropout rates, which range between 45% and 65% depending on the educational level (Bassi, Busso, & Muñoz, 2015).

Figure 8 - Net school enrolment rates, 2010 (%)



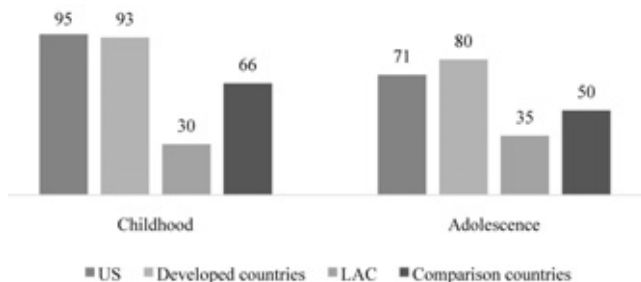
Source: Busso and Hincapié (2017)

Note: Comparison countries are economies with GDP per capita (PPP at constant 2011 dollars) in the same range as countries in LAC (between \$6,500 and \$25,500). These includes Albania, Algeria, Bulgaria, Hungary, Indonesia, Malaysia, Morocco, Philippines, Poland, Serbia, Thailand, Tunisia and Turkey.

Secondly, LAC still face serious shortcomings in the quality of education. Children in LAC do not learn basic skills in schools. As Figure 9 shows, only 30% of students surpass the lowest benchmark in mathematics required for their grade in primary education in international tests⁴. Countries with a similar economic performance double this percentage and developed countries triple it. In addition, the poor performance of younger students in LAC and the differences with other countries are not reverted when they become adolescents.

4. Busso and Hincapié (2017) uses the results from two international tests held in the region: Trends in International Mathematics and Science Study (TIMSS) and the Second Regional Comparative and Explanatory Study (SERCE).

Figure 9 - Students that achieve at least the low benchmark in math on international tests (%)



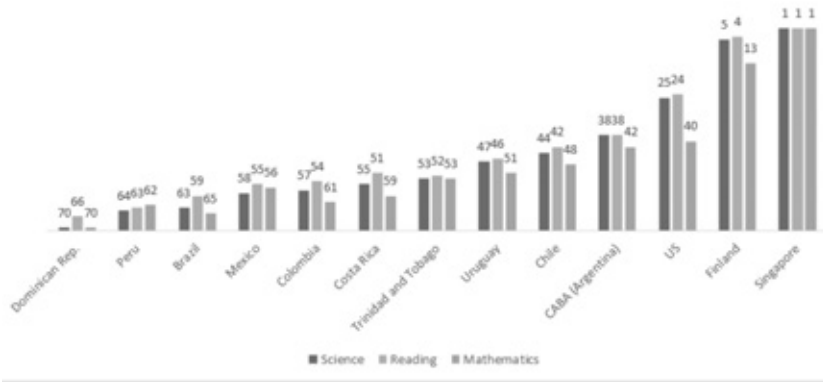
Source: Busso and Hincapié (2017)

Note: Comparison countries are economies with GDP per capita (PPP at constant 2011 dollars) in the same range as countries in LAC (between \$6,500 and \$25,500). These include Albania, Algeria, Bulgaria, Hungary, Indonesia, Malaysia, Morocco, Philippines, Poland, Serbia, Thailand, Tunisia and Turkey. The test in childhood is the Trends in International Mathematics and Science Study (TIMSS) for 4th graders held in 2007 and the Second Regional Comparative and Explanatory Study (SERCE) for 3rd graders held in 2006. The test in adolescence is the Programme for International Student Assessment (PISA) for 15 years old held in 2015.

This deficiency in learning explains the poor results of LAC in the Programme for International Student Assessment (PISA) test, which measures 15-year-old students’ reading, mathematics, and science skills. In the last assessment (2015), The Dominican Republic, Peru and Brazil are in the last 11 positions out of the 70 countries that took the test (see Figure 10). Furthermore, they are in the last 11 positions in the ranking of Math and Science. Although there are differences within LAC (e.g., the difference between Chile and the Dominican Republic in the Science test is equivalent to almost 4 years of schooling), countries in the region are far behind the leading countries in the rankings (e.g., comparable to almost five years less of schooling).

Higher education (HE) presents a similar situation. As Ferreyra et al. (2017) mentions, HE has rapidly expanded in LAC, in term of enrolment rates and the number of higher education institutions and programmes. The gross enrolment rate in HE rose from 21% in 2000 to 43% in 2013 and the number of HE institutions opened in the same period was around 2,300. However, HE in the region faces important equity and quality challenges. Although access has increased for all individuals, access is still larger among the rich. According to Busso et al. (2017), in countries such as Brazil, Costa Rica and Honduras, the enrolment rates for students from low-income households are at most 30%, while the ones

Figure 10 - Rankings (over 70 participants) in PISA 2015

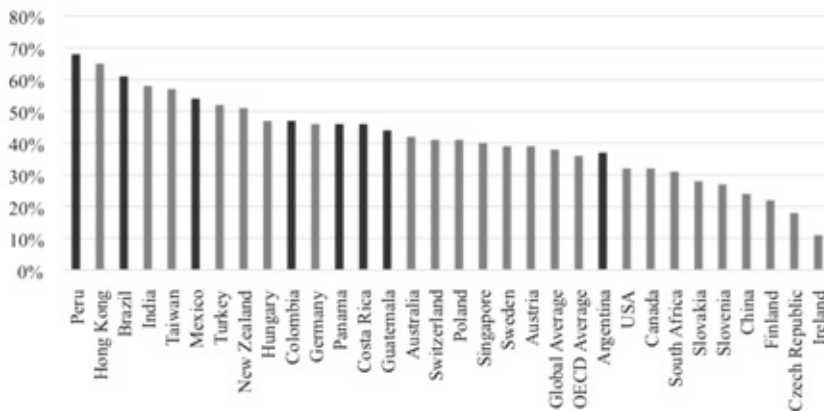


Source: OECD (2016)

form high-income households are 70%. Also, access to quality education is more prevalent at higher income levels. The low quality of HE is partially reflected in the low-income returns to education. Around 30% and 22% of university graduates in Colombia and Chile, respectively, experience negative net returns to higher education (González-Velosa, Rucci, Sarzosa, & Urzúa, 2015). The same study finds that the negative returns are twice as large (59% in Colombia and 51% in Chile) for those in post-secondary technical and technological programmes usually taken by low-income students.

Consequently, workers enter the labour market without the necessary skills. This is reflected by the proportion of employers having difficulties filling jobs due to the lack of workers skills. Using data from Manpower (2015), Figure 11 clearly shows that LAC countries are the most affected in this aspect. Similarly, Melguizo and Perea (2016) estimate that firms in LAC are three times more likely than South Asian firms and 13 times more likely than Asian-Pacific firms to face serious operational problems due to a shortage of skills. Moreover, Busso, Bassi, Urzúa and Vargas (2012) found that for employers in Argentina, Brazil and Chile the lack of skills is more prominent in social-emotional skills than in knowledge and specific skills. Flores-Lima et al. (2014) also found the difficulty of finding skilled workers motivates firms to offer training to workers.

Figure 11 - Employers having difficulty filling jobs due to lack of available talent (%)



Source: *Manpower Talent Shortage Survey (2015)*

Results from the Survey of Adult Skills (PIAAC) and the Skills Toward Employment and Productivity (STEP) provide additional evidence of the lack of skills in the workforce in LAC. Adults in Chile obtain substantially lower scores in the literacy and numeracy PIAAC tests than adults in OECD countries (18% and 22% lower scores than the mean adult in OECD countries, respectively). In addition, more than half of the sample in Chile (53.4%) scores the lowest level in literacy, which involves only completing simple reading tasks, compared to about 20% in OECD countries. Similarly, in the numeracy tests Chile obtains one of the smallest proportions of adults scoring at the level that requires complex tasks (1.9%), compared to about 10% in OECD countries.

Regarding digital skills, the PIAAC sample in Chile shows poor performance in problem solving in technology-rich environments, especially among the elderly. While only 14.6% of adults in Chile are proficient at the two highest levels of problem solving, 31.1% of adults in OECD countries are proficient. Adults in Chile also report using less information and communication technologies at work than adults in OECD.

Additional evidence on skills is provided by the World Bank’s STEP. The surveys of Bolivia and Colombia show that urban adults have a lower performance than the average OECD (Cunningham, Acosta, & Muller, 2016). About 60% and 36% of adults in these two countries, respectively, have a basic level of reading proficiency, compared to 15% of adults in high-income OECD countries. Ad-

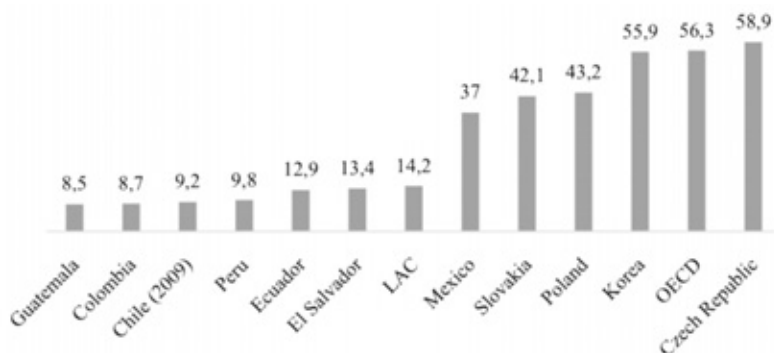
ditionally, only 11% and 23% of adults in Bolivia and Colombian are able to understand complex texts, compared to 52% of adults in high-income OECD countries.

Evidence from PIAAC and STEP shows that younger adults have better skills (digital, literacy, reading, numeracy and memory) than older adults. However, it also shows that young adults in LAC lag behind their counterparts in OECD countries.

As previously stated, the demand for non-cognitive skills by firms is increasing, especially in the context of new technologies that require non-routine, high cognitive, abstract and interpersonal skills (AfDB, ADB, EBRD, IDB, 2018). Regarding this, evidence from STEP show that young adults (15 to 24 years-old) in Bolivia, Colombia, El Salvador and Peru are less extroverted, perseverant and pleasant than older adults (25 to 49 years-old) (Cunningham, Acosta, & Muller, 2016). In these countries, low-educated adults also find difficulty in managing emotions, making decisions and working in teams (Cunningham, Acosta, & Muller, 2016).

Job training could potentially help reduce the lack of skills in the workforce. However, there is still not a systematic practice of continuous job training in LAC, which is reflected in the relatively low levels of workers that received some kind of training (according to household data) as can be seen in Figure 12.

Figure 12 - Workers receiving training, 2012 (%)



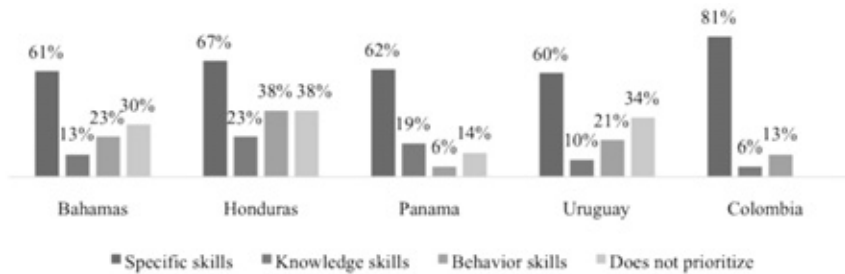
Source: *Alaimo et al. (2015)*

In the reduced-size formal sector this situation is different. Flores-Lima et al. (2014) found that the rate of formal firms in LAC offering training is relatively

high, ranging from 30% to 50% in most countries. However, this training is concentrated among large firms, is offered to the already most qualified workers and is of short duration and in firm-specific skills. Although training increases productivity of these firms, incentives to offer training to higher skills workers and in specific skills could compromise inequality.

Figure.13 shows that training offered by firms in LAC prioritises specific skills and assign less importance to knowledge and behavioural skills. ICT and computing skills are the most prevalent within the specific skills. For example, in Uruguay, between 7% and 11% of workers were trained in computing and ICT (De Mendoza, Di Capua, & Rucci, 2014). In Peru, 11.7% of firms include ICT skills in their training programmes according to the Encuesta de Habilidades al Trabajo (ENHAT)⁵.

Figure 13 - Proportions of firms offering training, by type of skills



Source: *Survey on Productivity and Human Resources Training in Establishments (EPFE)*

Note: EPFE is a Latin America-specific survey of human capital formation, which provides more detailed information about on-the-job training in five countries (the Bahamas, Colombia, Honduras, Panama, and Uruguay). The survey was carried out between 2011 and 2013.

3. New technologies adoption and potential effects on the labour market in LAC

There are concerns worldwide that the new technologies, such as automation and artificial intelligence (AI), could generate negative effects on employment. While some estimate that around 47% of employment in the US is at risk of automation (Frey & Osborne, 2017), others estimate that only 9% of labour is

5. ENHAT is a large employer skill survey collected in 2017-2018 in Peru.

automatable in 21 OECD countries (Arntz, Gregory, & Zierahn, 2016). In the case of developing countries estimates are more pessimistic, with estimates that approximately 66% of jobs could experience significant automation (World Bank, 2016). These potential negative effects could exacerbate the productivity and employment challenges that LAC countries are already facing.

In this context, it is important for LAC to properly identify the level of adoption of these new technologies, their potential effects on employment and the set of skills that will be required in the future. Unfortunately, there is a lack of information to properly answer these questions.

3.1 What is the level of adoption of new technologies in LAC?

Despite recent concerns about the potential negative effects of new technologies on employment, information on the level of adoption of these technologies in LAC is very limited. The available evidence seems to indicate not only that this level is lower than the level of adoption in developed countries but also that it is increasing. For instance, a recent report made by the regional development banks (AfDB, ADB, EBRD, IDB, 2018) shows that broadband development in LAC scored 4.28 in the 2016 Broadband Development Index compared to 6.12 for OCDE (excluding Chile and Mexico). It also showed that the density of robots (the number of industrial robots per 100 manufacturing workers) is also relatively lower. Mexico has the highest density in this index in LAC, with a value near 0.1, whereas developed countries have values near 1.

To the best of our knowledge, one of the few recent sources containing data on the level of adoption of technologies by formal firms in LAC is the ENHAT in Peru. This survey was implemented in 2017-2018 and asked about the use of technologies commonly mentioned in the literature, focusing on recent trends of automation jobs and new technologies (Störmer, y otros, 2014; Glenn & Florescu, 2016; World Economic Forum, 2016; Hogarth, 2017).

The analysis of ENHAT data confirms that the adoption of technology, at least in Peru, is low. New technology usage among Peruvian firms in 2017-2018 is still incipient, except in advanced network services (see Table 2). Overall, only 27% of firms uses at least one of these technologies. This proportion reduced to 7% when only adoption of technologies different than advanced network services was considered. There is a clear positive relationship between technology use and firm size, with 45% of large firms using these new technologies. It is also worth noticing that the share of high-skilled workers is higher among firms adopting new technology than among those not adopting it.

Table 2 - New technology use in Peru

Type of technology	Firms	Share of high-skilled workers in the firm
Artificial Intelligence	3%	44%
Advanced robotics	1%	52%
Autonomous transport	1%	41%
Advanced manufacturing	3%	48%
3D-Print	2%	59%
Advanced network services	24%	46%
Use at least one technology	27%	46%
• Small-size	24%	47%
• Medium-size	37%	45%
• Large-size	45%	39%
Do not use any technology	73%	40%

Source: ENHAT

3.2 Potential labour effects of new technologies in LAC

New technology may affect labour market outcomes in many ways. It might increase productivity and wages without affecting overall labour demand (Graetz & Michaels, 2015). Alternatively, it might increase employment through complementarity (Autor D. H., 2015) or product demand spill-overs (Gregory, Salomons, & Zierahn, 2016). New technology might also reduce employment by substitution of workers according to their position on the skills distribution. This skilled-bias technological change would reduce the demand for middle-skilled workers and increase the demand for higher-skilled workers (Autor, Katz, & Krueger, 1998; David, Katz, & Kearney, 2008; Atkinson, 2008; Carneiro & Lee, 2011; Autor & Dorn, 2013; Acemoglu & Autor, 2011).

There is little empirical evidence on the employment effect of these new technologies because firm level data on the use and effects of AI, machine learning and robotics is needed (Seamans & Raj, 2018). The available empirical studies usually evaluate the effects of the adoption of new technologies (e.g., ICT) on employment, skills, and wages using firm-level data. In developed countries, the adoption of ICT does not generally affect overall employment but tends to increase labour outcomes of high-skilled workers and to reduce the ones of low-

skilled workers (Bartel, Ichniowski, & Shaw, 2007; De Stefano, Kneller, & Timmis, 2014; Akerman, Gaarder, & Mogstad, 2015; Gaggl & Wright, 2017). Because of the scarcity of data, available evidence on its effects on employment in LAC is also limited. The available studies suggest that the adoption of new technology might increase total employment and might have heterogeneous effects throughout the skills distribution. In Argentina, Brambilla and Tortarolo (2018) found that ICT adoption among manufacturing firms increases their productivity and wages. Moreover, although adoption increases employment across the skill distribution, there is evidence of displacement of unskilled workers. Similarly, Iacovone and Pereira-Lopez (2017) show that the adoption of ICT increases the demand for skilled workers in the manufacturing sector in Mexico. In this case, the adoption of technology not only raises wages for both skilled and unskilled workers, but also reduces the wage gap between them. The authors argue that the reduction in the wage gap seems to be driven by low-skilled workers becoming more sophisticated due to organisational adjustments after ICT adoption.

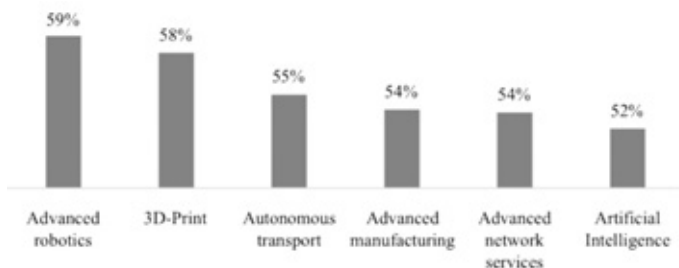
There is also evidence that the adoption of new technology affects aggregate labour market outcomes. In Brazil, although more Internet access does not affect aggregate employment, it negatively affects wages (Almeida, Fernandes, & Viollaz, 2017). It also provokes shifts in employment towards the most dynamic sectors. In these sectors (e.g., manufacturing), however, technology adoption positively affects employment and wages among high and medium-skill workers. Almeida, Corseuil and Poole (2017) also found that technology adoption affects local labour market outcomes, replacing workers in routine tasks for those in non-routine, cognitive tasks.

Contrary to the evidence in Argentina, Mexico and Brazil, in Chile the adoption of complex software reallocated employment from skilled workers to administrative and unskilled production workers. Moreover, the use of computers leads to increases in productivity and wages (Benavente, Bravo, & Montero, 2011).

Finally, the ENHAT of Peru also allows us to approximate the impact of adopting new technology on labour demand from the employer perspective. Employers already using these technologies and the ones likely to use them soon expect that the impact of adoption on employment will be positive. Figure 14 shows that more than 50% of these employers expect that the use of new technology, independently of the type, will increase employment⁶.

6. Contrarily to the ones who expect that technology use will not affect or reduce employment.

Figure 14 - Employers' expectations about the impact of new technology on employment in Peru



Source: ENHAT

4. Active Labour Market Policies in Latin America and the Caribbean

The poor results in terms of education and skills development in LAC emphasise the need to improve the education and workforce development systems whilst prioritising quality, to better prepare the future labour force. However, in the short term and in the context of a progressive irruption of new technologies, the productivity and employment challenges require the implementation of effective policies to support workers. In the economic literature, these policies are named Active Labour Market Policies (ALMP). Their aim is to generate more and better employment opportunities for workers (McKenzie, 2017), particularly for those who are most vulnerable, such as school dropouts, young people who lack the skills required by the labour market, and women who have been out of the labour market for a long time (Escudero, Kluve, Mourelo, & Pignatti, 2017).

There is an important disconnection between the importance LAC countries give to ALMP and the evidence of their results. A recent meta-analysis of ALMP in LAC (Escudero, Kluve, Mourelo, & Pignatti, 2017) found that, overall, these policies have positive impacts on labour outcomes (i.e., formal employment, wages, worked hours) and that the most effective ALMP in LAC is training⁷. However, the average public spending on these policies is low, representing around 0.2% of GDP, which is only a third of the expenditure of the OECD countries (Alaimo, Bosch, Kaplan, Pagés, & Ripani, 2015).

7. This study considers the following policies: (i) training programs; (ii) public works; (iii) employment subsidies; (iv) self-employment and micro-enterprise creation; (v) and intermediation services.

This section presents available evidence on the effectiveness of two of the most commonly used and evaluated ALMP in LAC: training memes, particularly those aimed at youths; and labour intermediation services⁸.

4.1 Training

Training programmes have been widely implemented across the region. A main reason behind their broad usage is the belief that they can compensate, with a short-term intervention, for workers' lack of skills (McKenzie, 2017) and help with their labour insertion.

In the mid-twentieth century, National Training Institutes (NTIs) were the main public entities offering training services in technical skills in LAC⁹. Although there is scarce evidence, the effectiveness of NTIs has been questioned for a long time. First, NTIs have been criticised for offering supply-driven training and for the low involvement of employers in the definition of training courses and curricula. Secondly, NTIs have weak quality assurance mechanisms. Third, most LAC countries lack strong national quality assurance systems for labour training. Finally, the collection of quality and periodical data and the implementation of monitoring systems are still deficient. This affects the assessment of NTIs impact on jobs, wages and productivity.

In the eighties, several LAC countries began implementing training memes that sought to depart from the classical model NTIs (Kluve, 2016). Supported by the IDB, Probecat of Mexico (1984) and Chile Joven of Chile (1991) were the first two demand-driven training meme in LAC that served as examples for other programmes (Ibarrarán & Rosas-Shady, 2009). Currently, these are the most commonly implemented programmes in LAC (McKenzie, 2017) and coexist with the NTIs. They work as a curative, rather than preventative, policy, that aims at completing youth formation before transiting to the labour market (Urzúa & Puentes, 2010). Despite the particularities that these programmes have in each country, the youth training programmes in LAC share common features (González-Velosa, Ripani, & Rosas-Shady, 2012): (i) their target population is young people, with low educational level, unemployed or underem-

8. For evidence of the other ALMP in LAC see Escudero, Kluve, Mourelo and Pignatti (2017).

9. SENA in Colombia, INFOTEP in the Dominican Republic, INA in Costa Rica, INADEH in Panama, SENCE in Chile, SECAP in Ecuador, Insaforp in El Salvador, INFOP in Honduras, HEART in Jamaica, INEFOP in Uruguay, and SNPP in Paraguay. In the case of Brazil and Peru, there is a sectorial training institute. For instance, the training institute for manufacturing is SENAI in Brazil and SENATI in Peru. More information about these institutions is available at: <http://www.oitcinterfor.org/>.

ployed; (ii) training services target urban areas and attend few beneficiaries relative to their public objectives; (iii) training is offered in private institutions but funded by public resources; and (iv) training covers technical and soft skills in a combination of off-the-job and/or on-the-job short term training.

These programmes have been widely evaluated. Evidence from Argentina (Alzuá & Brassiolo, 2006; Alzuá, Cruces, & López, 2015), Chile (Aedo & Pizarro, 2004), Colombia (Attanasio, Kugler, & Meghir, 2011), the Dominican Republic (Card, Ibararán, Regalia, Rosas-Shady, & Soares, 2011; Ibararán & Rosas-Shady, 2009; Ibararán, Ripani, Taboada, Villa, & Garcia, 2014; Novella & Ripani, 2016), Mexico (Delajara, Freije, & Soloaga, 2006), Peru (Díaz & Jaramillo, 2006; Díaz & Rosas-Shady, 2016; Ñopo, Saavedra, & Robles, 2008) and Uruguay (Naranjo, 2002) show positive short-term effects on labour market outcomes (mainly on the probability of having formal employment and labour income), particularly among women. These effects hold, in the longer term for certain groups in the case of Colombia (Attanasio, Guarín, Medina, & Meghir, 2015; Kugler, Kugler, Saavedra, & Prada, 2015) and the Dominican Republic (Ibararán, Kluge, Ripani, & Rosas-Shady, 2015)¹⁰.

In addition to training programmes for facilitating the transition of youths into labour markets LAC countries have also implemented and evaluated the effect of on-the-job training and training for active workers. Ibararán, Maffioli, and Stucchi (2009) and Flores Lima, González-Velosa, and Rosas-Shady (2014) study the effects of employer-provided training on productivity in manufacturing firms. On the one hand, Ibararán, Maffioli, and Stucchi (2009), using cross-section data in a sample of 16 countries, show a positive impact on productivity. On the other, Flores Lima, González-Velosa, and Rosas-Shady (2014), using longitudinal data from firms in a sample of 11 countries, observe that on-the-job training for active workers increases multifactorial productivity in firms with more than 100 workers. It is also apparent that training for active workers also seems to have positive effects on labour income in the medium term in Chile (Novella, Rucci, Vazquez, & Kaplan, 2017).

More recently, due to its effectiveness in developed countries, countries in LAC are paying attention to apprenticeship programmes (Novella & Pérez-Dávila,

10. In addition to improving labour outcomes, training programs in LAC have shown to positively affect other relevant individual wellbeing indicators. In the Dominican Republic, Novella and Ripani (2016) find that a training programme reduces teenage pregnancy by 20 per cent, through improvements in soft skills and expectations. Similar evidence on skills and expectations is found by Acevedo et al. (2017). In Brazil, Calero and Roza (2016) find that a training program also reduces the probability of adolescents engaging in risky behaviours.

2017). They differ from the previous training programmes in their target population, funding source, and cost, duration and organisation of training (Fazio, Fernández-Coto, & Ripani, 2016). Apprenticeships combine structured off-the-job and on-the-job training and a formal work contract between the firm and the apprentice. Argentina, Brazil, Colombia, Costa Rica, Chile, Peru, and Mexico have a regulatory framework for apprenticeship-type experiences. Nevertheless, these programmes lack some of the defining features of apprenticeships. Evaluations of these programmes in Argentina and Brazil show positive effects on youth turnover and formal employment (Corseuil, Foguel, Gonzaga, & Ribeiro, 2012; Berniell & de la Mata, 2016).

4.2 Labour Intermediation

LAC governments offer intermediation services through Public Employment Services (PES). However, most of the PES received very limited public investment. It reached 0.04% of the GDP in LAC (Cerutti et al., 2014) while in OECD was 0.17% (OECD, 2011). The scarcity of resources shows that, in general, PES in the region are not at an advanced stage of development, offer only basic employment services, and have low coverage (Mazza, 2011). For instance, the average number of job seekers served by a PES office in LAC is 38,872, while in Europe and Asia-Pacific this number is less than 4,000. Also, the average workload of PES staff in the region is 5,180 unemployed per staff member compared to 170 in Europe. Furthermore, most PES do not offer a diverse and integrated offer of services and programmes (IDB, WAPES, OECD, 2016). Moreover, LAC has made little advancements in the monitoring and evaluation of these programmes (Alaimo, Bosch, Kaplan, Pagés, & Ripani, 2015). The exception is Mexico, where a monitoring system based on indicators and a pay-for-performance system are established (Mazza, 2011). This situation explains that PES is not broadly used by job seekers or firms. Only 30% of people looking for a job use formal channels, such as those offered by PES.

Evidence of the effectiveness of PES in the region is scarce (Escudero, Kluge, Mourelo, & Pignatti, 2017). Betcherman et al. (2004) pointed out that the cost-benefit ratio of PES is favourable. However, based on non-experimental evaluations from Brazil and Uruguay, PES seem to be less effective in countries with large informal sectors where workers typically use other channels to find jobs. Another two non-experimental evaluations for Mexico and Colombia found some positive results. In Mexico, PES helps the unemployed to find jobs with higher salaries than the ones found by those using other job search channels. Results are however only significant among men (Flores Lima, 2010). In Colombia, the employment services increase the probability of having a formal job,

relative to those individuals who use other job search channels. Impacts on wages for the low skilled beneficiaries are also observed (Pignatti, 2016). Finally, Dammert et al. (2015) implemented an experiment to evaluate the impact on employment if information about job vacancies is provided to job seekers registered in the PES in Peru with announcements sent by SMS messages. The results indicated that the messages raise employment (6.2 percentage point) after one month. However, after the third month, the effect vanishes.

5. Conclusion and discussion

Although there have been substantial improvements in different economic and welfare indicators, LAC still face important challenges in terms of low productivity and poor skills development. The arrival of new technologies imposes further challenges on labour markets in the region, particularly for the most vulnerable groups of workers.

This document describes the main characteristics of LAC in terms of their labour markets and education and skills developments. Labour markets in LAC, in contrast to developed regions, are mainly characterised by high informality and precarious job quality, which primarily affect vulnerable populations (e.g., women, youth, and those from poor socioeconomic backgrounds). These conditions affect workers' chances of improving their human capital through training, and perpetuate their vulnerable status and low productivity. In terms of education, although the region has achieved considerable progress in increasing access to education, quality of education remains low. This deficiency is reflected in the poor results obtained by young students in the PISA test; in the proportion of graduates having large negative net returns to higher education; and the results obtained by adults in PIAAC and STEP, which confirm the lack of skills in the workforce in LAC.

The recent technological trends raise questions about the level of adoption of these new technologies and their potential effects on productivity and employment in LAC. The scarce available evidence suggests that new technology adoption is still lower in the region compare to developed countries (e.g., in Peru only 27% of firms uses at least one of these new technology). Skills shortage might contribute to constrain the adoption of new technologies by more firms in LAC and restrict the gains in productivity. Moreover, new technology adoption is expected to affect labor demand, particularly among less-skilled workers. To tackle the employment challenges, benefit from the effect of new technology on productivity, and minimise their future effects on less-skilled workers, countries in LAC should pay attention to policies for improving workers' skills. If

such policies are not implemented, the adoption of new technologies is likely to benefit higher-skilled workers and therefore increase the already high inequality level observed in LAC.

