2 The impact of technological advances on the labour market

Are we approaching a jobless future?

An increasing range of jobs will be at risk of automation due to ever-increasing computing power, improvements in artificial intelligence and the full-scale development of the "Internet of Things". Yet technological advances also introduce new and more complex tasks for humans and create indirect jobs.

Automation of increasingly complex jobs

The concerns of technology causing mass unemployment, due to machines replacing human labour, are hardly new in history. In fact, the idea of "technological unemployment" as a new disease was already highlighted by John Maynard Keynes in 1930[9]. Some years later, Wassily Leontief was also pessimistic and predicted more and more workers being replaced by machines and new industries not being able to employ all the labour supply. Although previous fears of technological unemployment had not been realised, Leontief thought that, with the advent of solid-state electronics, the relation between man and machine was being radically transformed. "Computers are now taking on the jobs of white-collar workers, performing first simple and then increasingly complex mental tasks", he argued in 1982, to conclude that human labour would not retain in the future its role of principal factor of production[10].

Nowadays, ever-increasing computing power, artificial intelligence and the "Internet of Things" threaten to further extend the scope of job automation to non-routine and cognitive tasks that were deemed non-automatable only a few years ago. These include, for example, driving a car or writing reports on stock market changes. Estimates by Frey and Osborne (2013) suggest that around 47% of total US employment is potentially automatable over the next decades[11]. A wide range of occupations would be affected, in transportation and logistics, office and administrative support tasks, production, construction, sales and services. A similar study by the World Bank (2016) finds an even higher share of the workforce at risk of automation in developing countries — 57% in members of the Organization for Economic Cooperation and Development (OECD)[12].

However, all these alarming figures are based on the average task content of each occupation rather than on the task content of individual jobs. Following the latter — more meticulous — approach, a recent study by the OECD finds much lower estimates of jobs at risk of automation: 9% on average across a sample of 21 OECD member states[13]. Estimates for individual countries range from 12% of the workforce at risk in Austria, Germany and Spain to 6% in Estonia and Korea. The report explains that this heterogeneity may reflect "general differences in workplace organisation, differences in previous investments into automation technologies as well as differences in the education of workers".

Estimates of jobs at risk of automation — either more or less conservative — cannot be considered as expected employment losses from technological advances for two main reasons. First, the adoption of new technologies is a process with economic, legal and societal hurdles, which makes job substitution a far from straightforward process. Second, and more important, new technologies not only displace existing jobs, but also create new ones, both directly and indirectly. In fact, Acemoglu and Restrepo (2016) see the dynamics

9: Keynes, J. M. (1930). Economic Possibilities for Our Grandchildren. In *Essays in Persuasion*, New York, Norton & Co.
10: Leontief, W. W. (1982).The Distribution of Work and Income. *Scientific American*, 247(3), 188-204.
11: Frey, C. B., & Osborne, M. A. (2013). The Future of Employment: How Susceptible are Jobs to Computerisation, *Oxford Martin School Working Paper*, No. 7.
12: World Bank (2016). Digital Dividends. World Bank Development Report 2016.
13: Arntz, M., Gregory, T., & Zierahn, U. (2016). The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis. *OECD Social, Employment and Migration Working Papers*, No. 189.

of modern labour markets as being characterised by a race between two technology-driven forces: automation on the side of machines, and the creation of new complex tasks on the side of humans[14].

New skilled tasks for humans and spillover effects

Technological advances introduce new and more complex tasks for which humans generally have (at least initially) a comparative advantage. These tasks give rise to new jobs such as app programmers, digital marketing managers, cyber security experts, data scientists or digital privacy lawyers. Acemoglu and Restrepo document the importance of new tasks in employment growth using data from the US labour market. They find that about half of total employment growth from 1980 to 2007 (8.8 out of 17.5%) is explained by the additional surge in occupations with new job titles — in which workers perform newer tasks than those in more traditional positions.

However, some authors point out that newer technology sectors are not creating the same employment opportunities as previous technological advances such as the railroad, the automobile or the telephone. There is indeed some evidence of a downward trend in job creation by technology industries since the computing revolution of the 1980s. For example, Lin (2011) suggests that, while around 8.2% of workers in the US shifted into new jobs during the 1980s which were associated with new technologies, this figure went down to 4.4% in the 1990s[15]. Berger and Frey (2015) estimate an even lower percentage for the following decade: less than 0.5% of the US workforce shifted into industries that emerged through the 2000s, including new activities such as online auctions, video and audio streaming[16].

The overall labour impact of technological advances is, notwithstanding, much greater. The new jobs created by technology