Job training programmes have the potential of being one of these policies and bring workers with the set of skills demanded by a changing labour market. These programmes have been extensively implemented and evaluated in LAC. Generally, they show some positive short and long-term effects on the quality of employment, particularly among women and youths. To become an effective policy tool in this regard, job-training programmes need to increase coverage (currently, access to training in LAC is considerably lower than in other developed regions), and improve the quality and pertinence of the contents (e.g., prioritising transversal, cognitive, digital and socio-emotional skills) and delivery (i.e., duration, use of new technologies, and certification).

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Robotics workshops and Contextualised Technological Education programme¹

Paola Mengoli and Margherita Russo

1. Introduction

Promoted by a programme of action research at Officina Emilia of the University of Modena and Reggio Emilia, the robotics workshops comprised an experiment run between 2005 to 2013 in the classes of primary and lower and upper secondary schools in Modena, Reggio Emilia and Bologna, involving over 2,700 students and more than 200 teachers. The participants observed, constructed and programmed LEGO® micro-robots, as examples of mechanisms and machines. Numerous promotional events also involved a group of adults and, over a period of time, various training events were realized for trainers and teachers.

The experimentation in the workshops took place in the context of action research which involved a coordinated series of actions. A sub-set of these actions, made up of *hands-on* workshops on machines, on production processes and on industrial jobs, included the robotics workshops. The robots were constructed, programmed and tested in order to promote knowledge of production techniques, the technology incorporated in the products, the expertise and competencies of employees in industry, as well as of the processes of innovation and technological change.

1. An Italian version of this paper has been published online by the review *Mondo Digitale* and we would like to thank the Editor for authorising its publication in English. The authors thank Donatella Poliandri (INVALSI) for her contribution with the initial setting up of the project to evaluate the activities with the schools within the action research program of Officina Emilia. They also wish to thank the organizers of the Convention “Giocare a pensare. Metodi e tecnologie per l’uso educativo e didattico dei robot” (Playing at thinking. Methods and Technologies for the Educational and Didactic Use of Robots), held at the University of Milan-Bicocca, May 20th 2017, and the participants in the session presenting an initial processing of the evaluation questionnaires of the robotics workshops of Officina Emilia. Our thanks also go to the two anonymous referees for the comments on the original paper. Whereas preliminary results were presented at the Convention, in this paper the results take into consideration all the questionnaires on the robotics workshops, since in recent months it has been possible to complete their digitalisation.

The entire research project was initiated and developed at the University of Modena e Reggio Emilia between 2000 and 2015. Following the end of the experiment with schools, research focused on the documentation and evaluation of the experience. Here a number of observations on the results of the robotics workshops are presented. The contribution is of a dual nature. On the one hand, an original context is presented in which experiences of technological and computer science education were realised with the use of a micro-robotic kit. On the other, a threefold evaluation of the experience of these workshops is presented: (i) the effect on the overall didactic activity of the schools involved, (ii) the effect on the knowledge, attitudes and abilities of the teachers involved, and lastly (iii) the effect on students' levels of knowledge, on their motivation to expand their knowledge and on the overall satisfaction of the workshop activities.

The paper is structured as follows. In section 2 the objectives of the Officina Emilia research project are illustrated. Section 3 presents the theoretical underpinnings of the project. Section 4 describes the robotics workshops while section 5 focuses on the evaluation of these workshops. Section 6 presents concluding remarks on the feasibility of the experiences of robotics education as a vehicle of contextualised technological education, and puts forward observations about ways of involving students, their teachers and schools. The aim is to simultaneously create significant learning experiences for new generations, in-service teacher training experiences, and innovation in pedagogical practice.

2. Action research

Numerous elements highlight the fragility of the traditional forms of cognitive mediation which for generations have introduced young people to an understanding of the social, economic and institutional context, as well as of the technological and professional context. Families do not seem to be able to transmit the knowledge and interpretations necessary to understand the social context, which is increasingly wide and complex. The same difficulties are to be found in schools. A growing number of teachers obtain their qualifications in different, and distant, geographical contexts from where they are teaching. The content of the courses they have studied, and above all the characteristics of their social relations, do not seem wholly adequate for the delicate task of including their students in the social, cultural and economic context (OECD, 2019).

In Italy, the educational experiences of young people up to the end of high school, is characterised by the poor quality of knowledge and competency in technological fields (i.e. reference to both production processes and products), and in the computer science field. Moreover, the enhancement of technological

education, with an explanation of the social and economic aspects connected to the use of technologies and to the development of scientific knowledge, generally remains beyond the scope of education of young people (Hutchings et al, 2001; Chatel, 2010; Baskette, 2013). These elements influence the level of interest in technical and scientific professions, highlighting also a big gender gap in these fields.

The Officina Emilia action research with schools was directed, above all, at teachers, in the form of support by means of educational actions which were innovative in method and content. All the teachers involved took part in the training course, observed systematically the experimental activities and contributed to their validation.

From 2004 and onwards, didactic modules on robots and digital programming (*coding*) were experimented with. The spread of numerous artefacts that incorporate programmable systems highlighted the need to possess scientific and mathematical knowledge, as well as basic engineering knowledge, for an informed use of many products in everyday use. Moreover, in areas with a marked manufacturing vocation, particularly in the mechanical engineering sector, such as for example Emilia-Romagna in Italy or the Rhine Basin in Germany, it must be ensured that the young work force entering the job market have, at all levels and for all jobs, much higher levels of knowledge and competency than has proved necessary hitherto. Many of the possibilities for firms to continue to foster the processes of innovation and growth in a competitive global market, depends, to a large degree, on this capacity of the educational system (Bellmann and Hubler, 2014; Azevado, et al., 2012; Bosch and Charest, 2010; Barber, 2003; Grubb, 1996).

The actions realised in collaboration with schools, within the Officina Emilia action research programme, allowed for the verification of, on the one hand, the possibility of a change in pedagogical practices and, on the other, the effectiveness of the means to foster knowledge of the technological, social and economic context. The aim of this is to develop in students the ability to choose between different pathways of study and work opportunities, as well as to develop their social identity, right from their early years of school.

The closure of the Museum Workshop in 2013 - resulting from the need of the University to reduce costs following national policies which imposed a reduction in public expenditure (Russo and Mengoli, 2017) - coincided with the conclusion of the central activities of the action research programme with schools. The programme continued with documentation activities, in-depth study encounters with other groups of researchers at national and international levels, and with the processing of the data for the evaluation, writing and publication of papers about

the research (Russo and Mengoli, 2013, 2014; Ghose et al., 2013, Russo, 2016). Other lines of research connected with the Museum Workshop experience have continued, above all with reference to the evolution of industrial structure (Russo, 2015), the efficacy of education systems (Mengoli, et al., 2013) and the experience of action research in the context of the politics of local development (Russo and Mengoli, 2017).

3. Theoretical underpinnings

The Officina Emilia action research is to be seen within the context of constructionist learning theories (Harel and Papert, 1991, Papert, 1993, Jonassen and Rohrer-Murphy, 1999). The perspective is that of active and contextualised learning, promoted by educational institutions which, in turn, operate under the influence of the institutional, social and economic conditions of the geographical area and country in which they are located. In setting up the action research the theoretical contribution of Vygotskij (1962) was of prime importance, especially for the interpretation of learning as a process of interaction between the individual and the environment, and of the social interaction and exchange between the less competent and the more expert. Furthermore, the contribution of the works of Dewey was fundamental (especially Dewey 1916, 1933) with regard to learning as an active social process in which manual experience constitutes a core feature that is integrated with reflective activities. A specific aspect of the action research project design was reference to studies on situated learning (Lave and Wenger, 1991), in the conviction that there is no acquisition of significant learning that does not take into account, in a decisive way, the context in which the learning itself, and the learner, are situated in space and time. Situated learning is also taken as the interpretative instrument of the factors that fuel motivation to make the effort to achieve successful learning (De La Garanderie, 1996).

Within this theoretical framework, the empirical background of the Officina Emilia robotics workshops is common to the experiences of *hands on* workshops which were widespread during the eighties in the main museums of science and technology, initiated by the pilot experience of the *exploratorium* of San Francisco², which was inaugurated at the end of the sixties (Quin, 1996; Polishuk and Verner, 2017). Through the disassembly and reassembly, also in a creative way, of products and artefacts using tools and instruments, effective educational action in the technological field was developed. In the Officina Emilia action research programme, the workshops on machines and on industrial production,

2. See www.exploratorium.edu/about/our-story (14th September 2017).

which included the robotics workshops, encouraged the exploration of artefacts, machines and the environments in which they are used. A strong connection can be seen with what, almost in the same years, was being realised in the *tinkering* workshops of the *exploratorium* of San Francisco³. As to the objectives and content, the empirical basis of the Officina Emilia workshops, including the robotics workshops, these can be found in the educational standards established from its first edition in 2000, by the International Technology and Engineering Educators Association (2007).

4. The robotics workshops

4.1 Objectives

Of the workshops on machines and industrial production of the Officina Emilia action research programme, two robotics experimental workshops were hosted: (i) “A robot that follows a line”, for students aged between 12 and 16 years and, with slight modification, for students aged between 17 and 19 years; and (ii) “Robot-Croco-Dile”, for girls and boys aged between 8 and 11 years.

The organisation of the workshops envisaged that a class, accompanied by one or more teachers, would go to the Museum Workshop in the morning to do the activities for four hours in the case of “A robot that follows a line” workshop and for three hours in the case of the “Robot-Croco-Dile” workshop. The workshops were programmed as stimulus events as part of a structured educational module of between a minimum of eight hours and a maximum of 20 hours. The teachers who accompanied the classes managed the other didactic activities connected with the workshop, using material and methodological indications given by the research team.

In the “A robot that follows a line” workshop, the students constructed a robot with LEGO® blocks, following instructions with no verbal indications. With only a very general presentation of the software tool, and proceeding by trial and error, the students wrote a program that allowed the robot to follow a black line on a white background. They tested the robot and competed to verify the accuracy of what they had done. A more complex version of the same workshop was hosted for girls aged 15-19 years, within the international program “Roberta”⁴.

3. See <https://tinkering.exploratorium.edu/> (14th September 2017).

4. Roberta is a project set up in 2002 by the Fraunhofer IAIS (Institute for Intelligent Analysis and Information Systems) in Bonn in response to the dearth of girls enrolling in technical-scientific courses. See <http://roberta-home.de/en>. (14th September 2017).

In the workshop called “Robot-Croco-Dile”, the children constructed an automatic mechanism in the shape of an animal which could move and use a sensor connected to a computer. The languages of the verbal and pictorial descriptions were conjugated with the forms in the flowchart and with the codification of the software WeDo®.

All of the documentation about the Officina Emilia didactic workshops is available on line⁵.

The objectives of the robotics workshops, in terms of learning and development of competencies, can be summarised synthetically as follows:

- The ability to identify problems, to choose between alternative solutions, to test the solutions and verify the results;
- Knowledge of the meaning of specific terminology to describe a machine and a robot, as well as knowledge of the principles of algorithms, their formalisation, and the basic instructions of any programming language (basic *coding*);
- Discovery of the fields in which robots have changed work and the living conditions of people, and of the geographical distribution and the characteristics of the firms that design, produce and sell robots;
- Discovery of the technological and scientific competencies necessary for the production, programming and testing of new robots.

The teaching of robotics as a discipline and as a set of specialised engineering competencies is not among the objectives. The main aim is to have all students acquire, irrespective of their school level and of the type of studies they have chosen, a concrete and functional knowledge of the basic elements of the technologies incorporated in machines and products.

The robotics workshops also pursued objectives of learning and professional training for the teachers involved with their classes. In summary, these objectives concern:

- Knowledge of the basic elements of the structure of a machine and of a robot and of the appropriate language to describe them;
- Knowledge of the principles of algorithms, of their formalization and of the basic instructions of any programming language (basic *coding*);

5. The documentation was created using MOVIO, an *open source* web application for the realization of virtual online exhibitions, developed by ICCU between 2012 and 2015. The MOVIO project used the Officina Emilia workshops in the test phases of the application. See www.officinaemiliaconlescuole.it/ (14th September 2017).

- Knowledge of the sources permitting the study of the social, economic and institutional structure of an area, in connection with the technologies used and the emerging organizational models;
- The practice of *hands-on* didactic units, with the use of multimedia materials and collaborative work in small groups.

What is presented above is not so very different from the numerous educational experiences that have been realised in museums, schools and *fab-labs* with the use of micro-robotics material. The action research programme, however, within which the experimentation of the robotics workshops took place set itself the aim of verifying the possibility of achieving two further important objectives: it is precisely these that constitute the peculiar characteristic of the experiences that are described.

In the first place, the robotics workshops were seen as an efficient means of encouraging an active knowledge of the technological, economic and social context, with particular reference to the areas where manufacturing is widespread. Secondly, the workshops, conducted rigorously under the strictures of action research methodology and connected with the in-service training of the teachers, aimed to foster in schools the diffusion of an innovative vertical curriculum which would benefit from the stimulus events, but would also make connections with other curricula and extra-curricular didactic actions.

4.2 *An evocative environment*

The robotics workshops, as stimulus events of a more complex educational programme, were experimented with, above all, in the Museum Workshop: an environment evoking mechanical processing, designed and realised as part of the action research to make possible: the observation and manipulation of machines, tools and products; bring about encounters with workers and business owners in the manufacturing sector, and develop contacts and connections with local firms. To all intents and purposes, it was a complex environment with space for simulation of the industrial work of the small and medium firms in the industrial districts of north east Italy. In support of the exhibition areas, the documentation Centre produced texts, films and original photographic material that made it possible to benefit fully from the exhibits and installations, and from the possibility of touching and manipulating everything that was exhibited⁶.

6. <http://www.officinaemiliaconlescuole.it/it/203/robot-cocco-drillo/show/48/186> and <http://www.officinaemiliaconlescuole.it/it/203/un-robot-che-segue-una-linea/show/48/246> (29th December 2017).

A simulation replicates an environment, a real system, the actions that are performed within it, and can make it possible to observe the changes that have come about in time, when there are artefacts available from different epochs. A simulated environment allows learners to interact with reality, to verify the effects and changes brought about by their actions, with due regard for individual learning times, as well as to make mistakes without compromising a real production process. A simulation makes use of technological support (hardware and software) to increase the opportunity of understanding how the environment and its artefacts work. (Kurt, 2001; Koehler et al., 2005). In order to function, a simulated environment needs to be constructed and operated by making reference to an informed model, both of the learning process to be activated, and of the reality which is simulated. For this reason, the Museum Workshop was designed in collaboration with numerous professionals and researchers of different disciplines: engineers, physicists, materials chemists, industrial and work economists, experts in industrial organization, learning psychologists, educators and pedagogues, and communication experts.

Simulations are used in many different contexts, generally when there are reasons that make it impossible for learners to have direct experience of the operational environment. This is the case, for example, when an operation has high costs of materials, when the time required for a real experience is long, or when there are ethical or legal constraints (Garris et al., 2002). In the case of *Officina Emilia*, the main limitation that justified the construction of a complex simulated environment was the difficulty of giving all the students, or at least a large part of them, access to the direct and meaningful observation of industrial production environments. The small firms in the manufacturing districts are characterised by limited space and a high level of specialisation so that it is often impossible to understand the production process if only one firm is observed.

Formative/educational simulations are intended to teach the fundamental elements of a system through observation of the results of actions or decisions, thanks to a feedback process which in turn is generated by concrete simulations. The research hypothesis was that the simulations of assembly, dis-assembly, software programming and testing of the artefacts could help students and teachers to understand technical events and concepts that are not only complex but also cannot be fully observed in a business organisation of small dimensions.

The importance of the industrial environment for transmitting learning became strikingly clear when some of the teachers who had taken part in the robotics workshops in the Museum Workshop with their classes experimented with the same workshops in their own schools, albeit with a version adapted to be re-

alised in the school classroom⁷. Unanimously, the teachers noticed a drop in attention and reduced motivation, particularly in the weaker students, and thus reduced effectiveness of the experiences in the classrooms compared with those carried out in the Museum Workshop.

4.3 Background and meaning of the workshop experiences

The robotics workshops are not only an opportunity to reflect on the parts a robot is made of, the main structures of a machine, the basic tenets of software programming, or on the difficulties that are encountered in getting the robots to interact with their environment. Opportune moments for information transmission and of educational dialogue can make explicit the connections between what is simulated in a workshop and the external environment, where people live and work and encounter the use of robots.

What makes the robotics workshops analysed here original lies not so much in the central role of the educational action, which develops basic technological competencies that are increasingly indispensable for everyone, but, rather, the originality is to be found in the initial phases and the final phases of the workshop. These introduce elements of knowledge and interpretation of the characteristics of the economic system under a technological, social and institutional profile, as well as elements of the world of work and of professions / jobs. Right from primary school, students can be introduced to this knowledge through stimulating experiences such as the robotics workshops. Often the new generations do not have easy access to instruments that can help them understand the world they live in and to reflect upon it. This is why the influence of certain factors from the cultural and social context they come from often produces pre-conceptions and scepticism. This weighs negatively on the choices made with reference to educational and professional courses, as well as on motivation to learn especially with regard to science and mathematics.

During the robotics workshops, with video-installations, films of recorded interviews and appropriate didactic action, the connections between what the students constructed and the robots used in firms, hospitals and airports were made explicit, with opportune adaptations taking age into account. Numerous examples were given to show how these machines interact with men and women who work, and who have seen their conditions change precisely as a result of robots being introduced. This didactic action constructs a background of meaning to

7. See: http://www.officinaemilia.unimore.it/site/home/oe-con-le-scuole/laboratori_online/un-robot-che-va-scuola.html (14th September 2017).

the experience of robotics and connects it not only with the school, but with a much wider perspective of knowledge and skills necessary to live and work (Zanelli, 1986).

During the robotics workshops, but more often in the didactic activities in the classrooms, conducted by the teachers after the participation of classes in the workshops, attention was focused on discovering the firms – not just ones in Italy - that produce robots. In other cases, the ethical aspects of the spread of robotics were studied further, with reference also to the substitution of work undertaken by humans and the use of robots in situations of armed conflict, or in the surgical field. One didactic unit was dedicated to literature and cinema in order to analyse how robots have become part of cultural production.

5. Evaluation

The literature on the evaluation of educational experiences that use robots and micro-robotics is very recent and generally reports good results, but it also suggests doubts and points to the need for further research (Benitti Barreto Vavasori, 2012; Bredenfelt, et al., 2010; Kandlhofer, M., and G. Steinbauer, 2014). The evaluation of the robotics workshops comes under the more general evaluation scheme of actions realised by schools within the *Officina Emilia* project. Presented here are some of the results, referring to the robotics workshops held between 2009 and 2013 and to the three dimensions considered:

1. The effect on the overall didactic activity of the schools involved;
2. The effect on the knowledge, attitudes and abilities of the teachers involved, and lastly; and
3. The effect on the knowledge of the students, their motivation to continue, and on their overall satisfaction with the workshop activities.

The collection of data for the evaluation of the workshops used four instruments:

1. In-depth interviews with teachers;
2. A questionnaire for teachers when their class took part in a workshop; a questionnaire about the degree of satisfaction of the students of the lower and upper secondary schools; and
3. A questionnaire with yes/no questions, compiled before and after taking part in a workshop, showed changes in the learning of students.

Table 1 records the main data, referring to the instruments used and their number.

Table 1 - Instruments used for the collection of data for evaluation

Instruments used	Number
In-depth interviews with teachers	30 of which 28 complete and usable ⁸
Questionnaires of accompanying teachers	121 in digital format ⁹
Satisfaction questionnaires of secondary school students	497 in digital format ¹⁰
Questionnaires on learning of students	86 ¹¹

Source: Authors processing of the evaluation instruments of the robotics workshops of Officina Emilia

The evaluative exercise presented in this paper is based on the analysis of the qualitative elements expressed by the participants regarding the changes in their knowledge and actions after participating only in the robotics workshops. The changes in the knowledge of students, the data-collection – at the beginning and at the end of the workshop – permitted a quantitative evaluation of the changes produced.

5.1 Effects on the functioning of school institutions

The participation of classes in the workshops was initially promoted by teachers who, out of personal interest, took an interest in the action research project. After that, the majority of classes of students took part in the workshops following decisions by the respective schools.

8. Of these, 18 are primary school teachers, 6 are lower secondary school teachers and 4 are upper secondary school teachers. The interviews were conducted in the school years 2011-2012 and 2012-2013 at the Museum Workshop of Officina Emilia in Modena.

9. Of these, 63 are primary school teachers, 39 are lower secondary school teachers and 19 are upper secondary school teachers. The questionnaires were compiled between 2009 and 2012 by teachers mainly from schools in Modena and Reggio Emilia. The composition by gender is weighted in favor of women (86%) and of mathematical and scientific subjects (35%), followed by humanities (31%), by technical/technological education (18%), and by social sciences (4%). 12% of the accompanying teachers were support teachers or educational assistants for disabled students.

10. 51% of the participants frequented lower secondary schools and 49% upper secondary schools, almost equally divided among grammar, technical and vocational schools. Gender distribution was 53% males and 47% female students.

11. Data collection about learning involved four classes and a total of 86 students, of whom 42 were from lower secondary schools (12-13 years and 48% females) and 44 from upper secondary schools (17-18 years and 51% females).

The schools involved were mainly from the province of Modena, and also from the neighbouring provinces of Reggio Emilia, Bologna and Mantova. Altogether the project involved 32 school institutions, of which 17 were primary schools, 6 lower secondary schools and 9 upper secondary schools¹².

The main effect of the activity on schools is measured by the number of school institutions that have integrated the *Officina Emilia* workshops into their general didactic plans, considering them as significant “stimulus events” and making them part of the educational opportunities available that are communicated to families. Three primary schools, two lower secondary schools and one upper secondary school made this choice, and they represent about 20% of the schools involved.

5.2 Effects of the activities on teachers

The robotics workshops made available to teachers the opportunity to further their basic knowledge of technology, coding, and the economic and social structure of the local and regional context. Moreover, the methodology of a workshop represented an example of an effective pedagogy that can be used in the teaching of numerous courses. The large majority of teachers involved were able to explore the possibility of acquiring knowledge and skills useful in realising meaningful teaching and learning pathways for their students.

In some cases, the teachers taking part in the workshops lacked enthusiasm and refused to collaborate for numerous reasons, prevalently the kind of university education they had experienced, an unwillingness to go beyond the boundaries of their individual subject, and a conception of technological education as being bound exclusively to vocational education. A humanities based university education characterised the profile of the most critical teachers, though not totally or exclusively. A university education in technological and scientific disciplines is not sufficient to sustain the motivation of teachers with regard to the didactic innovations proposed in the robotics workshops. In fact, the knowledge of robotics requires not only the crossing of boundaries between disciplines, but also changes in habits, and the overcoming of deep-rooted stereotypes. It is necessary to understand the connections and relations existing between numerous disciplinary areas, and that not all teachers, regardless of their initial education, appreciate this pathway towards professional growth. Lastly, some teachers who teach engineering and economic disciplines in technical and vocational upper secondary schools, who

12. In the years in which the workshop was most active, Comprehensive Institutes were not yet widespread and therefore primary schools were still separate institutions from infant schools and from lower secondary schools.

are in the habit of promoting specific knowledge and skills that are directly applicable in the workplace, had difficulty becoming involved in educational actions aimed at anybody preparing themselves to enter the world of work or simply wanting to benefit from the potentialities of digital technology.

Table 2 summarises the changes that teachers referred to in the questionnaires compiled after taking part in the workshops¹³.

Table 2 - Percentage of teachers who declare some effects of the workshop on their didactical activity (N. 121), multiple choice answers

20%	Before participation introduced the classes to the workshop activity, making explicit the links with the content of curricular subjects.
34%	The workshop activities are a stimulus event for the students and this aids the introduction of curricular topics by the teachers.
28%	The workshop activities stimulate the curiosity of the students and help to improve attention towards curricular activities.
12%	The workshop activities boost the capacities of students to orient themselves in their choices post-lower secondary and post-diploma of upper secondary school.
83%	Following the experience think they will do further work on the topics dealt with in the workshop and/or will introduce associated topics.

Source: Authors processing of the questionnaires of the teachers participating in the robotics workshops of Officina Emilia.

Only one teacher in five introduced the classes to the workshop activity making explicit the links with the content of curricula disciplines. Although this percentage, starting with percentages close to zero, increased during the course of the years of workshop activity, it never reached a high level. The majority of teachers continued to delegate the task of introducing and rendering meaningful the participation of students to laboratory operators. Little more than a third of the teachers involved (34% in Table 2) think that the workshop functions as a stimulus event and benefits their work when they have to introduce new topics connected with technologies, mathematics, and coding with knowledge of the economic structure of the local area. 28% of teachers (Table 2) think that participation in the workshops stimulates students' curiosity and helps improve their attention towards curricula activities. 12% (Table 2) of teachers see par-

13. In the processing, the open answers given by the teachers are codified. Differences between the answers of teachers of schools of different levels are not taken into account. A more detailed picture will be available with the complete analysis referring to all the Officina Emilia workshops, which is currently in progress.

participation in the workshops a helpful instrument to develop in students the capacity to choose between different pathways of study and different careers.

The action research set out to verify whether, and to what extent, new content could be transmitted in everyday actions through involvement of teachers in workshop activities with their students. This hypothesis has been confirmed, at least in the short term, given that 83% of the teachers intend to do further work on the topics dealt with in the workshop or to introduce topics connected to it.

5.3 Effect on the knowledge, motivation and attitudes of the students

The confirmation of the hypothesis that the robotics workshops develop an appreciable body of knowledge and skills can be deduced from Table 3, which is based on the processing of the in-depth interviews and on the answers to the open questions of the questionnaire for teachers. The key words located in the interviews and in the questionnaires have been catalogued in five categories: soft skills, creativity, logic, knowledge of technology, work and firms.

Table 3 - Skills and knowledge developed by the students during the robotics workshops

Skills and knowledge	Specifications and characteristics
Skills	
Soft skills	Precision, collaboration, communication, orderliness, cleanliness
Creativity	Construction of artifacts, choice between different shapes, use of space
Logic	Classifications, flow diagrams, algorithms, computational thinking
Knowledge	
Technology and work	Stages of manufacture, production technologies, software in machines and in products, history of techniques, economic development
Work and firms	Organisation of work, history of work, social development, entrepreneurship

Source: Processing of the interviews with teachers participating in the robotics workshops of Officina Emilia (N. 28) and of the answers to the open questions in the questionnaire for teachers (N.121)

All the teachers interviewed recognised that the workshop activity students took part in favours, in an almost generalised way, the practice of precision, orderliness and collaboration, even in the less motivated students. Other skills and knowledge are developed in a less decisive way. The persistence of the positive effects on the students can be attributed to the possibility of reinforcing the behaviours, knowledge and skills gained during the workshops.

As to learning, with particular reference to the development of knowledge (Table 4), despite the fact that the results of the tests administered to the participating classes with a before-after strategy were flattering even for the less intellectually able students, they are not statistically significant because they cannot be attributed exclusively to the experience of the robotics workshops. In fact, the data-collection questionnaire, which was a simple one with just a few yes/no questions, did not highlight the other elements that determine those results, such as: the social condition and previous school experience of the students, the quality and quantity of parallel didactic interventions and the other extra-scholastic experiences of the students. Although the quality of these results cannot be relied upon, it is worth noting that participation in the workshops develops (or consolidates) some basic knowledge, both in terms of the technical structure of a robot and the social and economic connections deriving from the use of robots in the world of work and in everyday life. It is important to observe that, without being able to measure its statistical validity, differences by gender or age (13-14 years and 17-18 years) in students were not evident.

Table 4 - Correct answers given by students about their knowledge before and after the workshop (N. 86)

Questions about knowledge	% correct answers	
	Before	After
Does a robot always and inevitably have the form of a humanoid?	15%	80%
Does a robot need to be programmed?	31%	98%
Does a robot use one or more sensors?	12%	99%
Can a robot replace the work of one person or more?	55%	87%
Are robots used in hospitals?	8%	97%
Are robots produced in Italy?	5%	99%

Source: Processing of the tests about learning, for students of lower and upper secondary schools participating in the robotics workshops

As for levels of attention and interest, reference can be made to the satisfaction survey questionnaires compiled by students who took part in the workshops.

Although over 69%, of both female and male students, express a high level of interest in the workshop (see Tables 5 and 6), the gender differences should not be underestimated. There are in fact elements which confirm that girls show themselves to be less willing to become involved in experiencing of technologies, due to the stereotypes that surround them at school, in the family, and in society at large.

Initial interest and curiosity, before participation in the workshop was fairly high, but a first gender difference emerges: 96.6% of the female students (Table 5),

compared with 92.9% of male students (Table 6), state that they are interested and curious. There were more sceptics among the male than among the female student, but whereas the male students who were sceptical or indifferent and allowed themselves to become involved expressed a positive opinion about their experience, a small minority (3.4%) of female students who were sceptical and indifferent at the beginning expressed a low degree of interest after taking part.

Table 5 - Answers of female students who participated in the robotics workshops about expectations and degree of interest after participation (N. 88)

Female students	After/Degree of interest				
	Before	Low	Medium	High	Total
I was curious and interested		1.1%	26.1%	69.3%	96.6%
usual things/I was indifferent		3.4%	0.0%	0.0%	3.4%
Total		4.5%	26.1%	69.3%	100.0%

Source: Processing of the satisfaction survey questionnaires of students participating in the robotics workshops of Officina Emilia

Table 6 - Answers of male students who participated in the robotics workshops about expectations and degree of interest after participation (N. 126)

Male students	After/ Degree of interest				
	Before	Low	Medium	High	Total
I was curious and interested		0.0%	24.6%	68.3%	92.9%
usual things/ I was indifferent		2.4%	4.0%	0.8%	7.1%
Total		2.4%	28.6%	69.0%	100.0%

Source: Processing of the satisfaction survey questionnaires of students participating in the robotics workshops of Officina Emilia

Table 7 - Answers of the students who participated in the robotics workshops about the desire to do further study on the experience (N. 497)

	Female students	Male students	Total
I expect to do further study at school	43%	45%	44%
I expect to do further study individually	25%	25%	25%
I do not expect to do further study	22%	19%	20%
Other answers	1%	1%	1%
Did not answer	9%	10%	10%
Total	100%	100%	100%

Source: Processing of the satisfaction survey questionnaires of students participating in the robotics workshops of Officina Emilia

As many as 44% of participants expect to follow up the experience with further study at school (Table 7), and a quarter expect to be able to do further study autonomously. Only 20% of the participants (with a slightly higher percentage among the female students) state that they have no interest in further study.

With these results, a greater gender differentiation might have been expected. In fact, above all the gender segmentation between different types of high schools might explain the different expectations about further study at school. It may be that the male students in the industrial pathway of upper secondary schools can reasonably expect, on the basis of the subjects in their curriculum, that there will be opportunities for further study of topics of a technological nature (linked to the industrial structure of the local area), but the girls who want to undertake further study they have to rely more on personal or extra-scholastic resources. This is because, more so than their male counterparts, they attend courses which do not foresee the study of technological subjects.

From Table 8 a clearer element emerges in favour of the differentiation between the two genders. The percentage of students who recognise that they have increased their knowledge is distinctly higher among male students (73%) than among female students (67%).

Table 8 - Percentage of female students and male students who declare that they have acquired new knowledge following their participation in the workshop¹⁴

	Female students	Male students	Total
N.	88	126	214
Increased my knowledge	67%	73%	71%
Did not increase my knowledge	33%	27%	29%

Source: Processing of the satisfaction survey questionnaires of students participating in the robotics workshops of the Officina Emilia

The overall evaluation of the participation in the robotics workshop is excellent both for males and for females: with most students – both male and female - giving an average grade of around 9 (out of 10) (see Table 9). It is worth pointing out that the average evaluation of the whole population of participants does not vary between males and females, but instead varies in relation to the individual’s perceived increase in knowledge. Students who have a positive opinion of

14. The question was not posed in the same way in all the questionnaires and therefore the processing refers only to a part of the questionnaires.

the knowledge acquired in the workshop evaluate the activity of the workshop relatively highly (9.4 out of 10 in Table 9) compared to students who do not recognise an increase in knowledge (8.3 out of 10 in Table 9). This is the case for both male and female students.

Table 9 - Average satisfaction grade (in tenths) and opinion about knowledge acquired (N. 214)

	Female students	Male students	Total
Average grade assigned by those who state "I did not increase my knowledge"	8.2	8.4	8.3
Average grade assigned by those who state "I increased my knowledge"	9.3	9.4	9.4
Average grade assigned by all the participants (N. 497)	9.0	9.0	9.0

Source: Processing of the satisfaction survey questionnaires of students participating in the robotics workshops of Officina Emilia

6. Final considerations

The experience presented seems to show that didactic activities which envisage concrete actions help the imagination and predispose positively towards learning of a technological nature. These results highlight a certain gender difference. It is well-known in the literature that girls and female teenagers show greater disinterest towards technologies and risk not being adequately supported even by teachers, who in turn are mostly women, thus fostering hesitations and doubts about the need to have technological competencies (Ajello, 2002).

The experience of Officina Emilia, with the robotics workshops, allowed for the investigation into the possibility of opening a new educational space allowing young people to make better connections between what they do at school and the experience of adults in the workplace, while also acquiring a better understanding of technologies. The evaluation of the robotics workshops makes it possible to say that the positive results observed can be attributed not only to the didactic use of micro-robotics materials, but to a combination of at least three elements that characterised the workshops. The experience of robotics education benefited from the construction of experiences - individual and small group ones - of a *hands on* nature, which reinforce inductive practices, the capacity for critical observation, the construction of feedback and the relational capacity to work together. Secondly, the activities which make explicit the relations between the learning outcomes and knowledge of the technological, economic and social

characteristics of the local area in which the students live, created a meaningful context which stimulated attention and interest. Lastly, the effectiveness of the robotics workshops derives from the environment in which they were realised: the Museum Workshop evoking mechanical engineering and industrial production. The possibility of experiencing first-hand the machines, materials, semi-finished products and products, together with the multimedia information about workplaces sustained interest in technologies, human work and its organisation. Especially for the older students, participation in the robotics workshops opened the door to the desire to undertake further study.

The action research programme of *Officina Emilia* with schools, in particular with the robotics workshops, provided a contribution which was appreciated by teachers in three main spheres. The first has to do with the creation of appropriate instruments to draw the attention and interest of the younger generations towards mathematics, sciences, technologies and engineering – which are all important fields of study - and of experience for the future of work, as well as for the informed participation in collective choices. The second sphere is the support of innovation in the didactic programmes the teachers realise in school working towards the construction of a curriculum which puts at its centre, as a special object to be understood, the social and economic characteristics of the context, and thus the technologies, the kinds of work and the organisational typologies of firms. The third sphere is that of the knowledge triangle¹⁵ and, in particular, the programme of action research that contributed to defining and validating the means of constructing effective and fruitful connections between the didactic programming of schools and the functioning of institutions, firms and organisations in society.

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Career services filling the gap: Reconciling labour market mismatches

Sally-Anne Barnes

1. Introduction

The labour market has undergone profound structural changes during the past decade as a result of the reconfiguration of work, new ways of working (such as the rise of task-based and platform economies) and the internationalisation of work. These shifts have resulted in workers needing to respond to new and rapidly changing demands for skills, competencies and attributes as the content of jobs continuously change. Within this climate, it is known that, typically, individuals are experiencing multiple transitions throughout their working lives and making important decisions about their participation in the labour market at every stage and phase of their career and learning journeys. Recent evidence suggests there is a compelling need for individuals to be adaptable as occupational prospects are less predictable (Bimrose, Brown, Barnes, & Hughes, 2011; Savickas et al., 2009, Savickas, 1997). This unpredictability may have implications for the way individuals experience and cope with their transitions (Cedefop, 2016a) and their attitudes towards, and engagement with, learning across the life course (Barnes, Brown & Warhurst, 2017).

The importance of career guidance and counselling services, and particularly, lifelong guidance, in supporting individuals with their decisions in shifting labour markets is well documented (Cedefop, 2011; Council of the European Union, 2004, 2008; OECD, 2004). Labour market information and intelligence (which encompasses skills anticipation data) on what the future labour market may look like in terms of occupations and skills, and how it might change, plays a key role in career guidance and counselling services. This labour market information and intelligence also helps individuals navigate complex labour markets (Cedefop, 2016b; Howat & Zaidi, 2010; Wilson, Tarjáni, & Rihova, 2016). Whilst there is evidence from recipients of career services on the usefulness and value of labour market data (Bimrose, & Barnes, 2007; Bimrose, Barnes & Hughes, 2008; Hiebert et al., 2011, 2012; Vilhjálmssdóttir et al., 2011), evidence on what information and intelligence is useful and how it can

be accessed is limited. Anecdotal evidence from the careers field highlights the tensions between career services providers, recipients of services and those producing labour market information and intelligence, as there is often a mismatch between what data can be delivered, what is expected and how it is provided.

This chapter explores where skills anticipation intelligence, as a part of labour market information and intelligence, sits within career guidance and counselling services and how it is often underplayed or neglected in this process by both policy makers and the labour market intermediaries who deliver career services. It first examines the shift in EU policy and the skills agenda away from career services before discussing the different labour market systems of data collection and dissemination across Europe. The tensions between labour market stakeholders are debated with regard to career services and the application of labour market information and intelligence, with particular attention to the tension between available data and user (their recipients of career services) expectations. Finally, the way labour market data are disseminated is reviewed highlighting the demand for personalised labour market and skills data. The chapter emphasises the need to reconceptualise the use of skills anticipation intelligence in career services in order to better address the match between skills demand and supply.

2. EU policies on skills

Over recent years, there has been a shift in EU policy with a greater focus on the importance of increasing the capacity to anticipate and forecast labour market trends, which is seen to be part of the agenda to support skills development and matching skills to labour market needs. There has also been a focus on the role of education and training systems in meeting those needs. The ten actions (underway at the time of writing) adopted by the European Commission in 2016 as part of the new skills agenda for Europe talks about upskilling pathways, creating sectoral cooperation and a skills profile tool (European Commission, 2016). These actions are founded upon intelligence on the labour market generated through forecasting and skills anticipation activities across the EU Member States.

Whilst recognising that labour market intelligence supports ‘informed career choices’, the new 2016 agenda neglects to discuss the role career guidance and counselling can play in supporting individuals’ labour market transitions and, more broadly, helping labour markets meet their skills demands. It also fails to take account of how career services support the interpretation and dissemination of labour market data, as they use it as part of their everyday service delivery.

However, the *New Skills for New Jobs* published in 2008 was clear that public employment services, career guidance, and online labour market information and intelligence had a key role to play in addressing skills mismatch in the labour market (Commission of the European Communities, 2008). It was very much focused on matching supply and demand using forecasts and skills intelligence, and where career services were seen to have a crucial role in helping to reconcile the skills mismatch. Given the importance of these services and their role in meeting labour market needs, it is unclear why there is no longer an obvious focus on career guidance and counselling services in the new skills agenda. However, despite the absence of career guidance and counselling services in the new European skills agenda, career guidance policies supported by national labour market data systems in a number of member states remain strong (namely Austria, Croatia, Finland, France, Germany, Italy, Lithuania, Luxembourg, Netherlands, and the UK) (Cedefop, 2017).

3. Systems of labour market data collection and dissemination

Many countries collect, conduct and disseminate labour market information and intelligence for a range of purposes. A system that achieves this successfully is coordinated, supports policy formation, contributes to education planning, and is used by career and employment services (ILO, 2015). Labour market information and intelligence that supports the understanding of labour demand and supply can include administrative data, economic data, population surveys, tracking or tracer studies, employee and employer surveys, skills assessments, sectoral studies, qualitative assessments, quantitative forecasts and foresight work. This information is collected and produced so that a range of stakeholders (at a national, regional and/or local level) can review the current situation in the labour market in order to make an informed assessment of the future. However, the importance of robust data in informing services and support is seen as essential (Andersen, Feiler, & Schulz, 2015). As, for example, the data collected and disseminated can be used to support education and employment planning and policy, and inform career guidance and counselling provision. Therefore, it is feeding into systems and services that support individuals in their career and learning journeys. Providing labour market information and intelligence is viewed as important to helping those providing career services understand the rapidly changing and increasingly complex labour market, understand jobs demands and skill requirements, plus identify labour market opportunities (World Economic Forum Global Agenda Council on Employment, 2014).

A number of recent studies have evidenced how the collection and dissemination of labour market data from a range of institutions is inconsistent and, in some instances, unreliable (Andersen, Feiler, & Schulz, 2015; Cedefop, 2016b; Hawley-Woodall et al., 2015; OECD, 2016; World Economic Forum Global Agenda Council on Employment, 2014). This is argued to be the result of varying levels of investment and different approaches to collecting and producing labour market data (both in terms of legislation and coordination), the importance placed on data, and how (and whether) it is disseminated and used by labour market intermediaries (such as policy makers, employers, employment services, education and training providers, career guidance and counselling services) (Hawley-Woodall et al., 2015). Labour market data are collected and analysed by a range of public and private institutions at a local, regional, national and international level. National labour market data systems vary in how well developed they are, but public and private employment service providers in 89 countries agreed, as part of the ILO Employment Service Convention in 1948 to collect, to analyse and share information on the labour market (see ILO, 1948). This continues to operate, but there are a number challenges with coding and structuring data to be overcome in order for it to be shared.

Those involved in skills anticipation and forecasting activities across Europe state that labour market data are invaluable to labour market intermediaries delivering career guidance and the improvement of career services (Andersen, Feiler & Schulz, 2015). Others recognise that it is part of the process of helping individuals make 'sensible' and informed career choices (Řihová, 2016; van Breugel, 2017; Wilson, & Zukersteinova, 2011). Some suggest that the application of labour market information and intelligence is a key characteristic or feature that makes career guidance and counselling services distinctive from other forms of employment advice and support (Offer, 2001). Importantly, when data are delivered objectively, and if it is of high quality and robust, it is an effective tool in a career guidance and counselling service.

4. Careers labour market information and intelligence

In terms of a definition, labour market data helps with understanding and elucidating the interaction between labour demand and supply, and the other factors that impact on that interaction, such as economic and political changes. Data can be both quantitative and qualitative and is derived from primary and secondary research, statistics and/or econometric modelling. Careers labour market information and intelligence is often defined broadly and can include: information on general employment trends and future demands; the structure of

the labour market; the operation of and variations between local, regional, national and international labour markets; occupational and skills data; data on diversity issues; vacancies; pay, hours and earnings; learning and training opportunities; and career pathways (Bimrose & Barnes, 2010; Bimrose, Hughes & Barnes, 2011; Bimrose, Marris, Barnes & Mason, 2006; DfES/LSC, 2004; Offer, 2001).

Within career guidance and counselling research and practice, skills anticipation intelligence (data specific to skills trends, skills gap and skills vacancies) often becomes absorbed into this catch all term 'careers labour market information and intelligence' and thus, it is easily neglected. Skills anticipation activities provide quantitative data on current and future skills supply and demand, but also more qualitative data on general skills trends. It provides an understanding of how skills are changing and evolving, and what skills may be needed in the medium and longer term. At an individual level, skills anticipation intelligence can support decisions about what skills to develop and which are likely to provide a return on investment. However, career guidance and counselling practitioners often focus on understanding and using other labour market data that report on current vacancies, occupational trends and local (and current) skills needs. It can be argued that these practitioners have a preference for these data as it has been available for a number of years and embedded in practice. There may be a reluctance to shift to thinking about longer-term skills needs and supporting individuals to adapt their skills to fit a changing labour market.

The data needs of career guidance and counselling practitioners are clearly understood with much evidence defining requirements and how labour market data are used in practice. Research evidences that comprehensive and disaggregated data (such as detailed occupational and pay data) are highly sought by those delivering careers services (Cedefop, 2016b; Howat, & Zaidi, 2010; Kuijpers, & Meijers, 2012; UKCES, 2012). Data disaggregated at the local level is especially required, including local employment trends, local future requirements, local skills needs, local opportunities and vacancies. Provision of these data are highly valued (Bimrose & Barnes, 2010; Bimrose, Barnes & Hughes, 2008; Pawlewski, 2003) playing a vital role in meeting demands at the local level. These data emphasise the short-term and enable those delivering employment and career services to fill vacancies; matching unemployed individuals to a vacant job in the local area. Due to pressures on services and reduced resourcing, these easy placements are seen as 'quick wins' whilst neglecting the longer-term implications. As a consequence, there is less demand for and understanding of skills intelligence that has a longer-term perspective and explains skill changes and the need to up-skill to continue to be 'employable' in a particular role or industry.

As a consequence of the need for 'quick wins', there is also a clear demand from those delivering careers services for detailed statistical information; a demand for 'a number' on how many people will be needed in the future in 'x' occupation or industry in a particular area. Although recipients of career services expect (and perhaps even demand) that those delivering services are able to access and understand these data in order for the service to be considered 'useful' (Bimrose & Barnes, 2007, 2010; Hiebert et al., 2012; Milot-Lapointe, Savard & Paquette, 2018; Pawlewski, 2003), their emphasis is less on specific numbers. Instead, recipients of career services are seeking confirmation that there will be returns on their (or any) investment in skills, further learning and training; asking questions: 'will I get a job if I do this course?' and 'how much will I get paid?'. This suggests that a better understanding of skills and skill trends over the medium and longer-term is needed by both providers and recipients of career services, as well an understanding of how skills can be adapted to meet the demands of a changing labour market.

The limited research on the labour market data needs of recipients of career guidance confirms that providers are expected to have knowledge of the labour market, but also highlights the complexity of the needs of recipients of career services. For example, a longitudinal study in the UK on the effectiveness of career guidance and counselling services, revealed that access to expert knowledge and information on the labour market is a key element of effective practice as it helps point the recipients of services in the right direction (such as finding employment, enrolling on a learning course, understanding local employment opportunities) (Bimrose & Barnes, 2007; Bimrose, Barne, & Hughes, 2008). This expert knowledge focused on labour market information and intelligence, and included: access to local labour market information; details of courses, training and employment opportunities; vacancy information; and how to develop career management skills and knowledge to better understand the labour market and the available opportunities. Interestingly, labour market data was seen to form part of the long-term understanding of future opportunities.

Across a number of studies recipients of career services were found to be keen to develop skills to help understand the longer-term trends within their labour markets. First, in the Nordic countries, a study from the user perspective showed that guidance interventions were not only about the career guidance and counselling practitioners gathering and giving information, but that it was also their responsibility to support individual information seeking behaviour (Vilhjálmsdóttir et al., 2011). A number of examples were found in these countries of web-based systems which offered a wide range of information on educational courses and programmes, information about professions and the labour market, labour

supply, imbalances and forecasts. Where a well-established system of cooperation and communication was found, data were considered to be robust. Individuals in the Nordic study identified information on work and educational opportunities and occupational information as useful labour market data. Overall the study reported that the recipients of career guidance view themselves as 'active agents' in the process of taking on more responsibility for seeking guidance services and information across the life course (Vilhjálmssdóttir et al., 2011). Further research in Canada (Hiebert et al., 2011, 2012) examined the impact of tailored labour market information within a career guidance setting on individual outcomes. Participants had a needs assessment interview resulting in a personalised labour market information package. The study had a positive impact not only on individual participant outcomes (which the participants themselves attributed to the programme), but the career guidance and counselling practitioners also reported a positive impact on their practice. Those participants who received a personalised labour market information work package alongside career guidance and counselling practitioners reported greater benefits over time.

Across these studies, labour market information and intelligence is viewed by the recipients of career services as an important feature of the process, helping with their decisions and outcomes. However, the emphasis on information seeking behaviour suggests that more data need to be readily available and accessible, and even personalised.

5. The integration of labour market systems in career services

Over the last few years, there have been a number of European studies that have examined how labour market information and intelligence is collected and whether (and how) it is being used by intermediaries delivering career services. The most recent pan-European study by Cedefop (2016b) investigated the provision of labour market data in 11 member states. The study examined types of labour market information and intelligence produced, factors that enable meaningful integration of these data into career service support and delivery to replicate good and/or interesting practice. Across 11 member states, the collection and provision of labour market data was found to be linked to education and employment policy in, for example, Austria, Belgium-Flanders, Czech Republic, Denmark, Estonia, Finland, Germany, the Netherlands and the UK. The study also identified countries with, what is considered to be, a strong career guidance policy with labour market information positioned in that policy. In some of these countries (namely Denmark, Estonia, Finland and Germany), they were also found to have strong national coordination with active national

forums or networks involving a range of labour market actors to debate and share intelligence on the labour market. Those countries with a local focus were found to be particularly effective, as it enabled regional and/or national trends to be discussed and put into the local context.

A further study of skills governance across Europe investigated how member states have developed or are developing systems to collect and analyse data on the labour market, how information is disseminated and who it is aimed at (Hawley-Woodall et al., 2015). Those countries determined to have established labour market systems were defined as having well-developed and/or mature processes for collecting, analysing and sharing data, involving stakeholders in the process of making data publicly available to support the work of a range of labour market intermediaries (including career services). Denmark, Lithuania and Sweden strive to integrate data into the career services, with data made available to those delivering the services. So, they were identified as having established systems. A number of countries were also identified as being in the process of developing systems for the production of labour market information and intelligence (such as Bulgaria, Croatia, Estonia, Greece, Hungary, Poland, Portugal and Romania). In these countries, data may be collected and policies put in place, but career services may not be informed by the labour market data available.

Labour market data is increasingly being used as part of profiling screening and targeting tools deployed by public employment services and external organisations providing employment and career services (Barnes, Wright, Irving & Deganis, 2015; Bimrose, Barnes, Brown & Hasluck, 2007). These tools help identify individuals needing targeted and/or intensive support¹, including career guidance and counselling, with the aim of supporting a speedier return to employment. These tools are commonly part of an integrated or coordinated approach to supporting all individuals (Berthet & Bourgeois, 2014). However, individuals are being encouraged to become more self-reliant by accessing help and information through online services in order to manage their own careers and learning pathways.

Recent research in Europe (see Barnes, Wright, Irving & Deganis, 2015) has identified four broad approaches to profiling; some of which are founded upon or use labour market data. There are a number of recognised procedures that are considered useful for assessing individual needs ranging from statistical tools

1. Supporting those individuals who are less able to access services, or who may take longer to return to work is seen as important, see Decision No 573/2014/EU of the European Parliament and of the Council of 15 May 2014 on enhanced cooperation between Public Employment Services (PES) Text with EEA relevance, <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32014D0573>

that require labour market intelligence to softer approaches that rely on the assessment undertaken by an employment service caseworker or a career guidance and counselling practitioner. In the past statistical profiling using data has been popular, but the research found that services have moved away from this profiling due to shifts in policy to provide equality of service provision (Barnes, Wright, Irving & Deganis, 2015). The role of the employment service caseworker or a career guidance and counselling practitioner has become more important in terms of directing or allocating resources to individuals, such as in Estonia and Slovakia (Duell & Kureková, 2013). This process places greater emphasis on career guidance and counselling practitioners to understand the labour market and the short, medium and longer terms trends impacting on skills and opportunities.

6. Labour market systems and the role of technology

Technology has rapidly developed over the last decade, which has changed the way data can be collected, linked, analysed, visualised and disseminated. It is, therefore, inevitable that labour market data collected as part of national labour market systems are being disseminated, presented and made available online to a range of stakeholders, including policy makers and employment and career services (Cedefop, 2016b; Hawley-Woodall et al., 2015; Howat, & Zaidi, 2011; Milot-Lapointe, Savard, & Paquette, 2018; Řihová, 2016). Some propose that labour market information and intelligence should be embedded within career guidance and counselling system to ensure that evidence-based support is provided to help people with their career and learning transitions (Bimrose & Barnes, 2010). Recent online developments using data have focused on career guidance services and the recipients of those services. It has been suggested that incorporating technological developments into existing services can lead to more efficient, effective and transparent ways of working. Whilst technology has long been accepted as an enabler of government services, some commentators advocate that there should be greater attention given to individual needs (Torres, Pina & Acere, 2006) to ensure that services remain relevant to service user needs.

Through these online developments information and intelligence is being presented in accessible and user-friendly ways, and so becoming an integral part of online employment and career services (Andersen, Feiler & Schulz, 2015; Bimrose, Barnes & Attwell, 2010; Cedefop, 2016b; Hooley, Hutchinson & Watts, 2010; Hutchinson & Parker, 2009; Howat & Zaidi, 2011; Milot-Lapointe, Savard & Paquette, 2018). There is evidence of innovative practice on the use and integration of labour market data into careers guidance and counselling mobile applications and websites. This is addressing recipients of career guidance ex-

pectations that information on the labour market is readily available and up-to-date on the web and through mobile applications, but there is increasing demand for data to be personalised at the point of access (Bimrose, Kettunen & Goddard, 2014; Bimrose, Brown, Holocher-Ertl, Kieslinger, Kunzmann, Prilla, Schmidt & Wolf, 2014).

Technology has also changed the ways in which people seek information on employment opportunities and job vacancies (de Hoyos, Green, Barnes, Owen, Baldauf & Behle, 2013; Green, 2017; Green, de Hoyos, Barnes, Owen, Baldauf & Behle, 2013; Green, Li, Owen & de Hoyos, 2012; Kinder, 2012). For instance, jobseekers are now using a range of social media and mobile applications to learn about the labour market and the opportunities (both work and education) available to them. They are using these tools to be more proactive in their job search (Green, Li, Owen & de Hoyos, 2012), as well as manage their own transitions. A self-service approach to accessing services and finding information on the labour market is becoming more prevalent within the current climate due, in part, to fiscal cuts and shifting user expectations.

7. Conclusion

This chapter has highlighted some of the current debates about labour market information and intelligence in career guidance and counselling services across Europe. It emphasises the need to reconceptualise the use of skills anticipation intelligence in career services in order to better address the match between skills demand and supply. However, the inevitable discord between those that collect and provide data, those intermediaries that facilitate access and the users or recipients of the data is highlighted. Labour market intermediaries, specifically career guidance and counselling practitioners explored in this chapter, are focused on estimates of occupational demands and vacancies, whereas recipients of career services are more likely to look at the return on investment on their skills and likelihood of gaining and maintaining employment. This suggests that whilst skills anticipation intelligence (particularly that focus on longer term trends) is neglected by providers of career services, recipients may value these data more than they are currently given credit for. With an understanding of labour market trends, an understanding of skills supply and demand and future labour market needs enables individuals to think longer-term about what skills they develop, and the value they have in the future labour market. It is, therefore evident that central and crucial to the delivery of evidence-based career guidance and counselling support is a broad range of labour market data and skills anticipation intelligence.

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Skills development for ageing workforce

Nicola Düll

1. Introduction¹

As a response to the demographic shift, the employment rates of older workers have been on the rise in the EU over the past decade (from 2006 to 2016: + 12.1% percentage points (ppt) for those aged 55-64 years old, + 3.0 ppt for 65-69 year-olds and 1.1 ppt for those aged 70-74 years old)². A number of factors have led to this increase, including pension reform. Raising employment rates is essential for the sustainability of the pension system and has been perceived as one solution for overcoming labour shortages in some countries.

In fact, employment rates of older workers have risen as retention rates have increased, while recruitment rates remain low³. Once they have become unemployed older workers face a particularly high risk of remaining unemployed or becoming inactive.

One of the key concerns is whether or not economies with a rapidly ageing workforce are well equipped to master technological change and the digitalisation of the economy and contribute to innovation and economic growth in general. Another concern is that some groups of older workers will be left behind and excluded from the labour market.

This chapter reviews briefly the literature on the relationship between age, productivity and skills. In modern economies, productivity is largely driven by the use made of human capital. The chapter will discuss whether or not older workers really are less productive, less innovative and have lower learning capacities.

1. This chapter has benefitted of the author's involvement in the OECD-EU project on "Identifying ways of raising effective retirement ages" from 2016 to 2018.

2. Labour Force survey data, see <http://www.oecd.org/employment/ageingandemploymentpolicies.htm>.

3. According to labour Force survey data, see <http://www.oecd.org/employment/ageingandemploymentpolicies.htm>.

What are the challenges and prospects to maintaining and enhancing their productivity through appropriate skills development? The second part of the chapter looks at the means to promote skills development over the life course in order to tackle the two main challenges of an ageing society: (i) sustaining contributions to economic growth; and (ii) reducing the risk of labour market exclusion. Examples of initiatives and strategies in European countries for setting up both a framework for adult learning as well as for setting incentives for investing in further training will be provided. In the final section, conclusions will be drawn.

2. Productivity, skills and age

Are older workers less productive?

The effects of ageing on productivity can be analysed from a macro or micro perspective. Lius and Westelius (2016) showed that the ageing (measured in the change in the age structure of the population) and the shrinking of Japan's population negatively affected total factor productivity over the period 1990 to 2007. The trend departed from the inverted U-shaped productivity pattern amongst age groups with those aged 40–49 being the most productive. Accordingly, the point of labour market departure for an ageing workforce is decisive. According to the authors, the point estimates indicate that a one-percentage point shift from the 30-year age group to the 40-year age group increases the level of total factor productivity by close to 4.4 percent. In contrast, a similar shift from the 40 to the 50-year age group would decrease productivity by 1.3 percent. A decline in the number of workers in their forties would therefore cause productivity to decline. Aiyar et al (2016) looked at the effect of workforce ageing on the growth rate of productivity. Using data on European countries, they could not find any negative effect of ageing on total factor productivity growth in most European countries (the exceptions are Latvia, Lithuania, Germany, Finland and the Netherlands, where growth rates had been slightly reduced between 1984 and 2014). They assessed that, for the next two decades in Europe, on the basis of population projections, that an increase in the share of workers aged 55–64 will lead to a significant and permanent increase in total factor productivity growth. However, they also predicted that growth rates will be reduced by a quarter due to the effect of ageing. The largest negative impact will occur in Spain, Italy, Portugal, Greece and Ireland, where rapid workforce ageing is expected. Lius and Westelius (2016) acknowledged also that other effects of ageing on employment come into play. Thus, ageing is likely to increase the relative demand for services (e.g., health care service), causing a sectorial shift towards the more labour intensive and less productive service sector. Furthermore, the size or density of the population may also have an impact on

productivity as it spurs technological change. There is a positive selection among those employed at older ages, and conversely those with, for example, poor health are likely to exit the labour market earlier. Most importantly, employment rates among older people increase with educational attainment (OECD 2017a). Raising employment rates of workers with a lower educational attainment would consequently negatively affect productivity growth.

A strand of older literature suggests that ageing results in reducing productivity. The “deficit model” was developed from psychological surveys in the 1970s and based on intelligence tests, where younger people achieved better results than older ones. However, the interpretation of the data leading to the “deficit model” neglected to account for different levels of education and led to the misconception that decreases in mental capability is a consequence of ageing. A number of studies carried out in the 1990s and early 2000s show a decline of productivity after the age of 40 or 50 years (for an overview see Lindley et al., 2006; Gelderblom and Vos, 2009; Skirbekk, 2003). Aubert and Crépon (2006) found that the average contribution of particular age groups to the productivity of firms increases with age until age 40–45, and remains constant afterwards. Using a longitudinal matched employer–employee dataset covering the entire workforce in manufacturing and the private service sector in Portugal over a 22-year period, Cardoso et al. (2011) found that productivity increases until the age range of 50–54 years.

Declining skills of the individual may be one explanation. The Survey of Adult Skills, a product of the OECD Programme for the International Assessment of Adult Competencies (PIAAC), shows that information-processing, literacy and numeracy skills decline with age. However, differences in skills proficiency that are related to age vary widely across countries (OECD 2016). Lower job satisfaction may also lead to lower productivity. It could also result from the misallocation of resources. For older workers this could result from a lower mobility of older workers in the internal and external labour market. Labour mobility has different functions over the life cycle. In the first phase, labour mobility reflects the matching process of skills demand and supply. High job mobility may indicate an inefficiency of the education system to provide the right skills as well as inefficiencies in labour market access. It is also linked to the type of tradability of occupational capital as well as firm’s policies with regard to lifetime employment. It can be supposed that job mobility decreases (and tenure rises) with age. Andersen et al. (2006) argued that according to the job matching theory, older workers are more likely to find a good employee-employer match and to benefit from a specific matching rent. In addition to this, older workers may prefer to stay in their jobs as they perceive their chances of finding another job to be low.

The simplistic view that older workers are less competent and that their skills are dated, has been partly disproved by research (see e.g. Bohlinger and van Loo 2010). Research shows that participation in continuous learning and the ability to acquire new knowledge is not simply an age-related matter.

The World Bank (2015) claims that older people are not less productive than young people. Börsch-Supan and Weiss (2016) found that the average age-productivity profile of individual workers in a large car manufacturer in Germany increased until age 65. Decomposition into the effect of job tenure and age reveals that it is indeed experience that keeps older workers' productivity from falling. They found that while older workers were slightly more likely to make errors, they hardly made any severe errors. The authors concluded that even in a work environment requiring substantial physical strength (assembly lines of car manufacturers), any productivity decline with age is compensated for by characteristics that appear to increase with age and are hard to measure directly, such as experience and the ability to operate well in a team when tense situations occur. The effect of experience itself on productivity over time is not self-evident (Guest 2013, Lindley et al., 2006). Under certain conditions experience may not enhance productivity after a certain age. This would be the case if the number of years of experience in physically demanding professions were likely to decrease productivity. Furthermore, the positive effect of experience on the individual's job related learning curve can disappear after a certain period, e.g. 10 years, meaning that it makes no big difference as to whether or not the person has 10 or 20 years of experience in their profession, or within the same company. The value of experience can be devalued in cases where the work takes place within a highly innovative environment. Furthermore, research has shown that the durability of skills varies in different fields of expertise. It will be decisive if the experience gained so far helps the worker to adapt quickly to the changing requirements of skills demand. A positive effect of experience on productivity can be discerned in cases where experience helps workers to maintain their productivity level or at least constrain any decline in productivity. This may be the case if older workers have strategies at hand based on experience to compensate for declining physical productivity. In contrast, in some professions the benefits of additional years of experience may continue to increase (e.g. consultants, doctors, etc.) The effect on productivity of experience is magnified if experience is coupled with continually updated knowledge.

Are older workers less innovative?

For a long time, it was commonly thought that young people have more innovative ideas. Following a panel of French firms over the second half of the 1990s,

Behaghel, Caroli and Roger (2011) showed that new technologies and certain innovative working practices tend to be tilted against older workers. The adoption of the Internet, of network-interconnected computers as well as the increased responsibilities conferred upon their operators, tended to boost the share of wage bill accounted for by workers in their 30s and reduce that of older workers. Moreover, the challenge is even greater for the less-educated older workers among them who are, according to Behaghel and Greenan (2010), less well placed to learn how to use new technologies. Thus, future skills development of older workers may also depend on the level of digital skills acquired at younger ages.

Another strand of research comes to more nuanced conclusions. Dworshak et al. (2012), after conducting research in Germany, took stock of the evidence on the different factors that determine the innovation capacity of the workforce: motivation, creativity, social competences and knowledge. Literature with regard to motivation is scarce, but the authors concluded that older workers may be as motivated as younger ones but simply need different incentives. Furthermore, they might be less willing to take on the role of pushing and implementing innovation and, in this respect, an ageing workforce can represent a risk to the innovation in a company. With regard to creativity, the authors concluded that it may require good cognitive skills which are better developed in younger workers. However, in relation to the role of the innovator, experience and social competences come into play and therefore “crystallised intelligence” is the focus, an acknowledged strength of older workers. Heidling et al. (2015) points to the better skills of older workers in dealing with unpredictable situations. This is an asset for the innovation process. Workers can acquire these informal competences if they have worked in an environment allowing for process-based learning.

Do older workers have good prospects to developing their skills?

Research shows that although skill gaps exist, the learning capacities of older workers are not necessarily inferior to those of younger workers. The large differences in the participation rates of older workers in workplace related education indicates that continuous learning is not simply an age related matter. One key aspect of individual performance from a life cycle perspective is the ability to acquire new skills. The importance of learning trajectories is widely acknowledged in the relevant literature (e.g. Luger and Mulder 2010). Mental abilities are acknowledged to be key for the performance of workers in a life cycle perspective. Learning abilities are influenced by a number of factors as set out below.

1. Educational level, vocational skills gained at a young age and mental abilities are key determinants of individual performance over the life cycle. Individuals with higher educational attainment are more likely to participate in formal and non-formal adult education and training (Cegolon, 2015). One explanation is that higher-educated people tend to work in more demanding and knowledge-intensive jobs which require more training. PIAAC results show that those workers with higher levels of participation in organised adult learning activities also demonstrate higher literacy and numeracy skills (OECD 2013a). Workers with a low qualification level and who have not benefited from continuous training to help stabilise their cognitive skills are most vulnerable to technological change.
2. Skills proficiency. Having higher levels of education does not appear to “protect” adults from cognitive decline. A high proficiency level is important in damping the decline of cognitive skills. One explanation is that more proficient adults have more opportunities to develop and maintain their cognitive skills throughout their lifecycle. OECD (2016) finds it therefore important that all young people, including those from disadvantaged backgrounds, leave school with good literacy and numeracy skills. Moreover, the Survey of Adult Skills shows a strong relationship between the effective retirement age and the literacy proficiency of men aged 55 and older, as the incentive to invest in training is lower.
3. Participation in formal and non-formal further training over the life course: The participation rate in further training is linked to a number of socio-demographic (e.g. occupation, educational level gained at young age), economic (e.g. company size, sector) and institutional factors. Overall, older workers participate far less in further training than prime age workers.
4. Informal learning takes place at the workplace. The learning content of jobs itself is an important factor, in-addition to training measures which are work-based (for an overview of the patchy landscape of work-based learning measures, see Cedefop 2015a)⁴. While jobs with rich learning content and an inspiring work environment are likely to further develop skills, jobs with poor learning content are likely to have a negative influence on skills. This can be one explanation for declining literacy skills with

4. Cedefop defined work-based learning as: (i) intended and structured non-formal learning; (ii) being of direct relevance to the current or future tasks of the learner; (c) taking place in a work-based context, that means either in the workplace, in settings simulating the workplace or outside the workplace, but with specific learning tasks that must be directly applied in the workplace and reflected upon afterwards (train, apply, reflect).

age for some groups of workers. Furthermore, skills are better sustained if used at work.

5. Experience can enhance skills. The importance of experience varies by tasks, occupations and sectors. Long-term work experience can improve a person's strategic thinking, intelligence, consideration and wisdom (Lindley et al., 2006). Older workers have access to so-called tacit knowledge i.e. technical know-how and cognitive knowledge on the one hand, and understanding on the other. According to case studies carried out in the Australian manufacturing industry, mature workers are valued for their ability to more readily adapt to change because of their wider life experience and broader understanding of an organisation's purpose (Smith et al 2007). The key policy question is how the portability and visibility of these skills can be increased, and how training can take advantage of the wealth of experience gained (in the sense of a cumulative advantage). Experience-based skills seem to also have the potential to compensate for the decline of other information processing skills (Paccagnella, 2016).

3. Reducing risks of an ageing society: investing in skills over the life cycle

3.1 Challenges for skills development in an ageing society

There are thus various factors that have an influence on the (skills-based) productivity from a life-cycle perspective:

1. Human capital accumulation over the life cycle. PIAAC data as well as Labour Force Survey data indicate that high-skilled older workers are by far more likely to participate in further training than low-skilled workers (OECD 2017a, OECD 2015).
2. Sector and the occupation. The role of experience will vary considerably between occupations. Experience may enhance or decrease productivity over the life-cycle and individual age-productivity profiles may vary considerably.
3. The age structure of the company (it is believed that a mixed age structure is favourable for productivity, as workers of different ages and years of experience may have complementary skills, see e.g. Peters 2016 using German firm data).
4. ICT skills and the adaptability to technological change. In view of the digitalisation of the economy ICT skills have become increasingly part of the portfolio of basic skills. It is worrying, that in some countries a high share

of workers aged 55-64 are not familiar with ICT. According to PIAAC data, this concerned around half of workers in Poland, the Slovak Republic and Greece, in contrast to around 10% in Denmark, Norway and Sweden. In all the compared countries digital skills among young people were similar (OECD, 2017a). Among European countries that participated in the PIAAC adult skills test, the share of older workers (55-64) who worked in ICT intensive occupations ranged between 10% and 20% in 2012 or 2015. Unsurprisingly, the share of older workers employed in ICT intensive occupations was highest in Norway, Sweden, Germany, Finland, and Denmark (OECD, 2017a). Martin (2018) showed, using PIAAC data, that there is a very strong positive correlation across countries between their participation rates in adult learning and their average proficiency in ICT-literacy skills.

5. Working conditions and the physical and mental strain of jobs. From a skills development point of view, the following two factors seem to be decisive: First, the learning content of jobs and second the possibility to re-train in case of permanent health problems.
6. The implementation of age management practices is oriented towards maintaining or increasing productivity over the life cycle by adapting the work environment accordingly.

From a life-cycle perspective, the objectives of lifelong learning strategies are manifold: avoid or dampen skills depreciation over time, maintain skills, adapt skills to labour market needs, increase internal and external job mobility, break the vicious circle between low skills or skills not in demand and low quality of work or poor employment prospects, increase incentives to work longer, and increase motivation.

Policies to promote lifelong learning, training measures and initiatives designed to meet these aims can be taken by a variety of actors, including the state, the social partners, sector or occupational organisations and single companies. The fields of intervention range from lifelong vocational guidance, to remedial education over the life course, to promoting participation in further training for all workers, to recognising and certifying skills derived from informally acquired knowledge. The different approaches and initiatives are embedded in the national institutional setting of the educational and vocational education and training (VET) system. In some countries there is longstanding experience with setting a high certified standard in the initial vocational training system (e.g. Germany and Austria) and tertiary education is rather specialised (e.g. in Germany), while in other countries initial training and education is less formalised and specialised, and on-the-job learning and further training play an even more

important role in skills development at the beginning of working life (e.g. in the UK). Certification of non-formal learning then becomes a key issue for the tradability of skills and mobility of workers.

Education and further training strategies have focused on catching up with educational attainment in most countries. This has led to a deep divide in educational attainment between different age groups (e.g. in Portugal) and a need to upskill older workers. For many years investments in human capital have been a pillar of the Nordic labour market and economic model and adult education and training have been developed in a more systematic way. Countries also differ quite significantly as to the role of formal and non-formal training.

The format of further/continuing training also differs by company size. A survey by the European Commission⁵ showed that the most common training methods within SMEs were on-the-job training and self-directed learning. Less common methods were enterprise-provided training courses. Thus, formal training settings seem to be less widespread in SMEs when compared with larger companies. Mentoring programmes, job rotation, learning cycles, study visits and exchanges or secondments were not common practice among SMEs. In contrast, the most common training methods for large enterprises were on-the-job training and internal and external training courses. Nearly half of them also used mentoring programmes, learning circles, study visits and exchanges (Cedefop, 2015b).

In the following, two aspects are focused on. First, the overall framework for lifelong learning will be looked at and examples of recent policy changes will be given. Second, interesting practices and approaches to set incentives to invest in further training will be given. The financing structure of lifelong learning will have an impact upon the level and structure of further training.

3.2 Setting up a framework for adult learning

Developing further training and skills updating in the formal certified system

Some countries have recently promoted the access of adults to apprenticeship schemes. In Finland, for example, a new adult VET programme was started in 2014 for low qualified adults aged 30-50. Within the system of Competence Based Qualifications, the possibility to study for a vocational qualification or part of it (a module) is offered to this target group. In Sweden, in 2009 the government initiated temporary measures for vocationally oriented upper second-

5. EIM Business and Policy Research 2011.

ary adult education including older workers. The main purpose was to counter the effects of the recession and labour shortages, and to reach individuals who lacked upper secondary education or needed to supplement their upper secondary vocational education. The three-year initiative was implemented in the form of targeted government grants to municipalities, associations of municipalities, and municipalities in collaboration, in order to provide places for a larger number of people. All higher vocational education programmes were offered free of charge and entitled students to financial support, and any associated fees for course materials must have been reasonably priced (OECD, 2018a). Experiences in other countries in this area include Slovenia where competency agencies have been set up to train workers. Two programmes were implemented with the aim to increase the competitiveness of enterprises and economic sectors, to enhance the engagement of enterprises in HRD, to define competence profiles of selected professions, and to implement targeted training to increase employees' competencies and competitiveness. In 2013, a total of 6,400 employees older than 50 years of age participated in the competence centres. In 2014, 4,200 employees participated. Originally a budget of EUR 1,000 per person was planned which was later lowered to EUR 700, allowing for more employees to be trained within the same overall budget (OECD, 2018b).

Strategies and institution building to upskill low-skilled adults

Many countries offer subsidised adult literacy and numeracy programmes to up-skill low-skilled adults (see for a literature e.g. Windish, 2015). A number of countries have developed lifelong learning strategies and have reformed their institutions. The approaches differ, as they have to respond to different institutional settings and tackle different challenges. In principle measures to up-skill low-skilled workers and unemployed people can involve remedial education, and skills development at the workplace or combined classroom-based and workplace-based approaches. One limitation of formal adult basic education programmes is that they are delivered in formal settings that do not reach low-skilled people. Therefore, non-formal and work-based approaches may have the potential to better reach and motivate participants. Active labour market programmes offering both classroom-based and/or workplace-based learning for unemployed (and sometimes also for employed) low-skilled people are an important pillar of up-skilling strategies and initiatives. A few examples of this are shown in the following.

- As mentioned above in Finland in 2014 a new adult VET programme was started for low-skilled adults aged 30-50. (OECD, 2018c).

- Portugal, a country that is confronted with a large cohort of prime age and older workers with a low level of education, has made important efforts to address this problem. The New Opportunities Initiative (INO) was run from 2005 to 2010 with the objective of up-skilling the workforce. Since then it has been further developed. The main elements consisted of training courses as well as a process for the recognition and validation of prior non-formal learning. In 2010 a programme of basic competencies, especially directed towards prime-age people with very low levels of education was launched. In 2013, Centres for Qualification and Vocational Education (CQEP) were created under the National Qualifications System replacing the New Opportunities Centres. The centres operate in network and partnership in a flexible manner, with various entities, including employers, training providers (schools, training centres, and approved organisations), social and solidarity networks, municipalities, associations and departments and public agencies, in order to optimise the use of human, financial and material resources. All Public Employment Service (PES) centres were running a CQEP. The main services of CQEP included identifying individual training needs of the young and adult population by taking the demand of the business sector into account; the development of recognition, validation and certification of school and professional competencies for adults; monitoring young people and adults forwarded to the different qualification offers to benchmark compliance or deviation from the defined trajectories; and collection of information regarding the interaction between the learning outcomes of young people and adults and the labour market, with a view to improving the quality of education and the training system. A new programme for the adult population was launched in April 2016 under the name of *Qualifica*. Its objectives are to qualify half of the labour force with upper secondary education, achieve a 15% rate of adult participation in lifelong learning activities, and expand the network of centres. Compared with the previous large-scale INO programme, a stronger focus is put on long and short training programmes, including the recognition and validation of prior learning processes (Duell and Thévenot, 2017).
- In 2006, the German PES started a new programme “WeGebAU” (Weiterbildung geringqualifizierter und beschäftigter älterer Arbeitnehmer im Unternehmen) to promote further training within companies for low-skilled workers and for workers aged 45 years and over. This was refocused in 2007 on the participation of employed people only. Wages or training costs can be subsidised under the programme. Since its introduction, initial low take-up has somewhat improved for larger and medium-sized com-

panies. Those companies who used the measure assessed the results positively. Take-up of the programme has improved in recent times. Nearly half of them participated in vocational training leading to a recognised occupation. From 2012 to 2014 it was also possible for people younger than 45 years to participate (Bundesagentur für Arbeit, 2013). A recent evaluation carried out by the IAB indicates that participation leads to improved job stability and survival in employment (Singer and Toomet, 2013).

- In the UK, the “Skills for Life” strategy was launched in 2001 to create a new infrastructure to support free adult basic skills learning opportunities over a seven-year period and improve the basic skills of adults. The programme was evaluated by Metcalf et al (2009), on the basis of a longitudinal approach. Adult literacy and numeracy learners were followed over a period of three years, with their outcomes compared with a group of individuals who did not take literacy or numeracy courses. The study found that college-based adult literacy and numeracy courses had a range of positive effects including increased learner self-esteem, improved commitment to education, and beliefs by learners that their literacy and numeracy skills had improved and continued to improve. Nevertheless, the study found no employment gains, although positive employability gains were recorded. A survey of national literacy and numeracy levels carried out in 2011 showed a mixed picture on the skills gains at national level (BIS, 2012). While literacy skills improved, numeracy skills declined in the eight years from 2003. Furthermore, the improved literacy outcomes seemed to be more the result of those already relatively literate improving their skills, rather than a reduction of poor performers. A criticism was that the programme was not targeted enough at those with the lowest skills levels.
- Germany and France have set up research and initiatives to tackle in particular illiteracy of adults (Agreement for a Joint National Strategy for Literacy and Adult Basic Skills in Germany 2012-2016 (BMBF 2012 and BMBF, 2014). In France, an agency was set up in 2000 to combat illiteracy of adults (ANLCI, 2014).
- In Greece, since 2012, the Greek NGO “50plus Hellas” has been providing free ICT training to older people with the support of a national telecommunications company and local authorities (OECD, 2018d).

Lifelong vocational guidance

Lifelong vocational guidance can be regarded as a part of the framework for lifelong learning. Cedefop (2015c) carried out a study to investigate the effect of

providing career guidance to workers. Case studies showed that career guidance stimulates older employees to work on their own employability, learning new skills and transferring expertise, and therefore increases job satisfaction. A further positive effect of guidance activities was reducing negative stereotypes of older employees.

Some countries have embedded lifelong guidance into their overall skills strategy. Thus, the issue of guidance has become a growing political concern over recent years in France, where the Law of November 2009 about lifelong guidance and vocational training created a new integrated service to ease access to career counselling. Lifelong career guidance is also a central instrument for the implementation of the new individual learning account scheme (Cedefop, 2015c). However, take-up could be higher. In Finland, the Ministry of Education and Culture has set up a task force on the strategy of lifelong guidance in order to create a national strategy for lifelong career guidance (Arnkil, 2012)⁶. In its memo, the task force set five goals for the further development of the guidance system in Finland including ensuring the availability of the guidance services for the citizens, improving the citizens' career planning skills as well as reinforcing the coordination and collaboration among the different guidance systems at national, regional, and local levels.

In many cases career guidance is implemented in active labour market policies. To give an example, in Slovenia, lifelong career guidance is available at the Public Employment Service for all citizens free of charge, regardless of employment or unemployment status. A similar service is also provided at a regional level by 13 contractors and is available to unemployed people via workshops to help them acquire knowledge and skills needed to follow their career objectives and improve their integration in the labour market. One of the workshops is the "Career after 50s". In addition, a programme was launched for career guidance offered to employers. Its objective is to develop HRD skills and identify HR needs. Employees of participating companies are offered the chance to gain soft, transversal skills provided through 66 pre-selected training organisers. In 2014, workers aged 55 or above represented only 7.6% of all participants (OECD, 2018b). In Austria, the PES also provides a counselling programme to employers with special emphasis on the development of life-cycle oriented educational programmes and the dissemination of the concepts of "diversity management" and "productive ageing" (OECD, 2018e).

6. OKM (2011). Elinikäisen ohjauksen kehittämisen strategiset tavoitteet. (*Strategic Aims of Lifelong Career Counselling*). Internet: <http://www.minedu.fi/export/sites/default/OPM/Julkaisut/2011/liitteet/tr15.pdf?lang=fi>.

Measures for recognition and validation of informal skills

Older workers have acquired in general much work experience and workers with a low formal qualification level might have learned a profession on the job, without, however, obtaining a formal vocational qualification. When these workers have to search for a new job, some of their skills are not visible or not tradable, limiting their chances to find a job (at all) or find a job that matches their skills. Furthermore, visibility of acquired skills will also aid them in making careers in their firms. Because of this, a number of countries have introduced measures for recognition and validation of informal skills (see for an overview Cedefop, 2015c).

One example is Malta, where the validation of informal and non-formal learning took off in 2012 following the enacting of legislation to this effect. These regulations provide a regulatory framework for the validation of non-formal and informal learning and for the granting of validation awards pegged to the Malta Qualification Framework (MQF). The National Commission for Further and Higher Education (NCFHE), established in 2012, is setting the benchmarks for the validation process against learning outcomes measured according to established occupational standards. At the Ministry for Education and Employment, sector skill units have been set up and are currently drafting occupational standards for a number of occupations in relation to the following fields: educational support services, hospitality and tourism, printing and creative media, health and social care, automotive, construction, hair and beauty. The output will serve as a basis for the validation of informal and non-formal learning (OECD, 2018f).

Methods applied include, in the case of France, the *bilan de compétences senior* for older workers, which is based on a portfolio approach. This approach also involved individual self-reflection. Introduced in 2002, the validation of acquired experience (VAE) is a highly complex measure with little momentum in France (OECD, 2018h). According to DARES (2016), workers aged 50 and over represented 19.2% of VAE candidates in 2014. Such candidates consistently failed more often than other age groups to obtain the VAE despite a significant improvement in 2014 when compared with 2013 (21.8% obtained nothing in 2014, compared with 27.6% in 2013). This finding for older workers persists after other factors, such as gender, employment situation and the qualification sought, have been taken into account. The portfolio approach rests on career management skills. A similar approach can be found in Portugal (Cedefop, 2015c), where priority was given to enterprises undergoing restructuring. Here the portfolio approach serves as a way of generating worker adaptability when facing change at a mature career stage and assuring the transmission of knowledge during restructuring.

It is often useful to link validation and recognition of prior learning to up-skilling activities. In Austria, a pilot project started in 2008. *Du kannst was!* provides documentation and validation of competences acquired through informal learning along with guidance and counselling services. The objective is to provide up-skilling in preparation for a final apprentice examination for nine occupations. Persons with low formal qualifications over the age of 22, including migrants without formally validated qualifications, are in the target group. The project is an initiative of the social partners and regional governments (OECD, 2018e). Portugal would be another example (in the context of INO and the new programme Qualifica, OECD, 2018g).

The role of further training arrangements in collective agreements

In some countries, the social partners increasingly address management issues in collective bargaining. In the case of France, for the period 2009-12, 18 industry-wide agreements were signed that contain career and skills development undertakings. Firms with more than 300 employees were under a three-year obligation to negotiate on anticipative management of employment and proficiencies (called “Gestion prévisionnelle de l’emploi et des compétences” (GPEC). In order to develop this tool for anticipating changes in the workplace, the 2013 Law on Employment Protection expanded the range of GPEC issues for negotiation in order to bolster the contents of agreements that are often deemed too formal and lacking a truly strategic and forward-looking approach to skills development and the needs of the firm. Some newly signed agreements seem promising, such as the three-year GPEC agreement signed by the MMA insurance company in July 2013. That agreement includes inter-generational arrangements for taking on board new employees and for the professional development of older workers (such as the generation contract) as well as job mobility.

In Finland, the framework agreement signed by the social partners on 28 November 2011 contains a special chapter devoted to the development of working life. On this basis, work is presently ongoing in several working groups addressing the following topics (Jokivuori, 2013): (i) age management programmes in organisations addressing working-time, education and health check-ups for senior workers; (ii) developing labour markets for part-time work for people with diminished working capacity⁷; (iii) development of personnel planning (flexible working time, reconciliation of work and family life, telework, temporary work, employment of people with diminished working capacity and skills

7. Internet: http://www.stm.fi/julkaisut/nayta/_julkaisu/1552539.

development); (iv) setting-up new tripartite initiatives by the end of 2012 in the area of labour protection addressing workload effects of working time on work ability and working careers; (v) further development of the so called ‘Change Security’ measures in redundancy situations⁸; (vi) promoting dissemination of good practice in staff skills development; (vii) setting-up an educational fund which accrues on an ‘individual training account’ and can be used by the individual for upgrading skills; and (viii) tax initiatives to encourage companies to invest in staff education. A national collective branch agreement for the food industry sector has influenced the type of age management measures taken (OECD, 2018c).

In Sweden, the trade union LO works for comprehensive collective agreements and covers issues on working environment. This includes: the insurance of Protection Delegates (*skyddsombud*) and training allowing and facilitating for him/her to perform the task; a zero tolerance policy towards serious occupational accidents and diseases; ensuring that all employers work on the issue in a preventive and systematic manner; that all employees have access to good health care and; reinforcing the liability of employers for job redesign and *rehabilitation* through legislation and agreements, including better opportunities to sanction. Social partners’ agreements are also regularly concluded on the matter of access to lifelong learning and on-the-job training opportunities (Said and Friers-Tersch, 2016).

In addition, in a number of countries the social partners release good practice guides for the implementation of age management. Interesting examples can be found e.g. in Germany and Norway (OECD, 2018k; OECD, 2013b). The European social partners agreed in the context of their 2015-2017 Work Programme to negotiate this agreement to build upon and enhance the existing measures and approaches that are in place in different contexts across Europe (European Social Partners, 2017). It outlines tools/measures to be taken into account by social partners and/or HR managers in the context of national demographic and labour market realities, and in accordance with national practices and procedures specific to management and labour. This includes: distributing tasks according to ability/skills/knowledge; tutoring/mentoring/coaching schemes to welcome and introduce younger workers to their

8. Measures and negotiation concerning redundancies and lay-offs has been enhanced by a new tripartite measure – launched in 2005 - called “*Change Security*”. It consists of early cooperation between employers, employees, unions, public officials (particularly PES) and others. The model enhances early cooperation between the firm, employees, trade unions, staff, employment and education officials and other local, regional and national players. Internet: http://www.mol.fi/mol/fi/00_työnhakijat/07_tyottomyys/03_irtisanotun_muutosturva/index.jsp.

working environment, including paths to allow them to fulfil their potential; knowledge/skills transfer programmes for both younger towards older workers, and older towards younger workers, including IT and digital skills, transversal skills, customer relations skills, as appropriate; the creation of knowledge banks to capture specific know-how and professional intelligence developed in-house and pass it on to newcomers; and awareness-raising on the importance of being age positive and promotion of age diversity including considering different possibilities regarding the balance between ages within teams.

3.2 Setting incentives for investing in lifelong learning

Financing structure of Lifelong Learning

Companies have fewer incentives to invest in the development of general skills than firm-specific skills, as there is a risk that the worker changes company. Therefore, there is a tendency for companies to underinvest in the general skills of their workforce. (see Oosterbeek and Patrinos, 2008, for an overview of the literature). Firms prefer to hire younger workers with general skills gained from publicly funded education than invest in the prime age workforce and older workers if they have the choice.

Another aspect to consider is that investments in learning at a young age make investments in learning at later ages cheaper and more efficient. Thus, the costs of investment in lifelong learning are lower for people for whom investments in early learning have been larger (Oosterbeek and Patrinos, 2008). Participation in the further training of workers with a high education level is higher than the participation of those with a low education level (see e.g. OECD, 2017a).

Workers have an incentive to invest more in general skills, as they are portable. They will do so if they can expect that their investments in training are rewarded with higher income (or the avoidance of loss of income e.g. through unemployment). Because there are positive externalities linked to education and training there is a tendency not only for companies but also for individuals not to invest optimally in further training. In many cases further training will be financed by companies and individuals, while for initial VET and tertiary education the share of public financing is in general much larger.

With regard to age, not only will already accumulated human capital affect the rate of return on investments, but also the expected remaining length in working life. This is certainly one reason as to why older workers participate less in further training. However, it is quite likely that the attitudes (see e.g. Bohlinger,

van Loo, 2010), expectations and prejudices of workers about their remaining working life may lower the investment in further education below the optimal level.

Individual Learning Accounts and training vouchers

Individual learning accounts (ILA) encourage savings for education while providing vouchers to people interested in pursuing training. In general, individual learning accounts can be used to develop knowledge, skills and abilities that increase their human capital. There are different aspects of the accounts, including individual saving accounts, individual drawing rights (which may be considered as “virtual accounts”), and vouchers (customised or lump-sum). The schemes can be universal or targeted at specific groups. The schemes vary with regard to the financial participation structure of the state, the government and the workers. Gautié and Perrez (2012) argue that saving accounts – when compared with vouchers - have the advantage, as public funding (and the potential employer’s contribution) is conditioned to the financial contribution of individuals themselves, in order to make them feel more responsible. A key objective of training accounts (as for vouchers) is to replace a supply driven by demand driven training approach. This implies the existence of a market for education and training with competing providers. It also implies that individuals are well-informed and able to make rational choices. The worker may not be in a position that allows him or her to obtain an overview of the training market (this will be more likely for those with lower skill levels). The worker may also not detect a training need, although those needs exist. It is more likely that, those at a higher skill level will identify training needs. The free choice of the workers enhances at the same time as choice and responsibility and makes them less dependent on the firm. Therefore, companies might be reluctant to promote individual learning accounts. The authors conclude that training accounts may increase dualism and inequalities. With regard to increasing incentives for the low-skilled to engage in lifelong learning, ILAs suffer from self-selectivity into training activities. They are more likely to be used by high skilled individuals rather than low-skilled ones. One reason for unequal take-up is likely to be the lack of information as well as financial illiteracy (OECD, 2017b). Countries have moved towards including the provision of information and guidance in ILA schemes in order to better cover different groups of workers as well as to steer the choice of training. In practice however, guidance was little used to steer training for occupations that are in demand in the labour market. In the following a few examples will be given:

- In the Netherlands an Individual Learning Account initiative has been running since 2001 (see an overview in Osterbeck and Patrinos, 2008). The project includes contributions from learners, employers, and the state. An in-depth study on the effects on recipients' educational intentions in the elderly care and technical installation services was carried out by Renkema (2006). In the first sector the study found no effect at all but for the second sector a modest positive impact on intentions was reported.
- In Sweden, as an alternative to state-sponsored initiatives, the corporation Scandia introduced “competency assurance” accounts in Sweden. These accounts allow learners to save up to 20 percent of their income for future use to cover training expenses and, when studying full time, foregone income. The employer contributes the same amount as the learner to the account (Osterbeck and Patrinos, 2008).
- In Finland, the new government programme includes mapping out possibilities to adopt the individual learning accounts and ‘cumulative learning eligibility’. It also includes widening the tasks of the adult training fund, and reforming the law on the study leave (OECD, 2018c).
- In France a new individual learning account scheme (*compte personnel de formation*) was introduced with the national multi-sectoral agreement of 11 January 2013 (OECD, 2014). Upon entering the labour market, every person has a personal training account. The person uses this account, whether employed or looking for work, to access training on an individual basis. Each member of the workforce has a credit of training hours (24 hours a year and after five years, 12 hours a year, capped to 150 hours) that they could use at any time for vocational training leading to a certificate. This credit is portable from one company to another. First results show that at the end of 2015 about 2.5 million people opened an individual training account: 210,000 training sessions were engaged in, 79% by jobseekers, through the individual training account at the national and regional level. The first results are positive but limited by the high rate of jobseekers among the users (CNEFOP, 2016). It remains to be seen whether or not this individualised approach will be able to improve the chances for low-skilled workers to be trained and progress in their career path (CEREQ, 2014). The individual training account has become part of the individual activity account. Along with the arduous work account and the community service account, the individual training account forms part of the individual activity account designed to safeguard individuals given increasingly fast-moving career paths. Since January 2017, all salaried workers have been able to create their individual activity account on the in-

ternet or via a mobile app. Self-employed workers will have access to the individual activity account from January 2018 (OECD, 2018h).

Training leave

Training leave can be linked to individual learning accounts, but may also exist in the absence of such schemes. One country that has recently promoted training leave is Austria where take-up of training leave has been made easier since 2009. Since 2009, only six months of employment has been necessary to be eligible for receipt of financial support accompanying training leave (the further training allowance). Since 2008, modular use has been possible. The maximum duration of training leave is one year within four, and the required minimum duration of one episode is two months. In 2010/11, the Institute for Advanced Studies conducted an evaluation of the training leave. A survey (1,000 participants in 2005, 2008, and 2009) revealed that around 90% of participants were very satisfied with training leave. Formal education during training leave is very important (in 2008: it accounted for more than 60% of the training undertaken by participants). The main occupational fields linked with training leave are health care; social services; and engineering and technical occupations.

Human capital contracts between companies and workers

A human capital contract is a contract where students agree to pay a percentage of their income for a specified period of time after graduation in exchange for funds to finance their education. If employees invest in more substantial certified further training, e.g. to obtain a master's degree in the dual vocational training system or in the tertiary sector, different financial models are in place. For example, in Germany some case companies take over a part of the tuition costs, in some cases they give the worker free time, and in some cases they do not provide any support. In case costs are shared between employers and workers, workers generally have to commit themselves to staying with the company, e.g. in the context of tertiary-level further training (Düll et al., 2014). However, these contracts do not generally involve state contributions, and the risk of under-investment in human capital will not have vanished.

Training Funds

Since 2010 in Italy, there has been a joint Multi-Sectoral Fund for Continuing Training (*Fondimpresa*) that provides rewards for funded programmes that benefit a share of over 20% of workers aged over 45 years (OECD, 2018i).

Training measures for jobseekers

Training measures are the most important forms of active labour market programmes. They vary in length and the type of skills promoted. A distinction needs to be made between short-term training courses and longer lasting ones that lead to up-skilling of vocational skills and are certified. This includes re-training in new occupations. In general, older unemployed people are less likely to be among the participants. Although older and low-skilled unemployed people seem to be registered more often than other groups of unemployed people, they are least covered by lifelong training efforts (European Commission, 2016). Therefore, in some countries specific programmes have been targeted at older workers. Examples include the following:

- In Austria the “productive ageing approach” was implemented in 2007 as part of the operational programme of the Public Employment Service (PES). Its focus was set on additional provision of qualification measures for older employees. (OECD, 2018e).
- In Portugal, the programme Active Life, (“Vida Ativa”) has the explicit objective of up-skilling unemployed adults using (i) modular short duration education and training, (ii) practical training in work environment as a complement to the modular training and (iii) processes of recognition and validation of competences in combination with other activities, in particular with modular education and training. Target groups for the measure are people registered as unemployed for more than six months, and unemployed people with less than nine years of school or without a qualification. Modular Training and Active Life have the highest participation rates of all measures, representing approximately one fourth of the total number of persons covered by the PES measures in the area of employment, professional training and professional rehabilitation (2007-2014) (OECD, 2018g).
- In Ireland the Springboard initiative was introduced in 2011 in the context of the downturn of the economy. It is a labour-market activation programme that provides free higher education opportunities for up-skilling and re-skilling in growth areas to unemployed citizens. It targets funding at part time higher education courses for unemployed people who have lost jobs in sectors where employment levels will not return to pre-recession levels, and who will need new qualifications and skills to re-enter employment in areas where sustainable opportunities may arise as the economy recovers. Springboard has had a positive impact on improving the labour-market prospects of older workers. A recent trend analysis evaluation of Springboard, published in December 2014, showed that enrol-

ments of those 45 or older have grown from 17% in 2011 to 23% in 2014⁹ (OECD, 2018j).

- Interesting examples of targeted training measures are found in the region of Piedmont in Italy. Here the Labour Department of the Province of Biella, in collaboration with the employment agencies, has developed the project “Women Over-40 – experience and professionalism”¹⁰. In the province of Rovigo, workers older than 45 years were the main beneficiaries of active labour market projects developed in 2008. The initiative used, *inter alia*, apprenticeships as a tool to build up the employment relationship and facilitate demand and supply matching. In this context employment agencies offered a counselling service intended to define an individual action plan, followed by an apprenticeship grant, and a mentoring service, throughout the timespan of the whole programme (up to six months) (Colombo, 2013). In the province of Padua, the Department of Work and Training, in collaboration with employment agencies and counselling and orientation agencies, implemented initiatives aimed at keeping workers older than 45 years in the labour market by investing in activities related to retraining and labour market re-integration¹¹. The projects were addressed at those workers on the earnings supplement fund and long-term unemployed people. It consisted of counselling, individual and group orientation, professional training in the areas of services, tourism, industry and tertiary sector, apprenticeships, internships and sometimes counselling for start-up companies (OECD, 2018i).

4. Conclusions

Older workers are in fact a highly heterogeneous group. In general terms, the heterogeneity of workers with regard to productivity augments with age, as the value of experience, career paths, and physical strains of work vary significantly among tasks and occupations. There is no evidence supporting the view that learning abilities depend solely on age. Over their life course workers tend to combine different set of skills in different ways. Most importantly, learning abil-

9. Higher Education Authority, Evaluation of Springboard 2011. First stage report. <http://www.springboardcourses.ie/pdfs/Springboard%20Trend%20Analysis.pdf>

10. <http://www.provincia.biella.it/on-line/Home/ServiziOnLine/Consiglieradiparita/Over40.html>.

11. The programme “Over45: mix of professionalism, skills and experience” and in 2009, “Over45 opportunities of reintegration in the labour market” in 2009.

ities depend on previous individual learning history. Learning abilities are strongly related to already accumulated human capital. Inequalities in the ability to acquire skills are influenced early on in an individual's life and may be deepened over the life course. Therefore, participation in further training is found to be more effective for the higher skilled. Thus, workers with a higher level of education and who participated in further training over their whole career are well equipped to adapt their skills to the changing labour market needs.

Governments could do more to support lifelong learning and not focus public support solely on initial vocational or tertiary education. A number of countries have up-scaled support provided for (short-term) training of unemployed people. Some countries have also developed programmes for low-skilled older workers. More generally, many countries must still further develop a well-structured and transparent further training system and, in doing so, strive for an appropriate financial balance between the state, the companies and the workers.

Those at risk of low productivity performance are those workers who have a low level of educational attainment, have not worked in an enriching work environment, and have participated little in further training. Often these factors come together. These workers tend to find themselves in a vicious circle of being trapped in low productivity work with little access to the skills development that will allow them to become more productive. An additional risk factor is that where skills are under-developed at an early age, there is sometimes little opportunity to improve those skills, and a life spent in low skilled relatively less productive work results in any initial skills accumulation being dissipated over time.

For those with a low educational level, it is important to break the vicious circle between low skill level and low productivity by up-skilling measures as well as improving the learning and working environment early on and over the whole life cycle. Therefore, not only is improving equal access to vocational education and training and higher education at a young age crucial but so is up-skilling low-skilled prime age adults. To start with, improving basic skills might be necessary, though they do show less direct immediate effects on employment. There is also room for improving more specific skills, such as the digital skills of older workers. Although some countries have made progress in setting-up specific education and training programmes for low-skilled adults, there is still a policy gap.

Increasing the flexibility of educational pathways and promoting adult vocational education is one important option for encouraging lifelong learning and opening up second, third, and fourth (and so on) career paths. Improving the further training system through more transparent certification of training is also relevant and can promote mobility and efficient labour market matching of older

workers. For older workers who have a low formal educational level but a wealth of work-experience and informal on-the-job learning, systems for the recognition and validation of skills are important approaches that help to make their skills visible and tradable and allow for the development of a meaningful further learning and career development. Many countries can either set up appropriate mechanisms or still improve their existing systems.

Furthermore, countries need to reconsider the appropriate split between workers, companies and the state with respect to further training. This is to avoid an under-investment in human capital from a lifetime perspective. This is particularly an issue for older workers for whom pay-off periods are shorter.

The introduction of lifelong learning accounts is a promising approach, though they seem to be not always well implemented. With regard to low-skilled older workers, more targeted measures may be useful in increasing their take up in training. In addition, lifelong vocational guidance can improve incentives for older workers to participate in further training and help to identify their skill needs. Lifelong guidance is highly relevant within companies as part of the career management system as well as at institutions such as the PES. Employer-employee contracts on sharing the financing of further training may enhance the willingness of both to invest in further training. Governments could also provide general support, e.g. through opening up the VET and tertiary education system for up-skilling and retraining either for free or at a low fee level. Government support focuses on financing training measures for (older) jobseekers and, in some countries, for low-skilled workers. These programmes are in general run by the PES. In the future this could be expanded so it is not just targeted at jobseekers. Governments can strive to achieve a new balance between employers, workers and the state in financing training over the life-course in order to bring about a more optimal mix in the provision and take-up of general and firm-specific human capital development and, in doing so, provide a robust base upon which skills development can flourish.

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Effects of the Dutch State Pension Age Increase on Employment and the Government Budget¹

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1. Introduction

The Netherlands has a mixed pension system. Every inhabitant of the Netherlands who has reached pension age is entitled to a state pension, which is set at the welfare minimum. Most pensioners have a supplementary private pension related to their work career. This chapter concentrates on the state pension. In view of the ageing of the population, the state pension age is set to gradually increase from 2013 onwards. By doing so, the government wants to prevent the state pension from becoming an increasingly large burden on government finances. This chapter aims at answering three questions. First, to what extent does the increase in the state pension age lead to higher employment among those whose state pension has been delayed? Secondly, does this increase in employment have negative consequences for the employment of other age groups? And third, what is the effect on the government budget, i.e. do the savings on the state pension outweigh the expenses involved with an increase in the use of other benefits?

Before the Second World War, most elderly men who could no longer work were dependent on poor relief and family, which often resulted in poverty. Therefore those who could still work continued working for as long as possible. As a result the participation rate among men older than 64 years of age was quite high. Data from the 1930 census (Statistics Netherlands, 2006) show that in that year 42 percent of men over the age of 64 were still employed. Women usually stopped working after marriage and, thus, were financially dependent on their husband. Hence, the employment among older women was quite low (8 percent in 1930). Being without employment, older women were even more vulnerable to poverty than older men, especially when their husband died.

1. This chapter is, for an important part, based on De Koning et al. (2017), a study commissioned by the Scientific Office of (political party) 50PLUS.

In view of the widespread poverty among older people, already before the war there was a call for a general income provision for the elderly. This would give them income stability, which in turn would allow them to enjoy their old age. After the war, this income provision became a reality with the implementation of the *'noodvoorziening voor ouden van dagen'* (emergency provision for the elderly) in 1947. In 1957, the emergency provision was replaced by the *Algemene Ouderdomswet (AOW; general old-age law)*. The implementation of this new law did not directly reduce employment above the age of 64 to zero. The decrease was gradual. For example, in 1960 and 1971 the employment rate for men aged 65 and over was 19 percent and 11 percent, respectively. It was not before 1990 that it almost reached zero. After 1990, the employment rate increased again. In 2012, 10 percent of men older than 64 years of age worked. This increase is probably due to the increase in educational level and the improved health of older people.

A pension age set at 65 years was considered to be reasonable given the context in which the law was passed: World War II had just ended and many citizens did not even reach this age. Those who did usually only had a limited number of years left. Since then, life expectancy has increased dramatically and is expected to increase even further. Nowadays, someone who has reached the age of 65 is expected to live another twenty years, twelve of which in good health.

If people live longer, they will also need more income throughout their life. This means that, given a stable age structure of the population and unchanging productivity, people would have to work more hours in their life in order to keep the same income level. The current de-juvenation in the Netherlands has further increased the urgency of this problem. The solution came in the form of steadily increasing the state pension age, with the first increase taking place in 2013. In 2022, the pension age will be 67 years and 3 months. Thereafter, it will be linked automatically to life expectancy.

Although increasing the pension age is not the only solution to this problem, it is – arguably – the most feasible one. There are limited options to increase the number of hours worked in younger age categories. One such option is to focus on the labour market participation of women, who – in comparison to men – have a lower employment rate and work shorter hours. However, it has proved to be difficult to influence female participation with the help of government measures and, as far as measures are effective, it takes time.

The structure of the chapter is as follows. The next section contains a review of studies dealing with the effects of early retirement schemes and pension age reforms in other countries. This will be the main source of

information about the effect of the pension age increase on the employment rates of younger age groups. In the third section microdata are used to analyse the employment effects on the people affected by the pension age increase. Section four will deal with the effects on the government budget. The last section contains the conclusions and discusses the policy implications of the findings.

2. The experience with early retirement schemes and pension age reforms in other countries

A number of countries have started earlier with pension age reform than the Netherlands. Therefore, it is useful to look at their experiences. Table 1 gives a systematic overview of available studies. The rise in the pension age leads to a marked increase in the participation rate of directly involved age groups in all studies. In studies where the effect is expressed as an increase of the employment rate, the effect varies from about 5 percentage points (mostly for women) to above 30 percentage points. Both the study by Hanel and Riphahn (2012) and Cribb, Emmerson and Tetlow (2014) shows that the size of the effect is smaller when the pension age shifts to a higher year of life (although in the last study the difference is not statistically significant). Some studies use a different measure of effectiveness and measure the effects of a pension age increase in terms of the shift in actual age of retirement when the statutory retirement age rises (such as Mastrobuoni, 2009) who concludes that an increase in the statutory retirement age of one year leads to an increase of the actual age of retirement with six months).

Most studies that also pay attention to the use of benefits show that an important side effect of increasing the retirement age is that a large proportion of the group involved (more often) enter into alternative schemes such as unemployment benefits or disability benefits. The increase of these alternative routes within the age group concerned is often about the same or sometimes even larger than the increase in the employment rate. An exception to this pattern is found in the study by Weber and Manoli (2016), where relatively little of such “substitution” (use of schemes other than retirement pensions) is found.

Table 1 - Overview of international studies about the effects of an increase in the pension age

Publication and country	Change in pension age	Data	Method	Employment effects on group concerned	Side-effects on other benefits
Saahbi and Zweimüller (2011)	Stepwise increase in the public retirement age of men from 60 to 62.2 and of women from 55 to 57.2. The pension system has a flexible component (retiring later results in a higher pension) and the level of the pension depends on employment history	Administrative data of people employed in the private sector	Difference-in-difference; the control group consists of those who are still able to retire earlier, on the basis of their employment history	Growth employment rate by 7 percentage points for men in the age group concerned and 10 percentage points for women in the age group concerned	Share of concerned age group receiving unemployment benefits increases by 10 percentage points for men and 11 percentage points for women
Austria					
Mastrobuoni (2009)	Social Security Amendments 1983: stepwise increase in the public retirement age by two months per year. The retirement age is flexible (retiring earlier results in a lower pension)	Monthly survey among citizens without handicap or disability	Measuring the effect of change of pension benefit at a certain age (lower benefit for younger cohorts) on the chance to retire	A one year increase in statutory retirement age leads to an increase in the actual average retirement age of six months	
US					
Weber and Masouli (2016)	Stepwise increase in the public retirement age of men from 60 to 61.5 (and 62) and of women from 55 to 56.5 (and 57)	Administrative data of people employed in the private sector	Fuzzy regression kink design; compare people who can still retire on the basis of their employment history (as a control group) combined with the use of different situations for cohorts	Due to a one year increase in the early retirement age, the age group concerned leaves the labour market on average 0.4 years later and claims their (early) pension on average 0.5 years later	Substitution effects of increase in the use of unemployment and disability benefits are limited
Austria					
Hanel and Kipflin (2012)	Stepwise increase in public retirement age of women from 62 to 63 and 64; retirement from 62 onwards remains possible, but results in structurally lower benefits	Representative data from panel of Swiss population	Difference-in-difference; comparing women who were 62 at the time of introduction with women who would become 62 after the introduction	Reduction in probability of claiming pension (increase of one year) at age 62 from 42% to 22% and from 40% to 30% at age 63. The effects are larger for people with a lower educational level	
Switzerland					

Table 1 >>>

Publication and country	Change in pension age	Data	Method	Employment effects on group concerned	Side effects on other benefits
Lalive and Staubli (2015)	Increase in pension age of women from 62 to 63 and from 63 to 64	Swiss Social Security data (SSSD) consisting of administrative data linked with large sample of labour supply	Regression discontinuity design making use of the different situation between women who were born on or after January 1st, 1939 (treatment group) and on or before December 31st, 1938 (control group)	Increasing the retirement age by one year leads to a delay of exiting the labour market of 7.9 months and of claiming pension of 6.6 months	
Switzerland					
Cribb, Emmerson, and Tetlow (2014)	Stepwise increase in the public (early) retirement age for women from 60 to 65 (where 62 had been reached during research). The pension is flexible (retiring later results in a higher pension)	Survey among a representative sample of families on quarterly basis	Difference-in-difference (probit model); comparison with last cohort that falls under old regulation	Growth in employment rate of women by 5.9 percentage points in the age group concerned. The increase from 60 to 61 led to slightly higher employment rates in percentage points for 60 year olds, than the increase from 61 to 62 for 61 year olds. However, this difference is not statistically significant	The group concerned is 4.2 percentage points more likely to be ill or incapacitated for work, and 1.1 percentage points more likely to be unemployed
UK					
Atalay and Barrett (2012)	Step-by-step increase in public (early) retirement age for women from 60 to 65	Ten cross-section surveys among representative samples of population	Difference-in-difference; comparison between different cohorts of women whose retirement age increases with men (control group) whose retirement age is constant	10 percentage points higher participation rate in the age group of women concerned	Significant increase in inflow of disability schemes (larger effect than on participation)
Australia					

Table 2 - Employment rate (percentage share of employees in the population) of 65 year olds by age in months^a

Year	0	1	2	3	4	5	6	7	8	9	10	11
2006	7.9%	6.9%	6.4%	6.1%	6.0%	6.2%	5.6%	6.2%	6.3%	5.9%	6.0%	6.0%
2007	7.9%	7.0%	7.0%	7.0%	6.8%	6.2%	6.7%	7.1%	6.9%	6.9%	7.0%	6.7%
2008	7.8%	7.4%	7.5%	7.3%	7.9%	6.7%	7.9%	7.7%	7.0%	7.4%	6.2%	7.5%
2009	8.2%	7.6%	7.4%	7.5%	7.7%	7.2%	7.5%	7.1%	7.1%	7.4%	7.6%	7.0%
2010	9.6%	8.2%	8.1%	8.1%	8.1%	7.6%	8.0%	7.9%	8.0%	8.4%	7.8%	8.1%
2011	9.5%	9.2%	9.1%	9.2%	9.2%	8.6%	9.0%	8.8%	8.6%	8.9%	9.0%	8.2%
2012	8.8%	8.6%	8.4%	8.8%	8.7%	8.2%	8.8%	8.4%	8.9%	8.7%	8.4%	8.2%
2013	16.5%	9.3%	9.1%	8.6%	8.9%	8.1%	8.3%	8.2%	8.4%	8.1%	8.1%	8.0%
2014	17.8%	17.5%	8.7%	8.6%	7.9%	8.1%	8.3%	8.3%	8.5%	8.4%	8.1%	7.9%
2015	28.1%	28.1%	27.8%	12.5%	11.2%	9.1%	9.2%	9.1%	9.1%	9.0%	8.8%	8.6%
2016 ^b	29.1%	29.1%	28.3%	27.7%	27.9%	26.4%	11.9%	10.6%	9.5%	9.0%	9.5%	8.3%

a) The shaded cells indicate the ages that are affected by the pension age increase

b) Second quarter of the year

Source: based on data analyses applied to microdata from Statistics Netherlands (CBS)

3. Effects on employment rates of the first cohorts that are affected by the pension age increase

Since 2013, the pension age has been gradually increased. The first group of people affected was those born between January 1, 1948 and November 30, 1948. Their pension age was increased to 65 years and 1 month. For people born between December 1, 1948 and October 31, 1949, the pension age became 65 years and 2 months. Initially this pattern – increasing the pension age by one month with each cohort – was supposed to continue. However, since 2016 the increase in pension age has accelerated, with three-month steps per cohort.

In Table 2 the employment rates of people aged 65 are given by month of age. The shaded cells apply to people who were affected by the pension age increase. For the table, microdata from Statistics Netherlands (CBS) are used, which cover every employee in the Netherlands. The data are taken from social security files. From the table, it is clear that the increases in the pension age have had a considerable positive effect on employment rates. Employment rates already tended to increase before 2013, but only weakly. Furthermore, the employment rates of 65 year olds who were not yet affected only show a small increase. Therefore, we can conclude that as a result of the higher pension age employment rates have gone up considerably. However, employment rates are still lower than 30 percent of the population in the age group concerned.

The microdata used for Table 2 only apply to employees. Such detailed data are not available for self-employed workers. Data including self-employed workers are available from the Labour Force Survey. Owing to the relatively small sample of this survey, these data can only be broken down by years of age. These data show that the self-employment rate of 65 years olds has hardly changed since 2012. It increased from 8.8 percent to 9.0 percent. For the age group from 60 to 64, the self-employment rate increased from 10.9 percent to 12.2 percent, a somewhat higher growth. Perhaps the pension age increase has induced employers to substitute some self-employed workers for employees or induced some workers to remain as employees. However, if there is a negative effect of the pension age increase on self-employed 65 year olds, the effect will not be more than a few percent. In absolute terms, this is much smaller than the positive effect on the employment rate of employees.

One might fear that increasing employment for 65 year olds would lead to lower employment for people of other ages. There is no evidence of displacement for the group of workers just below the age of 65. The steady increase in the employment rate of the latter group continued after 2012, as can be seen from Table 3. It is even possible that the pension age increase has had a positive effect

Table 3 - Employment rate (including both employees and self-employed) per year of age

Year	60	61	62	63	64	65	66	67	68	69
2003	32.9%	24.0%	19.0%	16.0%	15.4%	9.8%	7.0%	7.6%	6.5%	5.2%
2004	34.5%	25.9%	19.3%	15.2%	14.1%	10.4%	7.8%	7.7%	6.5%	6.3%
2005	35.1%	26.9%	20.0%	17.7%	13.9%	10.6%	7.6%	7.9%	7.9%	6.4%
2006	38.9%	28.8%	20.5%	16.8%	14.8%	11.3%	7.5%	9.5%	6.5%	6.4%
2007	42.6%	33.5%	23.4%	19.7%	16.4%	13.5%	11.7%	9.6%	9.3%	5.7%
2008	49.2%	39.6%	29.3%	21.9%	19.5%	13.3%	11.7%	11.0%	8.3%	7.1%
2009	50.9%	42.7%	31.6%	25.8%	21.0%	16.6%	13.1%	12.1%	11.3%	6.8%
2010	56.3%	43.9%	36.0%	26.9%	21.7%	16.3%	12.2%	12.3%	11.7%	7.0%
2011	58.9%	47.9%	37.8%	29.7%	22.8%	15.3%	11.3%	12.6%	10.3%	7.1%
2012	61.7%	54.2%	42.1%	31.4%	25.5%	16.8%	13.5%	11.9%	11.4%	7.9%
2013	60.7%	55.7%	49.1%	37.6%	28.0%	16.9%	15.3%	12.5%	11.1%	7.9%
2014	60.4%	56.1%	47.8%	43.0%	31.1%	18.3%	16.2%	15.2%	12.6%	10.1%
2015	61.6%	56.9%	52.4%	43.9%	36.8%	18.7%	15.0%	12.2%	9.4%	10.1%
2016	61.8%	60.7%	54.8%	47.8%	38.7%	23.3%	12.8%	10.6%	10.3%	9.3%
2017	66.4%	61.5%	56.1%	50.7%	41.9%	28.0%	13.6%	12.8%	9.8%	8.4%
Relative change since 2012	7.6%	13.5%	33.3%	61.5%	64.3%	66.7%	0.7%	7.6%	-14.0%	6.3%

Source: Statistics Netherlands (2018). Labour Force Survey

on the employment rate of this group. The pension age increase has made it financially less attractive to retire before the age of 65, since one has to rely on one's own resources for a longer period of time before receiving a state pension. Many workers also have an additional pension, which is arranged by individual companies or sectors. In many cases, this pension is flexible and can be claimed before the age of 65, but if one retires before the state pension age, one receives a lower pension. Furthermore, there are still many people who do not have a private pension, or only a low one. These people cannot afford to retire before the state pension age. This result for the Netherlands (no displacement of older workers) is in line with two other studies. Studies for Germany (Giesecke and Kind, 2013) and France (Hairault et al., 2010) confirm that an increase in pension age leads to higher participation rates and higher transition rates from unemployment into employment for the groups just below the pension age, respectively.

However, we cannot exclude the possibility that displacement did occur for people older than 65. For people aged from 66 to 69 the employment rate did not grow after 2014. Therefore, we cannot exclude the possibility that some displacement of people older than 65 has occurred.

What many people fear most about measures like pension age increases is that it might harm the employment opportunities of young people. Since 2003, youth employment rates have developed slightly less favourably than the macro employment rate. However, this may be to do with a rising trend in school participation. One would need longer time series and econometric methods to identify the impact of the increase in pension age among various other factors, such as the business cycle and structural factors affecting school participation.

In other countries, econometric research has studied the effects of employment rates of older age groups on the labour market position of young people, corrected for factors such as the business cycle. Most of these studies convincingly show that there is no crowding out effect with regard to young people (see for example Gruber et al., 2009; Kalwij et al. 2010; Kapteyn et al., 2010; Banks et al., 2010; Jousten et al., 2010; Lefebvre; 2012; Munnell and Wu, 2012). A minority of studies with opposite results (see for example Alecci, 2013; Boeri et al., 2016; Martins et al., 2009) focus on effects at the company level. These studies do not take into account any effects at the higher level through macro-economic mechanisms, such as wage adjustments and a better filling of vacancies.

Table 4 - Percentage of 65 year olds with unemployment, social assistance, or disability benefits by age in months^a

Year	0	1	2	3	4	5	6	7	8	9	10	11
2007	2.6%	1.9%	1.9%	1.9%	1.8%	5.2%	1.9%	2.0%	1.9%	2.1%	2.3%	2.7%
2008	2.6%	1.7%	1.6%	1.8%	1.5%	4.7%	2.0%	1.9%	1.7%	1.9%	1.8%	1.9%
2009	2.0%	1.5%	1.8%	1.6%	1.6%	4.4%	1.7%	1.7%	1.9%	2.0%	1.7%	2.3%
2010	2.8%	2.1%	2.3%	2.2%	2.2%	4.8%	1.9%	1.8%	1.8%	1.8%	2.1%	2.5%
2011	1.6%	1.1%	1.3%	1.0%	1.2%	3.0%	1.2%	1.0%	1.1%	1.2%	1.6%	2.4%
2012	1.9%	1.2%	1.1%	1.2%	0.9%	2.7%	1.0%	1.1%	1.2%	1.2%	1.2%	1.4%
2013	21.6%	1.6%	1.9%	1.2%	1.2%	2.8%	1.0%	1.1%	1.4%	1.4%	1.4%	1.7%
2014	22.6%	21.7%	2.6%	1.8%	1.1%	2.9%	1.2%	1.3%	1.2%	1.2%	1.2%	1.8%
2015	25.9%	25.3%	25.5%	3.0%	3.3%	5.2%	2.0%	2.2%	2.0%	2.4%	2.1%	3.3%

Source: based on data analyses applied to microdata from Statistics Netherlands (CBS). The marked cells indicate the ages that are affected by the pension age increase

4. Effects on the government budget

By increasing the state pension age, the Dutch government aims to reduce the burden of the state pension on the government budget. A higher state pension age leads to savings in state pension expenses, but at the same time could cause an increase in the use of other benefits and associated costs because more people become eligible for social assistance, unemployment and disability benefits. The existing literature suggests that a substantial proportion of people subject to an increase in the pension age enter into these alternative schemes, thereby “substituting” their retirement benefits (see Table 1).

Table 4 shows the share of individuals receiving unemployment, social assistance, or disability benefits aged 65 by month of age. As in Table 2, the shaded cells apply to people who were affected by the pension age increase. The increase in the pension age has indeed had a considerable effect on the use of benefits: a sharp increase (of approximately 20 percentage points) can be seen among those whose state pension has been delayed. When comparing the situation of 65-year-old individuals affected by the pension age increase with that of individuals in the age group just below 65 years, the percentage shares of people with a benefit are similar.

Table 5 shows the estimated yearly effects of an increase in the state pension age from 65 to 67 years on the government budget. To estimate how much the expenditure on benefits other than state pension benefits would increase, the effects of the increase in pension age on the use of benefits are extrapolated. Possible differences in the average amount of benefit between age groups are taken into account (e.g. unemployment benefits of older people are higher on average). The estimated increase in costs related to the implementation of social security and re-integration is calculated by proportionally increasing these costs with the expected change in the number of beneficiaries. This estimation should

Table 5 - Effects from an increase of the Dutch state pension age to 67 on the government budget (per year)

	In billions of euros
Savings on state pension benefits	+ 4.7
Increase in expenses on other benefits	- 1.8
Increase in costs of re-integration and implementation of social security	- 0.2
Difference	+ 2.7

Source: De Koning et al. (2017)

be seen as a maximum, because it is likely that economies of scale will play a role in the implementation of social security.

The increase of the state pension age has an expected positive net effect of approximately 2.7 billion euros on the government budget. The expected positive effects on the employment at the macro-level (in the form of additional tax-income and contribution to the state pension) are not taken into account.

5. Conclusions and final remarks

So far, the increase in the Dutch state pension age has led to a higher net employment rate of the group of older people directly involved. Admittedly, a considerable share of this group receives unemployment, social assistance or disability benefits, but the expenses of these benefits are less than half of the costs saved on state pension expenditures. Other additional government spending or societal costs as a result of the increase in the state pension age are relatively small.

The positive employment effects for the people directly affected by the pension age increase are, as have been seen in the literature review, in line with the experiences in other countries. This literature also tends to the conclusion that displacement effects are relatively small, implying that pension age increases have a positive effect on macro employment. On the basis of the available information, it is concluded that it is unlikely that the pension age increase has led to displacement of the age group directly below 65. It is even likely that this increase has had a positive effect on the employment rate of the latter group. However, there may have been a displacement effect on workers older than 65. In recent years, the employment rate of this group has even decreased somewhat. It is difficult to say whether the employment opportunities of young people are affected by the pension age increase, since these opportunities are very sensitive to the business cycle. Furthermore, the labour supply of the young is interrelated with school participation. Given the available evidence and the experiences with pension reforms in other countries, it is unlikely that displacement effects have completely nullified the positive employment effects that have occurred for the 65 years old and probably also for older workers between 60 and 65. It is more likely that macro employment was positively affected by the pension age increase.

In the coming years the state pension age will be increased to 70. From this moment on, it will follow expected life duration. The fact that we have found positive employment effects for the 65 years old so far does not necessarily mean that the same effects will be seen when the pension age is increased further. Already for 65 year olds it has been seen that a considerable number of them were unable to find a job or to remain employed. Particularly people in physically de-

manding occupations complain that it is tough for them to continue working until the age of 65. It might be the case that when the pension age increase extends to 66 year olds, an even higher percentage will not be employed. If that is the case, more people will claim unemployment and disability benefits. Therefore, it is important to monitor further increases in the pension age. Furthermore, it may be necessary to invest more in the human capital of older workers to keep them employed. In many cases a transition to a different type of work at an earlier stage of their career would be needed to keep workers employed for longer. Although the Dutch government and the social partners have already taken some measures in this direction, it is still far from enough.

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Creating a Socially and Economically Inclusive Economy and Labour Market: An urban challenge for an urban continent

Raffaele Barbato

1. Introduction

In 2010, in the aftermath of the global financial crisis, where the deep and long lasting effects had not yet totally unfolded, the European institutions and Member States agreed to anchor the strategic vision for the European Union (EU) in 2020 to concrete and measurable targets.

The EU2020 targets translate a strategy for an ambitious societal vision for Europe. The vision is of a Europe able to grow smartly, sustainably and inclusively. A Europe where innovative economic opportunities are continuously researched and explored while traditional welfare policies are radically rethought to make sure that no one is left behind and that the economic and social benefits of the growth are fairly shared among citizens.

To achieve the strategic targets and make the vision tangible, the EU is investing in important financial resources. It does so through EU-wide universal policies and instruments, harmonising national policies and legislation, but also, and increasingly so, through territorial instruments, actively involving local governments and stakeholders.

Here it is argued that some of the most promising experiences and solutions to achieve the EU2020 targets are those that have a clear territorial focus. Those that take into consideration the diversity of the European territories, recognise the key role of urban areas and local governments (mainly municipalities). This is because urban areas are the real engines for economic development and social inclusion in Europe and represent the right scale to test new bold solutions.

After an introduction on the framework for action for local governments for inclusive growth and a brief overview of the European policies and instruments supporting the achievement of the EU2020 strategy, the article will focus on four projects currently supported by the European Initiative Urban Innovative Actions (UIA), highlighting how local governments can forecast and anticipate major economic transformations by preparing and equipping their territories and citizens.

2. The fight against inequalities and polarisation: an urban challenge for an urban continent

Europe is one of the most urbanised continent in the world, with more than two third of the European population living in urban areas (approximately 350 million people); a share that is projected to grow in the coming decades. The logical consequence of this demographic and territorial dynamic characterising the European continent is that urban areas and local governments will play a key role in the lives of most Europeans.

European cities today are unanimously recognised as places where both problems emerge and new solutions are found, implemented and evaluated. This assumption is particularly relevant not only when looking at the weight and importance of urban areas in the EU's overall economic performance, but also in achieving social cohesion of the territories and the well-being of European citizens.

65% of EU GDP is produced in urban areas, two third of the European workforce live in urban agglomerations, and the employment rate within cities is, on average, around 70%. Urban areas in Europe have the highest concentration of training and research institutions. They are the places with the highest levels of investment in R&D (including the highest shares of foreign direct investment) and they represent the ideal test-bed for innovative upstart-ups, benefiting from the density and proximity of people, resources and ideas.

It is, however, in urban areas that the highest levels of jobless households, youth unemployment, deprivation, exclusion and social polarisation can be found. These phenomena create a negative spiral with dramatic impacts on other aspects of life such as education, health, life expectancy, or employment prospects. This spiral is negatively shaping the physical fabric of European cities as poor and rich people are increasingly living in separate neighbourhoods. The spatial isolation of low income people, often from an ethnic minority background, is bringing about a situation where they are being increasingly cut off from social networks and mainstream society, increasing the risks of social unrest, adding pressure on traditional welfare mechanisms, and further reinforcing patterns of inequality.

In the historical trajectory that has contributed to raising the importance of urban areas in fostering economic growth and job creation, the 2007 global financial crisis represents an important turning point.

As the crisis evolved from a financial crash into a global recession, several indicators were clearly pointing in the direction of an urban crisis. The bursting of the property price bubble and the collapse of the construction sector that fol-

lowed the initial financial downturn, have hit the main pillars of the local economies in several urban areas in the EU. Scenes of indebted and jobless homeowners and renters being evicted have been seen in many European cities. Consumers have reduced their purchases and industrial production has dropped back to the level of the 1990s, intensifying longer trends linked to the globalisation process. It was naturally in urban areas where the most dramatic consequences materialised with shockingly high levels of unemployment (although with important difference across Member States), especially among young people, women and migrants, exacerbating social problems and increasing inequalities and spatial polarisation.

The combination of those dynamics pushed local governments into what is commonly recognised as a “perfect storm”. On one side, as the most localised level of democracy and government, city councils have been persistently asked to face the immediate and daily consequences of the financial crisis and, at the same time, to find new solutions to increasingly complex and long-lasting societal challenges (an ageing population, the arrival of refugees, de-localisation of traditional economic activities, climate change, etc.). And in the last decade, their roles and responsibilities have been gradually increasing following a decentralisation processes, ongoing in several Member States. On the other side, however, due to austerity measures and budgetary cuts, local governments have suffered the most from the reductions of financial transfers from central governments, while the local tax base has spectacularly shrunk. Fiscal compacts for local governments, drastic reductions in municipal’s staff, horizontal cuts to programme and project budgets have been the norm across Europe. Municipalities and city councils have had no other choice than to do more with less.

In this grim scenario, a positive aspect is represented by the revolutionary effects that new communication technologies are having on our societies and in the way local governments operate. Here two aspects are particularly relevant. New technologies are spectacularly increasing the capacities of actors in the civil society to organise horizontally in order to contribute to the solution of societal problems and eventually creating new opportunities for sustainable jobs. The same communication technologies are producing disruptive effects on the way citizens establish relations and dialogue with public institutions. In both cases they are helping to unlock the potential for (social) innovation of the collective intelligence of citizens, firms, associations, NGOs, and are radically changing the processes of local policy design and delivery.

In 2017, after almost ten years of deep financial crisis, with GDP growing and unemployment standing at its lowest level since December 2008, President Juncker’s message was again positive. “Europe’s economy is finally bouncing

back”. But even the most cursory analysis of the evidence suggests that the picture is more blurred than it may initially appear. For instance, one has to consider that, while macro-economic indicators have been slowly improving, roughly one in four people in the EU experienced at least one of the following three forms of poverty or social exclusion: monetary poverty, severe material deprivation; or very low work intensity in the household. From 2008 a new trend began, which led to a rise of 6.1 million people at risk of poverty between 2008 and 2012. In 2015, a total of 119 million people (23.7% of the EU population) were at risk of poverty or social exclusion¹; both phenomena were mainly concentrated in urban areas.

European societies, especially urban communities, have emerged from the crisis more unequal and fractured.

Confronted with such an increasingly complex and polarised picture, looking at local models for inclusive growth is no longer a political and intellectual exercise but a necessity. Mayors, councillors and local civil servants have found themselves on the frontline to demonstrate, with concrete actions, that growth and cohesion are not in conflict but complement one another. Local governments have no other choice than to be innovative and test new ways to sustain dynamic economic growth that creates opportunity for all segments of the population and distributes the dividends, both in monetary and non-monetary terms, fairly across citizens and neighbourhoods.

If urban areas represent the right scale to test policies for inclusive growth, local governments do not always possess the competency to deal with these issues. Macro-economic decisions as well as legal and policy frameworks (for fiscal policies as well as for education and training, for instance) are normally decided at national and/or regional level. Tensions and frictions between different levels of government on conflicting competencies, diverging visions and resource allocations are common in almost all EU member states.

Yet, the role that local governments can play remains important and is gradually increasing.

In 2015, the authors of the URBACT Workstreams publication “More Jobs, Better Cities”² defined and advocated for a framework structuring a city’s action

1. Laura Colini – UIA Journal B-Mincome project based on figures published by Eurostat in 2016-2017 - http://www.uia-initiative.eu/sites/default/files/2017-12/FINAL%20VERSION_Barcelona.pdf

2. URBACT Capitalisation Report - More Jobs: Better Cities. A framework for city action on jobs - 2013 http://urbact.eu/sites/default/files/import/general_library/19765_Urbact_WS2_MORE_JOBS_low_FINAL_01.pdf

on jobs. Building on the analysis of several experiences of local governments involved in URBACT networks, in the aftermath of the global financial crisis, they convincingly argued that local governments can and shall act on three broad sets of issues: jobs, people, and connection mechanisms (see Figure 1).

- **Jobs:** it is the size and growth of the city's economy that primarily determines the number and increase of jobs available. From this perspective, local governments have several levers to deploy in a coordinated and integrated way. They include policies to increase local spending (supporting "buy local campaigns" as well as the creative use of public procurement) but also to support external demand (for example by investing in city marketing and positioning, or helping local businesses to access international markets) without underestimating actions to increase the competitiveness of the local economy (defining smart specialisation strategies, supporting product differentiation and cluster development. This makes it easier for employers to hire more people).
- **People:** the number of jobs created cannot be used as the only indicator of growth. Attention needs to be paid to their quality and sustainability. Here the room for cities to act is even wider. Local governments can play an active role in increasing the quality of existing jobs in terms of earning and working conditions, in facilitating labour mobility (across the city and between occupations and sectors) and, more importantly, in making sure that people have the right skills that local employers need. In this specific field local government can influence the labour market by increasing the quality of education and training provided locally and, more generally, they can generate a virtuous circle by forecasting and supporting the demand of new or upgraded skills and therefore reducing the mismatch between the supply of, and demand for, skills.
- **Connections:** the two previous sets of actions cannot be considered separately. They must be aligned so that they can work together and create an integrated system. To make this possible key stakeholders in cities (policy makers, practitioners, employers, education providers, etc.) need to be well informed and able to make good decisions about the local economy and jobs. This requires good economic and labour market intelligence on the changes, challenges and opportunities that are currently occurring (and are likely to continue doing so in future). Finally local governments need to recognise the limits of their competencies and resources while acknowledging the complexity of the landscape. This calls for the development of formal partnerships arrangements and the emergence of more informal networks of local stakeholders.

The cases analysed in the URBACT publication are only the tip of an iceberg comprising hundreds of local governments experimenting with new ways to fight against inequalities and socio-spatial polarisation while helping with the modernisation of their local economies.

The growing interest of local governments to act as frontrunners to influence the economic patterns of their territories and ultimately to foster a local inclusive growth is also witnessed by their increased activism in transnational initiatives for advocacy and exchange of good practice such as the URBACT programme. There are many other examples such as the OECD initiative Champions Mayors for Inclusive Growth³ and the Eurocities Social Affairs Forum⁴, to mention only a few.

A common conclusion of the empirical analysis, as well as of the different transnational discussions is that local government can only really make a difference and ignite a virtuous dynamic of local inclusive growth if they acquire and distribute the necessary financial resources and tools to act. These resources and tools are needed not only for the “hard” investments but also for the soft actions on new skills and competencies, to test small scale experiments of alternative welfare schemes, etc. This is where the European Union, with its policies and instruments, can make a decisive contribution.

Figure 1 - Inter-connectivity at the local level



Source: URBACT Programme

3. More info at: <http://www.oecd.org/inclusive-growth/champion-mayors/>.

4. More info at: <http://www.eurocities.eu/eurocities/forums/social-affairs&tpl=home>.

3. The EU investing in the potential for local governments to foster inclusive growth

The Europe 2020⁵ strategy is the EU's agenda for growth and jobs for the current decade. It emphasises smart, sustainable and inclusive growth as a way to overcome the structural weaknesses in Europe's economy, improve its competitiveness and productivity, and support a sustainable social market economy.

Unveiled in an extremely difficult period for Europe, the EU2020 recognises the complexity of the challenges faced and lays down the basis for interconnected solutions. It stresses, for instance, that better educational levels help employability and that progress in increasing the employment rate helps to reduce poverty. Similarly, it highlights how a greater capacity for research and development as well as innovation across all sectors of the economy, when combined with increased resource efficiency, can improve competitiveness and foster job creation. In the same perspective, it recognises that investing in cleaner, low carbon technologies can help the environment, contribute to fighting climate change and create new business and employment opportunities. It makes it definitively clear that investing in skills, fighting poverty and modernising labour markets, training and social protection systems are essential steps to building a cohesive society where no one is left behind.

It is structured around three main priorities (smart, sustainable and inclusive growth), the EU2020 strategy is anchored to five measurable targets⁶ and seven flagship initiatives (e.g. Innovation Union, Youth on the move, A digital agenda for EU, An Industrial policy for the globalisation era, An agenda for new skills and jobs, etc.). The delivery mechanisms of the EU2020 strategy reflect the complexity of the governance structures of the European Union. Each flagship initiative has a European and national level of intervention. The European institutions are committed to not only harmonising existing and new legislation in coherence with the specific targets, but also to channelling available financial resources towards the strategic objectives. In the meantime Member States are requested to adapt the targets to the national context while ensuring that national policies and resources contribute to the achievement of the vision.

5. EU2020 Strategy - <http://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%20%2007%20-%20Europe%202020%20-%20EN%20version.pdf>.

6. Increase of the overall EU employment rate, increase of the share of EU's GDP dedicated to R&D investments, achievement of the 20/20/20 climate/energy targets, reduction of the share of school leavers, reduction in the number of people at risk of poverty.

With a total budget of EUR 351.8 billion for the period 2014-2020 – almost a third of the total EU budget – the Cohesion Policy⁷ is the most effective policy and financial delivery mechanism providing the necessary investment framework and strategy to meet the agreed growth targets. The European Regional Development Fund (ERDF) and the European Social Fund (ESF) are the two main funds and provide national, regional and local authorities with the opportunity to invest locally in a wide range of priorities, all complementary and contributing to the achievement of the EU2020 strategy.

Cohesion Policy is delivered according to the subsidiarity principle. The Commission works with the Member States and the regions to define investment priorities and development needs. Programmes are managed and individual projects selected by Managing Authorities (mainly Regional authorities) in the Member States. This implies a territorial dimension which recognises that national and regional authorities have the most detailed knowledge and understanding of the specificities of each territory (in terms of challenges as well as assets) as well as the legal competencies to intervene. They are best placed to develop and experiment with concrete solutions for smart, inclusive and sustainable development.

Convinced of the importance of local governments in acting as frontrunners to experiment with new solutions, over the last 30 years⁸, the European Commission has helped further strengthen the territorial dimension of Cohesion Policy by supporting an explicit urban dimension and introducing tools for sustainable urban development.

Promoting an urban dimension within the Cohesion Policy means not only ensuring that urban authorities have direct access to Structural Funds, but also making sure that urban authorities will combine sources of financing linked to different thematic objectives. This will allow them to design and deliver integrated strategies and projects combining measures concerning physical urban renewal with those promoting education, economic development, social inclusion and environmental protection.

For the programming period 2014/2020, within the framework of Cohesion Policy, the EU institutions have designed a set of delivery mechanisms and tools providing financial resources directly to local governments. They allow for the design and implementation of integrated strategies for sustainable urban development. These are:

7. More info at: http://ec.europa.eu/regional_policy/en/policy/what/glossary/c/cohesion-policy.

8. The legal basis for Cohesion Policy was established in the Single European Act in 1986.

- **The provisions of the Art. 7 of the ERDF regulation**⁹. Member States are requested to allocate at least 5% of the national ERDF allocation to actions explicitly targeting urban authorities to support sustainable urban development. Recent reports show that €14.5 billion (7.8% of the total ERDF budget) are being invested by Managing Authorities to support urban integrated strategies whilst several new delivery mechanisms have been introduced to support their implementation (Integrated Territorial Investments, Community Led Local Development, etc.). An initial observation of the strategies being developed by local governments in this framework clearly shows the importance that they are giving to aspects such as supporting new and innovative economic sectors and activities while also investing in the human capital through training and education and more broadly in social inclusion;
- **URBACT**¹⁰. Building on the positive experiences of the previous programming period, the only urban European Territorial Cooperation Programme has been asked to continue working on the human capital behind the processes of urban planning and implementation. This will be achieved by facilitating the exchange of experiences and practices among urban stakeholders and also by strengthening the capacity building activities for the design of integrated urban strategies;
- **The Urban Innovative Actions Initiative (UIA)**¹¹. Conscious of the need for local governments to test new bold solutions to face increasingly complex challenges but also of the scarcity of the resources, especially for ideas with a higher level of risk, and of the relative rigidity of the Structural Funds, the EU decided to introduce a new tool for urban authorities. The UIA has the aim of identifying and supporting the most innovative urban projects by creating urban laboratories where local governments and a great variety of stakeholders can test the most promising solutions in a real urban environment. It does so by selecting projects through annual calls for proposals and financing each project with a maximum of €5 million. The UIA supports urban authorities not only financially but also by lowering the barriers for municipal-led innovation. An example of this is providing 50% of the financing in advance and facilitating the involvement of a diverse range of stakeholders. The UIA also aims to capture the

9. More info at : http://ec.europa.eu/regional_policy/en/policy/themes/urban-development/.

10. www.urbact.eu.

11. www.uia-initiative.eu.

knowledge generated by selected urban authorities during project implementation and share it with a wider audience of urban stakeholders and policy makers¹².

The three mechanisms above represent only a small part of the financial resources available for urban authorities in the current period. The ERDF and ESF globally support local development, and local governments can also secure financial support from other sectoral initiatives led by a different Directorates General of the European Commission. The three mechanisms above have the capacity to translate into concrete plans and projects.

4. Four UIA projects to test new solutions for urban inclusive growth

The UIA is the most recent and one of the most ambitious tools explicitly designed for local governments in the framework of the Cohesion Policy. It is thematically aligned with the topics identified in the framework of the Urban Agenda of the EU¹³. Municipalities can apply to test new solutions on a wide range of topics ranging from urban poverty and inclusion of refugees and migrants to the circular economy, adaptation to climate change, or urban mobility.

Looking at the broader perspective of inclusive growth and its complex interconnections with almost all aspects of our daily life, it can be seen that all UIA projects, no matter which topic they focus on, will help demonstrate that local governments can experiment with bold ideas which balance growth and economic innovation with inclusion and social innovation. And they can do so by changing the way they work with local stakeholders (co-responsibility with agencies, NGOs, private multinationals, social start-ups, etc.) and by focusing heavily on results and final impact, as explicitly requested by the UIA.

12. Each selected UIA project is supported and followed by an UIA Expert. Their role is to provide advice to the actors involved but, even more importantly, to capture the knowledge that projects will generate by implementing such bold and innovative ideas. The main output of their work is a Project's Journal published by the UIA expert every six months. More info at: <http://www.uia-initiative.eu/en/uia-knowledge-first-uia-expert-journals-published>.

13. More info at: http://ec.europa.eu/regional_policy/en/policy/themes/urban-development/agenda/.

Four projects selected in 2016, in the framework of the 1st UIA Call for Proposals, explicitly working on the topic “Jobs and skills in the local economy”, are considered below¹⁴.

- The **Bridge project, led by the city of Rotterdam (NL)**¹⁵. In 2017, in anticipation of the so-called Third Industrial Revolution, the Metropolitan Region Rotterdam - The Hague (MRDH) launched its Roadmap Next Economy (RNE). This bold strategy defines complementary transition paths focusing on new promising and sustainable economic sectors (green economy, circular economy, digital economy and smart manufacturing, the social economy with focus on health and food). Focusing on Rotterdam South, the city’s most deprived neighbourhood, the Bridge project is important in ensuring the inclusiveness and eventual success of the RNE strategy. The project aims at improving the life prospects of people living in the neighbourhood by helping them to make more informed career choices leading to sustainable jobs rather than towards sectors with limited job opportunities. In the meantime, the project aims to increase the capacity of firms and companies operating in innovative sectors to find the right skills and competencies needed to grow. To bridge the gap between demand and supply in the labour market, thus creating pathways from education to new promising economic sectors, the partners involved will start with an extensive information campaign for all a neighbourhood’s pupils, from nine years old onwards, about the new economic sectors and the types of jobs they can offer. The information and orientation efforts will be continuously updated and enriched thanks to skills and jobs foresight activities. The extensive orientation process will be strengthened by the project’s most innovative element: the Career Start Guarantees. Through this mechanism, employers in the sectors targeted by the orientation process will guarantee a starting position for young people in Rotterdam South who complete the relevant high level vocational training. This will create a win-win situation for employers (who help create a pipeline of skilled workers) and for students from deprived areas (who know they will start, on graduation, a career in a promising economic sector). To ensure

14. For this topic UIA received 124 proposals from almost all EU Member States (out of a total of 377 proposals for the call, which was open also for three other different topics). The four projects presented below were deemed as the most innovative proposals by the European Commission.

15. The first issue of the Project’s Journal, written by the UIA Expert Eddy Adams, can be found here: http://www.uia-initiative.eu/sites/default/files/2017-12/FINAL%20VERSION_Rotterdam_0.pdf.

the long-term sustainability of the process, Rotterdam is already exploring different scenarios in the field of social investment and finance and it is therefore paying great attention to the project's impact assessment. The landscape of the stakeholders involved reflects the complexity of the project. Young people, school and teachers, parents and employers all have an important role to play in the process while the municipality plays the key role of broker and facilitator in this complex ecosystem.

- The **AS-Fabrik project, led by the city of Bilbao (ES)**¹⁶. The progressive shift of the local manufacturing industries towards the Industry 4.0 (extensive use of AI, robotics, 3D printing, etc.) is an objective of the Basque Smart Specialisation strategy, but also a serious challenge for the city's KIBS sector (Knowledge Intense Business Services) that generates 16.5% of local GDP. For the KIBS sector to continue creating sustainable jobs and for the manufacturing sector to continue finding the necessary knowledge and expertise to innovate, a radical rethinking of academic and vocational training is inevitable. With AS-Fabrik, the municipality of Bilbao decided to anchor those efforts for new skills to a major physical re-development of a former industrial site. Within the framework of the Zaha Hadid's masterplan for the Zorratzaurre area, which envisages a major transformation of the former industrial site (a mixed programme of retail, housing, offices, production spaces and two industrial parks), a dilapidated building will be transformed into a hub for the development of industry 4.0. Co-designed and co-managed by a rich and diverse group of partners (including several industry consortia as well as research centres for advanced industrial production as well as local cooperatives known for their innovation capacities. Examples of these are Deusto University and the Mondragon Research centre), the new hub will be a training centre on all aspects related to Industry 4.0 technologies. It will also function as a space for experimentation and incubation of new industrial services that together will make a crucial contribution to local economic competitiveness.
- The **OpenAgri project, led by the city of Milan (IT)**¹⁷. Building on the political momentum generated by the Universal Expo held in Milan two years ago, and even more importantly on the Milan Urban Food Policy

16. The first issue of the Project's Journal, written by the UIA Expert Willem Van Winden, can be found here: http://www.uia-initiative.eu/sites/default/files/2017-12/FINAL%20VERSION_Bilbao.pdf.

17. The first issue of the Project's Journal, written by the UIA Expert Miguel Sousa, can be found here: http://www.uia-initiative.eu/sites/default/files/2017-12/FINAL%20VERSION_Milan.pdf.

Pact (launched by the mayor of Milan and signed by more than 100 all around the world), the municipality decided to explore the innovative potential of the agricultural sector not only in terms of healthier food and lifestyles, but also for the creation of sustainable jobs. The renovation of an abandoned farmstead, in the peri-urban area south of Milan, will create a living lab to foster innovation in the entrepreneurial, social, sustainable and technological dimensions of the agri-food sector. Strongly rooted in the open and social innovation philosophy, the project aims at incubating and accelerating social enterprises that will experiment with new models for agri-food production and distribution while prototyping and testing new technologies for agriculture and food production (for example, a new aquaponics installation will be tested). The project will also contribute to the overall redevelopment of the area by introducing a new function (and related uses) and by creating the key infrastructure for an innovative cluster. The rich and diverse partnerships, including not only world class local universities and research centres but also dynamic actors fostering social innovation locally, demonstrates the project's ambition to go beyond what has already been tested and to look for disruptive solutions of city's key sector.

- **The Mares project, led by the city of Madrid (ES)**¹⁸. Rethinking the local welfare policies while creating new economic opportunities and sustainable jobs is a key political priority for the municipality of Madrid in order to recover from the crisis and create the basis for a prosperous and inclusive future. Trying to unlock the potential of small-scale social economy initiatives, while contributing to the physical regeneration of abandoned buildings in deprived neighbourhoods, is the aim of Madrid in the framework of the UIA. By coupling five core thematic areas (energy, mobility, food, recycling, and care) with five of the city's most deprived neighbourhoods, the project intends to harness the collective intelligence existing in these territories and the willingness of NGOs, cooperatives and start-ups to experiment with new solutions for societal challenges. Starting from a complex and comprehensive mapping exercise of the competencies and skills existing in the different neighbourhoods (*laboratorios de competencias urbanas*), the municipality, with the strong support of a wide range of partners, will identify the most promising social and solidarity economy projects that will be incubated and accelerated in the five new hubs (one

18. The first issue of the Project's Journal, written by the UIA Expert Alessandro Coppola, can be found here: http://www.uia-initiative.eu/sites/default/files/2017-12/FINAL%20VERSION_Madrid.pdf.

per each thematic areas). The spaces will be co-designed with the individuals and groups that will use them and will become new drivers for cohesion and inclusion within the neighbourhoods. Great attention will be given to the business models and hence to the sustainability of the new social economy projects being nurtured (including a gradual but radical re-thinking of the municipal processes for procuring social services).

Selected in 2017, with a duration of three years, the projects are now half way through the implementation process. It is still too early to gauge tangible results. But from a first observation, and building on the UIA Experts' first journals, it is possible to highlight some initial commonalities and learning points.

First, the four municipalities are not reacting to major economic and technological transformations, but instead are **anticipating them**. Building on their detailed knowledge of the local assets and specificities, they have identified economic sectors (food, health, energy, mobility, advanced manufacturing) that are being completely revolutionised by new technological developments, which are promising in terms of growth (and hence in terms of jobs creation) and even more importantly, have a clear societal focus and impact. They do so by incubating and accelerating the most promising ideas and by making sure that those new companies and cooperatives will be successful in the long term as they can easily find, in the local labour market, the skills and competencies they need. To achieve this, the four projects are working on skills' forecasting while radically changing the concepts of training and vocational activities and investing public money in promising start ups and social enterprises. They do so by targeting the most deprived groups and in doing so make concrete the concept of inclusive growth.

The four municipalities are taking the initiative. The composition of their partnership for project delivery demonstrates that they recognise that they cannot do this alone. They need to bring on board local stakeholders from different fields and with different perspectives, but with the capacity to complement each other. The richness and diversity of partners involved is impressive. Partners as diverse as chambers of commerce, international think-tanks specialised in social impact, prestigious universities and small NGOs specialised in assisting particular target groups are all joining forces. This ensures a 360° perspective to the projects and increases the level of inclusiveness. Working with a similar range of local stakeholders is one of the most innovative aspects of the projects as it also implies a radical change in the way the municipality works with its partners. By sharing the responsibility of the implementation phase, and even more importantly, by co-designing the project with ideas and inputs from partners, municipalities are shifting from a traditional approach of "main service provider" to one of "ecosys-

tem manager”. This requires new ways of ensuring coordination and project management as well as new forms of leadership able to equip their civil servants with new skills and capabilities. One of the challenges of the four projects will be ensuring a higher level of involvement from the different levels of governments (ministries as well as regional authorities) as they have the key competencies (for defining educational curricula or for ensuring coherence with a wider strategy for economic specialisation for instance) and the financial resources to ensure the upscaling of the solutions and hence their long-term sustainability.

The third commonality of interest is the “area-based” approach, with the explicit attempt by the four municipalities to anchor the projects to a specific area or neighbourhood. For Bilbao, Madrid and Milan this implies renovating brownfield sites or abandoned buildings in peripheral areas, whereas for Rotterdam it means focusing on an entire, and mostly deprived, neighbourhood. By doing so the four municipalities are pursuing different but complementary objectives. On one hand, by giving new life to abandoned buildings they are introducing new economic and social functions to the neighbourhood while equipping the local communities with new facilities. The aim is to increase the internal cohesion of the neighbourhoods by offering new opportunities to meet and gather while also increasing the overall attractiveness of the area, generating a positive trickle-down effect on the area’s aggregated value. On the other hand, the projects’ focus on deprived areas is reinforced by a strong focus on the people living there. They are considered as the primary beneficiaries of the new economic opportunities being tested in the new facilities, and are the ones that the projects shall not leave behind. From this perspective, the specificities of the area are not only physically shaping the renovation of buildings but are also influencing the degree of diversification and adaptation of the “soft” measures (training, coaching, access to finance, etc.) aimed at ensuring the active inclusion of local inhabitants.

Last but not least, the four projects show how municipalities can be at the forefront of testing new ways to monitor and evaluate the results being achieved. What the four municipalities are experimenting on is a radical shift from the traditional ex-post evaluation of public policies. With the strong involvement of the scientific partners (universities, research centres, think-tanks), they are designing new monitoring and evaluation mechanisms that are particularly innovative for at least two reasons. First because they are developing systems that will allow ongoing monitoring and evaluation of various indicators, with the systems aiming at creating a virtuous learning loop, ensuring a continuous assessment and the capacity to adjust plans and actions almost in real time. Secondly because they are increasingly focusing the evaluation mechanisms on the qualitative as-

assessment of the results achieved. The focus is not only on the number of jobs created but on their quality and sustainability; not only on the number of start-ups incubated but also to what extent the new solutions prototyped contribute to increased quality of life for inhabitants. From this perspective, the points of view and the perceptions of the target groups and final beneficiaries become more and more important while disciplines such as ethnography and anthropology and methodologies such as Theory of Change and Randomised Control Trials are best suited to the evaluation and monitoring activities.

5. Conclusions

The European integration is a unique process and the multi-level governance framework that it has generated is one of its most distinctive aspects. The European Union's capacity to perform its role and achieve ambitious strategic objectives depends not only on its institutional organisation but, above all, on the degree of involvement of different tiers of government and non-institutional stakeholders.

The mechanisms of multilevel governance within the EU are far from being perfect and stabilised. Conflicts and tensions among different tiers of government are still common across Europe. The responsibilities and competencies of the different actors are being continuously modified and shaped. In this dynamic scenario, municipalities and city councils have gained more importance, legitimacy and room for manoeuvre over the last 60 years.

This evolution reflects the growing recognition that local governments are the best placed among institutional actors to find innovative answers to the challenges posed by the increasingly polarised and unequal communities and territories. Facing socio-spatial polarisation while maximising the local assets and making sure that no one is left behind, require adaptation and diversification of public policies. Due to their proximity and relative agility, local governments, can prototype and experiment to find bold solutions, adapting them to the specificities of territories and target groups.

From this perspective, all the efforts made by European institutions to legitimise and empower local governments to take the lead when solving challenges, traditionally under the responsibilities of regional and national governments, should be fully and positively acknowledged. Experiences such as those supported by UIA clearly point in this direction. The European Union must continue to invest in urban areas, and recognise the key role that local governments can play. In doing so, it should take into consideration two important aspects. First, local governments will need to be actively and systematically supported in

their radical shift from “main service providers” to “ecosystem managers”. Tapping into the collective intelligence of territories, co-designing solutions with local stakeholders, and using virtuous public spending to foster local innovation, prototyping and testing new financial mechanisms, represents a revolution concerning the roles of local civil servants. This revolution requires new skills, attitudes and competencies within local governments, especially in countries where the turnover of civil servants has been blocked for decades due to budgetary constraints. Empowering local governments to find concrete solutions to societal challenges does not only mean providing financial resources for investments but also investing in the human capital behind each policy and project. Second, and of equal importance, asking municipalities and metropolitan authorities to take the lead in testing new and bold solutions does not necessarily imply a smaller role for regional and national authorities. On the contrary, the increased proactivity of urban areas and municipalities, calls for a higher level of coordination and cooperation among the different tiers of government. Only by better coordinating efforts and resources will it be possible to scale-up and mainstream the successful local experiences, eventually generating positive systemic changes.

Involuntary Non-standard Employment: Evidence from Italian Regions

Ilias Livanos, Simone Salotti and Glauco de Vita

1. Introduction

Attention on labour market trends has traditionally focused on the unemployment rate as the yardstick of reference. Yet it is increasingly recognised that such an indicator provides only a partial understanding of socio-economic labour market developments, especially following economic crises (Basso et al., 2011). For example, individuals losing their job may exit the labour force and become 'hidden unemployed' (Agbola, 2005).

The focus of this paper is on an altogether different construct that deals with individuals accepting, involuntarily, part-time and/or temporary non-standard jobs due to the lack of alternatives. Involuntary non-standard employment (henceforth, INE) has only recently become the focus of policy (CEDEFOP, 2012) and public debates (for Italy, see *Il Sole 24Ore*, 2013). A key feature of this labour market indicator is the involuntary nature of this type of employment, with those employed in such jobs explicitly declaring that they accepted them only because they could not find a full-time and/or permanent position (De Jong et al., 2007).

There is no universally accepted definition of *non-standard* employment and its boundaries are still the subject of debate. However, since the work by Kalleberg et al. (1997) much of the literature refers to it as employment relationships that differ from what has been traditionally practiced as the 'standard' (employer-employee) work arrangement, namely, full-time work, based on a contract of open-ended duration. Thus, as understood for the purposes of the present study, the term 'non-standard' is used to refer to employment arrangements such as part-time and/or temporary contracts, performed under an employer's administrative control (this rules out self-employment), which – albeit relatively common – are by this definition 'non-standard' (for an analogous definition, see Pintaldi, 2008; Tealdi, 2011; Green and Livanos, 2015).

It could be argued that non-standard forms of employment such as part-time and temporary work may simply result from labour market negotiations, with contract duration and working hours seen as mere attributes of labour contracts that are directly subject to the interplay of demand and supply forces in the labour market. They are thus determined as a natural equilibrium outcome (Eutwals and Hogerbrugge, 2006). However, the Italian figures on INE that are inevitably also the result of labour market policies and are precisely meant to regulate the balance of forces between the social parties, are far from what could be regarded as a 'natural' - let alone socially just - institutional labour market 'equilibrium position'. This appears to be particularly so when regional patterns are taken into account.

Given the above, the INE labour market indicator should be regarded as important, especially given the current economic climate. Increasing levels of INE may, rather than signal the future pool of those to be employed full-time and permanently, simply reflect increasing levels of precariousness which is, by definition, an insecure, lower-paid and unprotected form of employment vis-à-vis standard work arrangements (Standing, 2011).

Despite its importance, academic research on INE is still relatively scant. Cam (2012) investigates the relationship between involuntary part-time work, demographic and working circumstances, finding a positive correlation of the former with low educational and occupational levels in the UK. Kauhanen (2008) examines the determinants of both part-time work and involuntary part-time work in the private service sector in Finland, finding that females, middle-aged, and low-educated people are more likely to be involuntary part-timers. Kauhanen and Natti (2011) report negative consequences of involuntary part-time employment on job quality indicators such as training and career prospects. Few studies on temporary employment have focused on the differences between workers accepting temporary contracts willingly, and those doing so involuntarily. Amuedo-Dorantes (2000) finds that temporary employment in Spain is primarily involuntary, while Nunez and Livanos (2011) investigate the causes of different types of temporary employment in Europe and find that females, younger people, singles and non-national workers are more likely to be in temporary employment involuntarily.

As can be gauged from this brief review, the limited work has focused more on involuntary part-time employment than on involuntary temporary employment, and rarely have the two been investigated within the same framework. Nevertheless, even though the two forms of employment are distinctively different, the "lack of choice" element enables them to be considered jointly within a single framework, as done by Green and Livanos (2015) on the determinants of INE

in the UK. Their findings suggest that young people, individuals from non-white ethnic groups, and those in economically weak regions are at particular risk of INE.

The present study contributes to this debate by investigating the determinants of INE in Italian regions from 1999 to 2014. The existing literature is added to in multiple ways. First, the analysis takes into account involuntary part-time and involuntary temporary employment both separately and concomitantly, the latter by making use of a unique cross-tabulated INE index constructed from EU Labour Force Survey (EU-LFS) data on over 4.8 million workers in Italy. High quality data on INE are notoriously difficult to come by, but an additional advantage of this dataset is that the up-to-date sample period also allows us to investigate the effect of the most recent economic crisis on INE.

Secondly, with very few exceptions, the limited research on INE has mainly focused on demographic (gender and age group) characteristics thus overlooking the spatial dimension particularly with respect to intra-national, regional disparities (especially in countries like Italy, where they are particularly marked). The INE is investigated not only by accounting for specific socio-demographic characteristics and economic conditions but also by considering the regional context in which such employment occurs. Although Green and Livanos (2015) account for regional differences within the UK, it should be made clear from the outset that this is not a mere replication study, and that the study has the ability to advance knowledge of INE. The Italian setting provides a novel and particularly informative case where two additional dimensions connected to the INE phenomenon can be analysed.

The first pertains to the impact of labour market reforms. At the end of the 1990s a wave of reforms started changing the institutional set-up of the Italian labour market with the declared aim of increasing flexibility. By (de)regulating many forms of non-standard employment these reforms reduced the strength of employment protections thus favouring the spreading of temporary and part-time contracts (Nannicini, 2004a). In 1997, Law 196, known as '*Legge Treu*' (Tiziano Treu was Minister of State for Employment at the time) began this liberalisation process by concentrating on temporary employment. In 2001, Law 368 effectively freed the widespread usage of fixed term contracts. As noted by Garibaldi and Taddei (2013), the reform – based on an EU directive – lifted all restraints on temporary contracts as long as the motivation for their use was given in writing. Two years later Law 30/2003, known as '*Legge Biagi*' (Marco Biagi, a labour law government consultant, was murdered by terrorists in 2002 for his work on that reform), updated Law 196 and introduced further measures around the controversial issue of part-time employment (alongside 'project

work'). Several additional legislative decrees and laws subsequently updated '*Legge Biagi*' (including decree D. Lgs. 251/2004, and laws 80/2005 and 133/2008). Because of the sample period, the choice of Italy permits the investigation of the impact of such institutional factors.

The second dimension that makes the Italian landscape interesting relates to the large economic disparities between Northern and Southern regions (see Terrasi, 1999). Of course, the Italian regional divide has also been studied in relation to the labour market (see among others DeStefanis and Fonseca 2007; Ichino et al., 2008; Bruno et al., 2012). Some of this literature also investigated the so-called 'stepping stone' effect of temporary employment (toward standard employment; see also Barbieri and Sestito, 2008). Yet none of the work conducted thus far has specifically examined Italian regional labour market disparities with a focus on the involuntary nature of part-time and temporary employment, thus leaving a glaring gap to be filled by this study.

2. The Italian Context and Some Stylised Facts

Since the early 1990s, most European countries embarked on a process of labour market reforms aimed at increasing flexibility and security, now commonly referred to as 'flexicurity' (Heyes, 2011). Notwithstanding the inevitable cross-national differences in the strength of employment protections, Heyes (2011) unveils convergence by EU member states in labour market policies over the past two decades, a convergence marked by an 'emulation' pattern reflecting the less generous traditions and a dominant trend actually characterised by less security. Heyes (2013) also observes that in several EU countries the implementation of austerity measures following the crisis undermined further use of the social protection components of flexicurity. This process appears to have led to an increase in non-standard contracts at the expense of full-time and permanent ones (Barbieri, 2009; European Commission, 2009).

Italy, in this respect, was no exception (Tealdi, 2011). In particular, '*Legge Treu*' legalised 'temporary work agencies' (forbidden under the previous 1960 Law 1369), without imposing any limits on the cumulated duration of fixed term contracts or legal reasons for using temporary labour. Moreover, '*Legge Biagi*' legalised 'project contracts' while abolishing any form of labour rights for employees on such contracts including holidays, sick leave and maternity leave.

Whilst some commentators might argue that 'precariousness' is just a job feature that could be used to describe all jobs, it is precisely legislation of this kind that - in our view - draws a clear demarcation between standard and non-standard work contracts. This gives strong explanatory power to the dichotomy of vol-

untary-involuntary employment, particularly when analysed in relation to the effects of this legislation on both part-time and temporary forms of non-standard employment (for an insightful re-examination of the theoretical and conceptual frameworks that scholars bring to bear on precarious employment, see also Val-las and Prener, 2012).

Although flexibility is generally perceived by many European policy makers to be a positive feature of labour markets (European Union, 2010), part-time and temporary employment is often associated with negative working conditions, such as fewer opportunities for training and career progression, lower salaries, and limited access to supplementary benefits and social protection (Eurofound, 2007; McGovern et al., 2004).

Non-standard employment assumes particularly negative connotations when it occurs involuntarily, that is, as a result of labour markets being unable to provide the right matching between employers and employees, forcing the latter to accept non-standard contracts due to the lack of better alternatives. Factors advanced to account for involuntary employment include the inadequate distribution of skills, informational problems and geographical rigidities (Pissarides, 2000). These frictions are more likely to happen in a fast-changing environment leading firms to manage their human resources more flexibly (Kalleberg, 2000).

Arguably the Italian labour market qualifies as a fast-changing environment, at least in so far as the incessant legislative interventions over the past twenty years are concerned. Most Italian firms have been increasingly reluctant to offer full-time and/or permanent jobs (Nannicini, 2004b). The diffusion of flexible contracts, temporary and part-time, has mainly affected the younger generations and women, thus reinforcing labour market segmentation while accentuating social inequalities (Barbieri and Scherer, 2009; Barbieri, 2011). Flexibility has been perceived as a labour market feature favouring endless precariousness, thus increasing social conflict (Lodovici and Semenza, 2008).

Possibly owing to the low levels of household debt, the economic consequences of the financial crisis started being felt in Italy only from 2008/09. However, unlike other European countries such as Ireland and Spain that were booming before the crisis, Italy had been experiencing sluggish growth for almost two decades. Another difference between the Italian economy and most of the other European countries lies in the large public debt, which in Italy was already above 100% of GDP in 2007, leaving an already unstable government with little room for manoeuvre.

An analysis of Italian data cannot disregard the impressive regional differences in terms of income, development, and social factors (González, 2011). The country suffers from a well-known North-South divide making it imperative to

consider the regional dimension in our analysis. In order to do so, it seems opportune to present some stylised facts on the dynamics of the shares of part-time employment and involuntary part-time employment in Italian regions over the sample period 1999-2014. Table 1 shows the shares of part-time employment and involuntary part-time employment in Italian regions shortly after the first labour market reform (in 1999), after the second major labour reform (in 2004), immediately after the recent economic crisis (2010), and at the end of the sample period in 2014).

Table 1 - Part-time and involuntary part-time employment (percentages)

Regions	Part-time/ Total employment				Involuntary part-time /part-time employment			
	1999	2004	2010	2014	1999	2004	2010	2014
Piemonte	7.4	10.4	14.4	17.3	36.5	31.0	46.8	60.6
V. d'Aosta	8.8	11.3	13.5	17.0	33.3	17.6	30.8	52.1
Liguria	9.0	14.4	18.6	20.1	33.8	33.3	46.7	62.5
Lombardia	8.5	12.2	16.1	18.3	24.2	21.5	37.3	55.9
Trentino	13.0	17.1	21.3	23.9	8.4	7.4	17.6	24.7
Alto Adige	8.5	16.9	18.6	22.1	9.8	13.1	28.8	38.6
Veneto	8.5	13.2	15.9	18.2	21.0	15.5	34.0	50.4
Friuli	11.2	14.3	16.9	19.1	25.3	18.4	37.0	46.6
E. Romagna	8.2	12.7	14.5	17.8	27.4	18.0	36.6	55.3
Toscana	9.8	14.6	16.5	17.9	34.1	28.6	43.5	64.0
Umbria	6.9	14.0	17.5	19.3	34.8	28.2	48.7	66.5
Marche	8.3	13.6	14.3	18.7	31.4	25.5	41.8	58.7
Lazio	6.7	14.7	16.0	20.0	51.5	46.2	56.0	72.6
Abruzzo	5.6	11.4	12.8	16.4	50.5	36.0	50.4	72.8
Molise	6.9	9.9	12.0	17.2	55.0	49.4	60.2	76.5
Campania	5.7	11.0	10.6	15.5	57.9	64.2	68.5	80.8
Puglia	5.8	8.7	12.9	15.8	59.2	57.2	68.8	79.4
Basilicata	5.5	9.8	11.1	14.9	46.2	50.9	66.6	80.2
Calabria	8.8	10.7	12.9	18.2	77.0	63.1	74.5	84.1
Sicilia	8.3	11.6	14.0	19.1	65.4	66.1	74.0	86.0
Sardegna	9.5	12.7	16.7	20.7	52.8	49.8	66.7	78.1
Italy	8.1	12.5	15.2	18.4	37.5	33.3	47.0	62.3

Note. Authors' elaborations based on Italian LFS data.

A number of interesting features arise from Table 1. First, the share of part-time employment over total employment increased significantly after the 2003 ‘*Legge Biagi*’. The share of this type of non-standard employment remained consistently lower in the Southern and insular regions, with the exception of Sardegna, where the incidence was comparable to that in Central regions. The share of involuntary part-time employment over part-time employment displays even more diverging regional patterns. In 1999 less than one part-time worker out of three was unwillingly in that position in the Northern regions and in the Centre (with the exception of Lazio). However, this changed to more than one out of two in the rest of Italy, while for Calabria, three workers out of four were involuntarily employed part-time. In 2004 the regional divide was still evident. In 2010 and 2014 the data pertaining to almost all Southern and insular regions are particularly pronounced.

In all cases the shares of involuntary part-time workers are considerably higher than those reported for other countries. For example, in the UK, in 2010 only 12.2% of part-time workers could be classified as involuntary part-timers (Green and Livanos, 2015), versus 47% in Italy in the same year. Abstracting from obvious differences in labour market characteristics and cultural attitudes, this may also reflect the different economic environment of the two countries, with Italy being characterised by low, if not negative, growth rates over the last two decades.

Table 2 - Temporary and involuntary temporary employment (percentages)

Regions	Temporary/ Total employment				Involuntary temporary/ temporary employment			
	1999	2004	2010	2014	1999	2004	2010	2014
Piemonte	7.2	8.7	11.2	11.7	33.9	43.5	59.7	63.1
V. d'Aosta	10.2	13.0	11.7	13.1	53.0	57.4	74.9	80.3
Liguria	6.7	11.8	11.0	11.5	46.5	51.2	60.6	69.3
Lombardia	6.2	8.5	9.2	10.2	32.4	48.2	62.8	64.8
Trentino	9.7	13.2	15.1	14.4	41.2	43.4	58.1	70.0
Alto Adige	7.5	12.4	14.0	16.8	39.3	48.2	65.1	73.5
Veneto	8.1	9.7	10.2	12.4	34.2	50.0	56.9	60.6
Friuli	8.3	8.6	11.8	11.3	32.2	44.8	64.0	72.4
E. Romagna	7.9	11.0	12.0	13.8	37.3	46.6	62.4	69.8
Toscana	8.3	12.5	14.0	14.4	35.3	51.1	63.4	69.1
Umbria	8.9	12.5	14.4	14.1	52.9	48.1	54.2	68.1

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Table 2 >>>

Regions	Temporary/ Total employment				Involuntary temporary/ temporary employment			
	1999	2004	2010	2014	1999	2004	2010	2014
Marche	6.8	12.7	12.9	14.1	31.1	43.3	50.6	67.3
Lazio	8.6	12.6	10.9	11.5	46.4	65.2	69.7	73.7
Abruzzo	7.3	13.6	12.9	15.7	35.3	64.0	72.9	82.5
Molise	11.9	13.1	11.4	12.4	72.7	66.4	79.9	80.3
Campania	12.5	12.4	12.3	14.7	64.2	79.2	81.6	84.8
Puglia	13.5	16.7	18.3	18.2	66.0	74.7	81.9	87.3
Basilicata	11.8	13.9	14.7	14.0	58.9	75.0	78.1	81.7
Calabria	18.5	19.5	21.3	21.8	80.4	76.1	86.8	90.8
Sicilia	16.3	18.2	17.8	18.9	74.8	77.2	87.6	89.0
Sardegna	17.2	16.8	17.7	16.6	66.1	69.1	79.1	88.3
Italy	10.2	12.3	13.0	13.7	51.3	60.2	70.0	74.5

Note. Authors' elaborations based on Italian LFS data.

Table 2 shows that the share of temporary employment over total employment is higher in Southern and insular regions than in the rest of the country, consistently throughout the sample period. As for the proportion of involuntary temporary workers, once again the numbers are smaller in the North and Central regions. However in this case even in the latter regions the proportion of involuntary workers is extremely high, especially after the 2003 '*Legge Biagi*'. By 2014, 74.5% of the temporary workers in Italy were involuntarily, with shares as high as 90.8% and 89.0% in Calabria and Sicilia, respectively. The magnitude of these figures and their revealing spatial patterns suggest a potential failure of institutional factors (reforms) to counter the evident distortions of any adjustments to or from any 'natural' labour market equilibrium, even when contextualised within the deteriorating situation of the Italian economy over the sample period.

Table 3 shows that the share of INE over total employment is unevenly distributed across Italian regions, with a larger proportion in Southern and insular regions. An upward trend is also evident, as the INE share increased in every region since 1999. The country average went up from about 7% in 1999, at the beginning of the process of labour market reforms, to almost 20% in 2014.

Finally, Table 4 presents descriptive statistics of the data used in the econometric analysis broken down by the full and INE samples of employees, according

Table 3 - INE share of total employment (percentages)

Region	INE/Total employment			
	1999	2004	2010	2014
Piemonte	4.3	6.7	13.0	17.0
V. d'Aosta	6.1	8.6	12.4	17.5
Liguria	5.1	9.6	14.7	19.3
Lombardia	3.3	6.2	11.4	15.6
Trentino	2.5	6.1	12.1	14.8
Alto Adige	3.0	7.4	13.0	19.1
Veneto	3.7	6.2	10.3	15.5
Friuli	4.3	5.7	12.5	15.3
E. Romagna	4.6	6.7	12.1	17.7
Toscana	5.4	9.6	15.6	20.2
Umbria	5.4	8.9	16.1	20.8
Marche	4.1	7.7	11.8	18.3
Lazio	5.8	12.8	15.3	21.3
Abruzzo	4.3	12.0	14.8	22.5
Molise	10.2	13.0	15.0	23.2
Campania	8.0	14.1	15.7	22.7
Puglia	9.2	15.7	22.6	27.0
Basilicata	8.3	13.5	17.4	21.1
Calabria	15.3	18.7	26.0	31.2
Sicilia	12.6	18.2	23.0	30.0
Sardegna	12.3	16.4	22.8	27.7
Italy	6.6	12.0	15.2	19.9

Note. Authors' elaborations based on Italian LFS data.

to various characteristics. The most vulnerable groups of workers who have a higher share in INE than in total employment are females (62.4% in INE while just 41.0% in total employment), younger workers, and workers in elementary occupations. Albeit a small group in comparison to others, it is worth noting that 1.6% of the individuals of the sample are 'moonlighters', meaning that they hold multiple jobs. This can be an important factor when focusing on part-time workers, and indeed the number rises to 3.9% among involuntary part-time workers. As for notable regional differences, 'Sicilia' stands out, with a share of 11.3% for INE compared to 6.9% for total employment.

Table 4 - Sample characteristics

	Full sample (%)	INE (%) (%)	Involuntary temporary	Involuntary part-time
<i>Gender</i>				
Male	59.0	37.6	46.6	27.7
Female	41.0	62.4	53.4	72.3
<i>Age band</i>				
16-25	6.1	11.6	12.3	10.7
26-35	20.6	27.8	29.5	26.0
36-45	31.0	30.4	30.4	30.4
46-55	28.9	22.2	20.5	23.8
56-65	13.2	7.0	7.1	9.0
<i>Education level</i>				
Low	38.6	43.3	42.2	42.3
Medium	45.6	42.4	39.9	44.2
High	15.8	14.3	17.9	13.5
<i>Marital status</i>				
Married	62.5	50.5	51.0	49.2
Single	30.3	40.6	42.5	39.7
Other	7.2	8.9	6.5	11.1
<i>Occupation</i>				
Moonlighter	1.6	2.6	2.0	3.9
One year ago employed	92.2	75.6	71.1	75.8
One year ago unemployed	4.7	17.5	21.1	16.8
Legislators	6.3	0.4	0.5	0.1
Professionals	12.5	9.1	12.5	18.6
Associate professionals	18.7	11.1	12.6	11.0
Clerks	11.9	11.9	10.4	13.3
Service workers	13.6	21.6	17.0	26.2
Skilled agricultural	2.7	1.9	2.7	1.3
Craft	16.1	9.4	10.2	8.1
Plant and machine operators	8.3	5.6	7.3	2.7
Elementary occupations	9.9	29.0	26.8	18.7
<i>Region</i>				
Piemonte	8.8	7.0	5.8	8.0
Valle d'Aosta	2.1	1.7	1.9	1.5
Liguria	2.7	2.4	1.9	1.5
Lombardia	14.1	10.6	8.9	11.8

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Table 4>>>

	Full sample (%)	INE (%)	Involuntary temporary	Involuntary part-time
Trentino	1.8	1.1	1.4	0.6
Alto Adige	2.7	2.2	2.7	1.5
Veneto	4.3	2.4	2.5	2.2
Friuli Venezia Giulia	1.8	1.1	1.2	1.0
Emilia Romagna	4.9	3.1	3.3	2.6
Toscana	4.3	3.2	3.3	3.2
Umbria	1.4	1.1	1.1	1.2
Marche	1.8	1.2	1.2	1.2
Lazio	4.1	3.7	3.5	4.2
Abruzzo	2.1	2.0	2.1	2.1
Molise	2.0	1.9	1.9	2.1
Campania	5.7	6.3	6.6	6.6
Puglia	4.8	6.8	7.7	5.6
Basilicata	2.6	3.0	3.2	2.9
Calabria	4.0	6.7	8.2	5.4
Sicilia	6.9	11.3	12.4	11.0
Sardegna	2.9	4.1	4.2	4.4
<i>Sector of economic activity</i>				
Agriculture	4.7	9.7	15.1	3.2
Manufacturing	29.0	15.5	19.0	10.0
Services	66.3	74.8	65.9	86.8

Note. Authors' elaborations based on Italian LFS data.

3. Data and methodology

The econometric analysis is based on the EU-LFS, a household-level survey designed to gather information on the labour conditions of EU residents. The survey contains data on demographic characteristics, education, labour market status, first job and flexible working patterns, second job, previous employment, and job-seeking methods. The EU-LFS, conducted by the national statistical agency of each member state under the guidance of EUROSTAT, is widely considered to provide reliable information due to its large sample size and the sampling methods adopted (for a full description see European Commission, 2012). The Italian LFS started as a quarterly survey in 1959, with additional yearly data (annual averages) being released each year. Annual data is employed.

Given the focus on INE, our attention centres on individuals that the LFS classifies as being employed under an employer's administrative control, i.e. individuals who: 'during the reference week performed work, even for just one hour a week, for pay, profit or family gain or were not at work but had a job or business from which they were temporarily absent because of, e.g. illness, holidays, industrial dispute and education and training'. There is no specific question on being in INE in the LFS. There is therefore, a need to combine information from a number of questions to create a variable indicating INE status. The full-time/part-time distinction refers to the main job and is based on a spontaneous response by participants (not provided by the self-employed, who are not featured in this analysis). The type of contract, temporary or permanent, is also self-assessed. According to the EUROSTAT definition, employees with a limited duration contract are those whose main job will terminate either after a predetermined fixed period or a period not known in advance, but nevertheless defined by objective criteria such as the completion of an assignment. Those questions do not carry any information on the *involuntary* status though. However, LFS respondents are required to declare whether they work part-time as a result of being unable to find full-time work, and whether they work under limited duration contracts due to the inability to find a permanent job. In particular, follow-up questions ask both part-time and temporary workers about their reason for not being in either full-time or permanent contracts. Those answering 'Person could not find a full-time job' and/or 'Person could not find a permanent job' are classified as being involuntary part-time and involuntary temporary workers, respectively. We use this information in order to construct two separate binary variables, taking value 1 if someone is in involuntary part-time (temporary) and 0 if otherwise (when in any other form of "voluntary" employment, whether standard or not¹). The two measures are also combined to create a unique INE binary variable taking value 1 if in INE and 0 if otherwise. It should be noted, however, that even though temporary and part-time employment may differ substantially regarding the type of workforce they attract, our interest centres on the involuntary nature of such non-standard contracts. Accordingly, we focus on the difficulty of the individuals in finding jobs according to their preferences. This rationalises the choice of grouping the two phenomena together in ad-

1. Regarding involuntary part-time, we have excluded from those counted as 0 the individuals that are in full-time employment but involuntary temporary. In a similar manner, regarding the involuntary temporary, we have excluded from those counted as 0 the individuals that are permanent but involuntary part-time. This has been done so as clear the reference category from any involuntary element.

dition to considering them separately. For the econometric analysis Italian LFS data from 1999 to 2014 are used, capturing various different periods of the economic cycle as well as various institutional changes, such as a number of recent labour market reforms. The regional dimension of the data is exploited at the level of the 21 NUTS2 regions of Italy.

The estimation of the socio-economic and regional factors explaining the incidence of INE are complicated by the need to use selection models, being the dependent variable only observed for a selected sample (labour market participants). Typically, this complication occurs with the sample of females, while the sample of males is not considered to suffer from self-selection problems. Nevertheless, the use of INE as a dependent variable for the full sample of both males and females leads to a sample selection problem, as factors related to the outcome variable may intervene in the selection of the sample. In particular, sample selection occurs when the outcome variable ($y_2 = 1$, being in INE) is observed only for certain values of a selection variable y_1 ($y_1 = 1$, participation into the labour market). There are two possible scenarios arising from this. The first occurs when the outcome variable y_2 is independent of the selection variable y_1 . In this case a two-step econometric model can be adopted to ensure both flexibility and computational tractability. However, when the outcome variable y_2 is not randomly selected from the population, as is the case in the present analysis, selection models are more adequate as they control for dependency in the two-step model (Heckman, 1979). In particular, the two-step Heckman procedure allows for the sequential modelling of the selection equation and the INE equation. The first step consists of a Probit regression with y_1 as the dependent variable, to estimate the likelihood of labour market participation (this makes this model a Heckman-Probit model). Then, the coefficients of this first-step regression are used to estimate the conditional probability of being in INE (y_2).

A number of socio-economic and regional variables are used in the model, and in order to avoid identification problems, additional explanatory variables are used in the first-step regression. Labour market participation is controlled for especially by using a number of variables that are typically encountered in the literature, including marital status, number of young children in the household, highest educational attainment, and the level of regional unemployment. Data availability prevents us from using a longer list of variables that may potentially influence labour market participation. For example, recent studies note that female participation can be influenced by the legal framework around divorces (Bargain et al., 2010) and by housing prices (Johnson, 2014). Nevertheless, our choice of variables covers most of those discussed in the literature (Humphries and Sarasua, 2012). It is worth emphasising that the estimation of this first-stage selection equation is merely instrumental to removing the selection bias

from the second-step regression, which is our object of interest², rather than modelling female labour market participation per se. Given that for females the choice to enter the labour market is typically influenced by a number of factors as discussed above, separate regressions are run for males and females as well as for the total sample. A Heckman probit is adopted for the full and the female sample. Since the sample of males is free from issues of sample selection, a simpler probit model is used instead. This procedure results in a total of nine models being estimated: three (males, females, and both genders) for each type of INE (i.e. involuntary part-time, involuntary temporary, and the combined INE measure).

The second-step equation includes individual-level socio-demographic and work-related variables, and NUTS2 region-specific variables. The socio-demographic variables are the following: 1) gender (a dummy taking value 1 for females, with males as the reference category); 2) nationality (a dummy taking the value 1 for nationals); 3) age (four dummies taking value 1 when the individual is in one of the age groups 16-25, 36-45, 46-55, and 56-65 since in Italy the retirement age is from 66 onwards, with 26-35 being the reference group); 4) marital status (two dummies taking the value 1 for 'singles' and for 'other' -widowed or divorced-, with being 'married' as the reference category); 5) education level: 'low' (pre-primary, primary, and lower secondary education), 'medium' (upper secondary and post-secondary education such as vocational diplomas), and 'high' (first and second stage of tertiary education and above), with 'medium' used as the reference level; 6) second job holding (the *moonlighter* dummy taking value 1 if the individual holds more than one job); 7) labour market status a year before the survey (two dummies for employed and unemployed status, with inactive being the reference category); 8) occupation (dummies indicating the type of job: legislators, professionals, clerks, service workers, skilled agricultural, craftsmen, plant/machine operators, elementary jobs; with associate professionals as the reference category); 9) economic sector (two dummies for agriculture and manufacturing, with services being the reference category). Regional dummies are also included in the results - one for each of the 21 NUTS2 regions with Lombardia (the biggest and richest region of the country) as the reference one, with standard errors clustered by region. Finally, three variables accounting for the two major labour market reforms of 2001 and 2004 (the first assumes the value one from 2001 to 2003, the second from 2004 to 2008) and for the recent crisis (assuming the value one from 2009 onwards) are also included in the model.

2. In order to ensure consistent estimates, the two equations are estimated jointly using the command 'heckprob' in STATA.

4. Analysis and results

This section reports the results arising from estimation of the various model specifications used to uncover the factors affecting the likelihood of being in INE in Italy over 1999-2014. As it is fairly standard in reporting probits and Heckman's estimations, marginal effects are reported rather than the estimated coefficients, so that the numbers in the tables can be interpreted as *ceteris paribus* marginal (not average) effects on the probability of being in INE.

Table 5 - INE determinants in Italy, 1999-2014

Variables	Full sample	Males only	Females only
Female	0.10*** (45.23)		
National	-0.02*** (4.40)	-0.03*** (-6.88)	-0.01 (-0.89)
15-25	0.00 (-0.76)	0.00 (0.35)	-0.01 (-1.53)
36-45	-0.03*** (-9.95)	-0.02*** (-7.23)	-0.05*** (-11.50)
46-55	-0.08*** (-29.70)	-0.04*** (-24.06)	-0.11*** (21.38)
56-65	-0.11*** (-17.30)	-0.04*** (-11.78)	-0.18*** (-14.57)
Single	0.02*** (12.96)	0.03*** (25.43)	0.02*** (7.20)
Other Marital	0.02*** (7.17)	0.02*** (8.38)	0.02*** (7.14)
Low education	-0.02*** (-4.76)	-0.02*** (-8.57)	-0.01 (-1.14)
Medium education	-0.03*** (-9.85)	-0.03*** (-13.42)	-0.02*** (-5.73)
Moonlighter	0.12*** (23.54)	0.07*** (23.44)	0.15*** (17.34)
One year ago employed	-0.13*** (-27.79)	-0.09*** (-32.12)	-0.15*** (-22.27)
One year ago unemployed	0.08*** (9.77)	0.05*** (8.97)	0.09*** (9.08)
Legislatives	-0.06*** (-8.67)	-0.03*** (-5.57)	-0.11*** (-12.95)
Professionals	-0.01** (-2.29)	0.00 (0.44)	-0.03*** (-3.84)
Clerks	0.01 (1.47)	0.02*** (4.67)	0.01 (0.49)
Service workers	0.07*** (16.58)	0.05*** (17.26)	0.08*** (13.82)
Skilled agricultural	0.10*** (10.65)	0.06*** (10.04)	0.12*** (6.33)
Craftsmen	0.06*** (7.33)	0.03*** (5.58)	0.11*** (10.41)
Plant/machine operators	0.04*** (8.03)	0.03*** (8.84)	0.07*** (6.52)
Elementary	0.17*** (23.40)	0.10*** (18.81)	0.21*** (21.50)
Agriculture	0.13*** (8.28)	0.09*** (7.62)	0.14*** (9.18)
Manufacturing	-0.08*** (-23.87)	-0.04*** (-20.37)	-0.12*** (-24.24)
2001 Law	0.03*** (5.17)	0.02*** (4.55)	0.03*** (5.68)
2004 Law	0.07*** (9.88)	0.04*** (6.93)	0.08*** (12.12)
Crisis	0.06*** (7.34)	0.04*** (4.98)	0.07*** (8.93)

>>>

Table 5 >>>

Variables	Full sample	Males only	Females only
Time	0.01*** (22.83)	0.01*** (20.16)	0.01*** (18.95)
Piemonte	0.01*** (25.01)	0.01*** (84.07)	0.01*** (19.51)
Valle d'Aosta	0.01*** (8.92)	0.01*** (48.57)	-0.01*** (-6.90)
Liguria	0.02*** (21.98)	0.02*** (35.86)	0.03*** (18.52)
Trentino	-0.02*** (-2.57)	0.00*** (-2.95)	-0.03** (-2.39)
Alto Adige	0.03*** (8.77)	0.01*** (6.13)	0.04*** (10.91)
Veneto	0.00 (0.35)	0.00 (0.03)	0.00 (0.42)
Friuli	0.01*** (9.89)	0.01*** (21.32)	0.00*** (5.91)
Emilia Romagna	0.01** (2.19)	0.01* (1.91)	0.01** (2.49)
Toscana	0.03*** (12.80)	0.02*** (6.20)	0.03*** (28.74)
Umbria	0.03*** (8.42)	0.01*** (8.62)	0.05*** (9.11)
Marche	0.02*** (3.19)	0.02*** (4.05)	0.02** (2.34)
Lazio	0.04*** (11.42)	0.03*** (15.72)	0.06*** (9.45)
Abruzzo	0.05*** (39.34)	0.03*** (140.73)	0.06*** (25.61)
Molise	0.06*** (34.52)	0.05*** (93.26)	0.07*** (21.28)
Campania	0.05*** (19.11)	0.05*** (79.15)	0.04*** (10.75)
Puglia	0.07*** (30.54)	0.06*** (41.17)	0.07*** (17.62)
Basilicata	0.06*** (31.18)	0.05*** (45.21)	0.07*** (19.81)
Calabria	0.09*** (31.48)	0.07*** (40.72)	0.10*** (20.60)
Sicilia	0.10*** (30.80)	0.07*** (53.68)	0.11*** (18.89)
Sardegna	0.07*** (27.08)	0.05*** (70.17)	0.08*** (18.59)
Number of observations	3906623	1100524	2134534
<i>Participation (first stage)</i>			
Total young kids	0.074*** (19.76)		0.019*** (5.04)
Single	-0.289*** (-6.02)		-0.135*** (-4.13)
Other marital	-0.009 (-0.38)		0.250*** (17.66)
Unemployment	-0.037*** (-27.02)		-0.048*** (-23.75)
Medium education	0.684*** (54.56)		0.866*** (55.01)
High education	1.052*** (41.73)		1.341*** (25.71)
Constant	0.036** (2.07)		-0.293*** (-10.61)
Athrho	0.182*** (5.23)		0.148*** (4.08)

Note. Marginal effects are reported for the second stage, estimated coefficients are reported for the first stage; z-statistics are calculated using clustered standard errors and are reported in parenthesis. ***, * indicate significance at 10 and 1%, respectively. The models passed a battery of diagnostic tests: Wald χ^2 (p-value) = 0.000 (full sample), 0.000 (females only); Likelihood ratio χ^2 (p-value): 0.000 (males only).

Table 5 reports the results obtained for the composite INE indicator, while tables 6 and 7 report the results for involuntary part-time and involuntary temporary employment, respectively. Starting with the selection equations (regarding the samples of females as well as the total sample) the results of the Wald tests allow for the hypotheses that the two equations are independent in all cases to be rejected. This supports the use of the Heckman selection technique. As for the results of the variables included in the first step, there are common patterns across specifications. In particular, it is found that female participation in the labour market is influenced positively by the level of education, being married and, to a lesser extent, the number of young kids in the household. On the other hand, the level of unemployment is found to negatively affect the decision to enter the labour market. Such findings are mostly in line with those encountered in the literature (see Humphries and Sarasua, 2012, for a review of factors affecting women's labour force participation), while the few differences can be attributed to country-specific social and economic factors.

Turning to the second step equations, the likelihood ratio chi-squares and *p*-values suggest that our models are overall statistically significant. Moreover, most of the variables included in the analysis present statistically significant results. Starting with gender, the results suggest that women have a significantly higher chance of being in INE compared to men, with the marginal effect being higher for part-time than for temporary employment. Although it is reasonable to expect a larger proportion of females to be in non-standard employment due to either them voluntarily striving to practise their own preferential employment arrangements to suit their life's trajectories (Casey and Alach, 2004) or factors such as their greater involvement in caring and child-care commitments (OECD, 1990), there is no justification for females being more likely to be in non-standard employment *involuntarily*. In terms of quantitative effects, the 0.10 marginal effect for the full sample in the INE specification of the model should be interpreted as follows: a female individual will have a 10 percentage points higher probability of being in INE compared to a male with identical characteristics (except gender, of course). The rest of the numbers reported in the tables should be interpreted quantitatively in the same vein. The nationality dummy suggests that Italians are more likely to be involuntarily employed with non-standard contracts than non-nationals, although the additional specifications of the model suggest that this is only true for males, while for females with temporary contracts (see last column of Table 7) the opposite is true.

As for age, it is important to recall that the reference group is individuals aged 26 to 35. There seems to be little difference between the 16-25 and the 26-35

Table 6 - Involuntary part-time determinants in Italy, 1999-2014

Variables	Full sample	Males only	Females only
Female	0.10*** (29.43)		
National	-0.02*** (4.29)	-0.02*** (-6.99)	-0.01* (-1.76)
15-25	-0.01** (-2.22)	-0.01*** (2.78)	-0.01 (-1.38)
36-45	-0.02*** (-7.09)	-0.01*** (-10.55)	-0.06*** (-12.15)
46-55	-0.04*** (-16.59)	-0.01*** (-10.55)	-0.06*** (9.24)
56-65	-0.06*** (-7.76)	-0.01 (1.32)	-0.10*** (-9.24)
Single	0.02*** (10.16)	0.03*** (28.02)	0.01*** (5.65)
Other Marital	0.02*** (9.70)	0.02*** (15.80)	0.02*** (9.42)
Low education	-0.01** (-2.18)	0.00 (0.16)	0.00 (0.40)
Medium education	-0.01*** (-4.55)	-0.01*** (-5.01)	-0.01** (-2.36)
Moonlighter	0.12*** (23.11)	0.05*** (34.42)	0.15*** (18.74)
One year ago employed	-0.10*** (-19.46)	-0.06*** (-40.15)	-0.11*** (-18.00)
One year ago unemployed	0.04*** (7.63)	0.02*** (7.94)	0.06*** (7.78)
Legislatives	0.01** (2.06)	0.00 (0.68)	0.03*** (4.48)
Professionals	0.00 (0.60)	0.01* (1.75)	0.00 (0.27)
Clerks	0.03*** (2.78)	0.01** (2.31)	0.03*** (3.06)
Service workers	0.07*** (15.06)	0.03*** (8.16)	0.10*** (15.33)
Skilled agricultural	0.13*** (12.98)	0.06*** (10.09)	0.20*** (9.78)
Craftsmen	0.07*** (9.02)	0.02*** (4.23)	0.12*** (11.47)
Plant/machine operators	0.01* (1.84)	0.00 (0.50)	0.02** (2.43)
Elementary	0.13*** (22.77)	0.05*** (12.24)	0.18*** (19.36)
Agriculture	-0.03*** (-7.01)	-0.01*** (-4.63)	-0.04*** (-3.94)
Manufacturing	-0.09*** (-21.34)	-0.04*** (-20.25)	-0.11*** (-21.80)
2001 Law	0.03*** (12.78)	0.02*** (12.53)	0.04*** (10.79)
2004 Law	0.02*** (3.96)	0.01*** (2.84)	0.03*** (5.89)
Crisis	0.02*** (2.87)	0.01 (1.08)	0.03*** (5.12)
Time	0.01*** (21.41)	0.01*** (28.20)	0.01*** (17.53)
Piemonte	0.01*** (24.59)	0.01*** (55.39)	0.01*** (17.98)
Valle d'Aosta	-0.03*** (-20.89)	-0.01*** (-36.15)	-0.03*** (-19.94)
Liguria	0.02*** (22.68)	0.01*** (33.80)	0.02*** (18.58)
Trentino	-0.06*** (-20.90)	-0.03*** (-25.64)	-0.08** (-13.89)
Alto Adige	-0.01*** (-3.48)	-0.01*** (-11.38)	-0.01* (1.81)
Veneto	-0.01 (-1.16)	-0.01*** (-4.92)	0.00 (-0.58)
Friuli	-0.01*** (-7.97)	-0.01*** (-36.19)	-0.01*** (-4.48)

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Table 6 >>>

Variables	Full sample	Males only	Females only
Emilia Romagna	-0.01 (-1.16)	0.00 (-1.35)	-0.01 (-1.08)
Toscana	0.02*** (14.71)	0.01*** (8.44)	0.02*** (18.03)
Umbria	0.02*** (15.16)	0.01*** (10.35)	0.03*** (17.64)
Marche	0.01** (2.16)	0.01*** (3.11)	0.01 (1.40)
Lazio	0.03*** (10.35)	0.02*** (13.87)	0.04*** (8.94)
Abruzzo	0.03*** (29.51)	0.01*** (43.57)	0.04*** (21.41)
Molise	0.04*** (26.97)	0.02*** (68.44)	0.05*** (19.63)
Campania	0.03*** (15.69)	0.03*** (50.54)	0.02*** (8.51)
Puglia	0.03*** (20.80)	0.03*** (75.50)	0.04*** (13.08)
Basilicata	0.04*** (25.48)	0.02*** (69.76)	0.05*** (17.09)
Calabria	0.05*** (24.05)	0.04*** (91.58)	0.06*** (15.65)
Sicilia	0.06*** (22.75)	0.04*** (76.68)	0.08*** (15.77)
Sardegna	0.04*** (21.81)	0.02*** (52.36)	0.05*** (15.59)
Number of observations	3811066	1045399	2094102
<i>Participation (first stage)</i>			
Total young kids	0.076*** (21.71)		0.021*** (5.81)
Single	-0.302*** (-6.42)		-0.143*** (-4.77)
Other marital	-0.002 (-0.09)		0.259*** (17.97)
Unemployment	-0.039*** (-28.00)		-0.049*** (-24.02)
Medium education	0.700*** (64.69)		0.880*** (56.87)
High education	1.063*** (36.35)		1.344*** (24.51)
Constant	0.017 (1.02)		-0.317*** (-10.34)
Athrho	0.283*** (8.67)		0.237*** (7.05)

Note. Marginal effects are reported for the second stage, estimated coefficients are reported for the first stage; z-statistics are calculated using clustered standard errors and are reported in parenthesis. ***, * indicate significance at 10 and 1%, respectively. The models passed a battery of diagnostic tests: Wald χ^2 (p-value) = 0.000 (full sample), 0.000 (females only); Likelihood ratio χ^2 (p-value): 0.000 (males only).

groups for INE in general. Results in tables 6 and 7 suggest that this is especially the case for males with temporary contracts, while some differences exist for the other categories of individuals. More in general, age correlates negatively with INE, and the marginal effect increases with age. This result highlights the poor working conditions (less secure and lower paid working arrangements) faced, in particular, by younger generations in Italy (for a compelling analysis of how occupational, economic as well as demographic perspectives for the 'youngsters' have been severely compromised in contemporary Italy, see Barbieri, 2011).

Marital status also significantly affects the probability of being in INE. Married individuals are less likely to be in INE than singles and widowed or divorced ones, and this result too survives the INE disaggregation between involuntary temporary and involuntary part-time workers. There is no consensus in the literature about the effect of being married on the probability of being in INE. Some studies find a positive relationship (for the UK case, see Green and Livanos, 2015) while others find a negative one (also for the UK, see Cam, 2012). One possible explanation for the finding for Italy may be that non-married individuals are less likely to be satisfied with the non-standard part-time or temporary job they have unwillingly accepted.

With respect to educational levels, individuals with low and medium educational levels are less likely to be in INE than highly educated individuals (Table 7 reveals that the result for 'low education' appears to be driven mainly by involuntary temporary employment). In terms of marginal effects, the difference between having a low and a medium level of education is extremely low. This result, which may appear to be counter intuitive is, nevertheless, indicative of the limited opportunities for highly educated individuals in the Italian labour market over the sample period. This evidence is consistent with that provided by Nunez and Livanos (2011), who found that having a degree does not increase the likelihood of employment in countries such as Greece, Portugal, and Italy.

Turning the attention to work characteristics, moonlighters are at a greater risk of INE, as well as people who were unemployed the year before taking the survey. On the other hand, people with a job the year before are less likely to be in INE. With respect to occupation, associate professionals, legislative workers and plant operators are less likely to be in INE (in both cases, the marginal effect is stronger for temporary contracts). All the other work categories except clerks (for which there is a marked difference between part-time and temporary employment resulting in an overall not significant effect in the model with the composite INE indicator) face a greater risk of INE. Interest-

Table 7 - Involuntary temporary employment determinants in Italy, 1999-2014

Variables	Full sample	Males only	Females only
Female	0.06*** (27.02)		
National	0.00 (0.04)	-0.01*** (-3.86)	0.03*** (5.28)
15-25	-0.01** (-2.50)	0.00 (-0.63)	-0.02*** (-3.85)
36-45	-0.03*** (-6.52)	-0.01*** (-5.46)	-0.04*** (-7.07)
46-55	-0.07*** (-19.63)	-0.03*** (-14.84)	-0.11*** (-22.69)
56-65	-0.11*** (-29.51)	-0.04*** (-20.98)	-0.18*** (-27.68)
Single	0.02*** (9.63)	0.02*** (18.33)	0.02*** (4.62)
Other Marital	0.01* (1.87)	0.01*** (5.72)	0.01** (2.05)
Low education	-0.04*** (-8.18)	-0.02*** (-10.43)	-0.03*** (-3.67)
Medium education	-0.04*** (-14.02)	-0.03*** (-13.89)	-0.04** (-9.52)
Moonlighter	0.06*** (17.04)	0.04*** (15.88)	0.08*** (10.85)
One year ago employed	-0.13*** (-24.44)	-0.08*** (-28.10)	-0.16*** (-21.49)
One year ago unemployed	0.07*** (9.05)	0.04*** (9.01)	0.09*** (8.30)
Legislatives	-0.07*** (-9.72)	-0.02*** (-6.17)	-0.13*** (-12.25)
Professionals	-0.03*** (-5.53)	-0.01*** (-3.79)	-0.06*** (-6.64)
Clerks	-0.03*** (-3.11)	0.00 (-0.24)	-0.06*** (-4.10)
Service workers	0.01*** (2.58)	0.02*** (7.84)	-0.01* (-1.72)
Skilled agricultural	0.03*** (3.59)	0.03*** (4.99)	0.03* (1.64)
Craftsmen	0.01 (1.19)	0.01*** (3.57)	0.01 (0.69)
Plant/machine operators	0.02*** (3.28)	0.02*** (7.65)	0.04*** (3.40)
Elementary	0.09*** (11.26)	0.06*** (13.95)	0.08*** (10.32)
Agriculture	0.18*** (13.03)	0.10*** (10.08)	0.24*** (15.97)
Manufacturing	-0.04*** (-13.20)	-0.02*** (-10.99)	-0.08*** (-13.15)
2001 Law	0.01** (2.02)	0.01*** (2.90)	0.01 (9.96)
2004 Law	0.06*** (7.53)	0.03*** (5.56)	0.07*** (9.96)
Crisis	0.05*** (6.54)	0.03*** (4.59)	0.07*** (8.37)
Time	0.01*** (11.00)	0.00*** (9.98)	0.00*** (6.65)
Piemonte	0.01*** (24.21)	0.01*** (99.12)	0.01*** (18.57)
Valle d'Aosta	0.04*** (34.16)	0.02*** (58.39)	0.04*** (28.04)
Liguria	0.02*** (22.10)	0.01*** (28.81)	0.03*** (21.30)
Trentino	0.03*** (12.56)	0.01*** (29.40)	0.04** (12.13)
Alto Adige	0.05*** (13.62)	0.02*** (8.60)	0.08*** (15.87)
Veneto	0.01*** (3.76)	0.01* (1.71)	0.03*** (7.50)
Friuli	0.02*** (16.33)	0.02*** (19.31)	0.03*** (15.52)

>>>

Table 7 >>>

Variables	Full sample	Males only	Females only
Emilia Romagna	0.03*** (4.78)	0.02*** (2.64)	0.03*** (10.18)
Toscana	0.03*** (16.85)	0.02*** (5.24)	0.04*** (14.52)
Umbria	0.03*** (8.91)	0.01*** (18.62)	0.04*** (5.99)
Marche	0.03*** (5.23)	0.02*** (3.37)	0.03*** (23.68)
Lazio	0.04*** (6.60)	0.02*** (8.21)	0.05*** (5.87)
Abruzzo	0.05*** (39.32)	0.03*** (101.02)	0.07*** (33.32)
Molise	0.06*** (34.72)	0.04*** (51.96)	0.07*** (26.71)
Campania	0.06*** (23.01)	0.04*** (50.67)	0.07*** (18.49)
Puglia	0.07*** (25.51)	0.05*** (27.26)	0.08*** (20.20)
Basilicata	0.06*** (25.71)	0.04*** (28.07)	0.07*** (20.62)
Calabria	0.09*** (25.20)	0.06*** (25.56)	0.12*** (21.26)
Sicilia	0.10*** (29.59)	0.06*** (32.55)	0.12*** (24.20)
Sardegna	0.07*** (28.26)	0.05*** (45.84)	0.09*** (24.94)
Number of observations	3809253	1078866	2058822
<i>Participation (first stage)</i>			
Total young kids	0.079*** (21.54)		0.026*** (7.46)
Single	-0.297*** (-5.87)		-0.145*** (-4.06)
Other marital	-0.043* (-1.72)		0.221*** (16.11)
Unemployment	-0.039*** (-29.26)		-0.051*** (-26.17)
Medium education	0.694*** (54.37)		0.902*** (55.34)
High education	1.077*** (40.90)		1.407*** (25.60)
Constant	0.013 (0.79)		-0.351*** (-12.23)
Atrho	0.123*** (3.74)		0.081*** (3.00)

Note. Marginal effects are reported for the second stage, estimated coefficients are reported for the first stage; z-statistics are calculated using clustered standard errors and are reported in parenthesis. ***, * indicate significance at 10 and 1%, respectively. The models passed a battery of diagnostic tests: Wald χ^2 (p-value) = 0.000 (full sample), 0.001 (females only); Likelihood ratio χ^2 (p-value): 0.000 (males only).

ing results arise regarding the differences between part-time and temporary employment and those related to gender. For instance, the result for service workers is driven by the effect for females (both part-timers and temporarily employed). The positive marginal effect for craftsmen is driven by the results of part-time employment, while the one for plant operators is driven by temporary employment. The sector of activity also matters. With respect to third sector workers, agricultural workers are more likely to be involuntarily employed with non-standard contracts. However, this masks opposite effects for part time and temporary employment: the effect is negative for the former and positive for the latter that eventually dominates in the overall INE model reported in Table 5. Finally, workers in the industrial sector are less likely to be in INE than third sector workers.

The analysis now turns to the national and regional variables. The risk of being in INE increased over time in Italy during the reference period, as proven by the positive coefficients associated with the time trend. Notwithstanding the inevitable caution that always needs to be exercised when interpreting legislative interventions proxied by time dummies, the positive coefficients of our time band dummies (2001-2003 and 2004-2008) would suggest that the successive waves of labour market reforms have in fact increased the probability of being in INE. This is particularly evident when considering that the significance of these effects cannot merely be attributed to a 'time trend' in the data generation process, which is accounted for separately in our model so as to capture how the incidence of INE is affected by time given the possible influence of other macroeconomic factors. Beccarini (2009) also highlights the negative consequences of frequent labour market reforms on labour productivity. Unsurprisingly, the crisis dummy too records a positive coefficient.

Regional dummies (with Lombardia as the benchmark) also provide results of considerable interest. Results for Northern regions mostly support the lower risk of INE if working in Lombardia, although this is only true for temporary workers rather than part-timers (most coefficients are negative in Table 6, but positive in tables 5 and 7). Being in Central regions (Toscana, Umbria and Marche) is associated with a higher probability of INE compared to Lombardia, but the difference is not that high when compared to the Southern and insular regions, which strongly confirms the North-South divide. The coefficients associated with regions such as Calabria and Sicilia, are by far the highest among those of the regional variables.

5. Conclusions

This study employed Italian data from the EU-LFS for the period 1999-2014 to offer evidence on INE, looking both at temporary and part-time employment. In addition to examining individual-specific socio-demographic characteristics and working conditions, the regional dimension was accounted for. The study also investigated the incidence of the recent economic crisis and the effects of successive Italian labour market reforms.

The findings suggest that the incidence of INE increased over time, including after the recent major labour market reforms. With regard to socio-demographic characteristics, the findings indicate a higher INE probability for women and young individuals, all else equal. Interesting results stem from the estimation of the model for males and females separately, as well as for involuntary part-time and temporary employment.

But what do these findings and, in particular, the regional perspective, contribute to our understanding of INE, especially in terms of the spatial dynamics of this phenomenon in the Italian context? To start with, the findings affirm the notion that INE is manifested and shaped differently by spatial context, with the probability of being at risk of INE differing considerably by region. Moreover, it was found that individuals with higher educational qualifications are at greater risk of INE than those with a medium level of education (e.g., secondary school leaving certificates or vocational diplomas).

Part of the Italian regional disparities are, of course, resource-related and have emerged over decades as part of the industrialisation process as economic activity tended to concentrate in the North of the country. Yet it is clear from the data that this historical contextualisation does not suffice in shedding light on the INE phenomenon. On this account, the findings lead us to two important conclusions.

First, the deteriorating situation of the Italian economy, accentuated by the recent economic crisis has, somewhat inevitably, augmented occupational problems throughout Italy as INE levels kept rising considerably across all Italian regions during the sample period (a period during which also the unemployment rate kept increasing, with a large number of individuals losing their 'standard' job). Yet, regional differentials are not due to purely economic factors, calling for an institutional explanation.

Second, whilst it is true that in the absence of the proverbial counter-factual one will never know what would have happened if the Italian labour market reforms had not been implemented, our estimations suggest that the legislative interventions from '*Legge Biagi*' onwards have not done much in addressing the ex-

isting and pronounced regional disparities. The infamous Italian North-South divide is evident in the data, with a much higher likelihood of being in INE than before these waves of reforms were implemented, particularly in Southern and insular regions.

It is evident that in terms of labour market policy, supra-national agendas have long supplanted intra-national regional concerns. For example, the OECD (1994) Jobs Strategy, which promoted flexibility for Europe as a whole, did not address regional disparities. At a time when the debate on labour markets is increasingly shifting towards the extent of national convergence, a core policy implication that flows from our findings is urgently needed to redirect attention towards the increasing intra-national, regional labour market differentials.

By way of acknowledgement of limitations, it is worth noting that some of the regional differences unveiled by the results may, of course, be shaped also by factors that were not controlled for (social wage, support network, etc.). These factors, and the way in which such factors may interact with INE, provide a fruitful avenue for future research.

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Quaderni Fondazione G. Brodolini

Since its establishment, the **Giacomo Brodolini Foundation** has been concerned with spreading knowledge of the scientific and cultural activities carried out. Over the years, the publishing activity has become increasingly intense, to the point of starting, in 1984, a new line to publish the main results of the research activity. The **“Quaderni della Fondazione Brodolini”** were born. Over the years, a series of volumes have been collected. They make the results of the research carried out by the Foundation in all the areas of study available to the scientific world, the universities and the social organizations.

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The series **“Le culture del socialismo italiano”** publishes the results of the cultural initiatives (proceedings of conferences, essays, researches, reprints, unpublished) promoted by the permanent interdisciplinary seminar “Le culture del socialismo italiano”. The seminar, active at the Foundation, has undertaken an activity of study, research and political-cultural debate on the different periods that characterize the history of Italian Socialism. The series also includes the publication of texts, which, without being a product of the seminar's cultural initiatives, have a direct bearing on the themes dealt with.

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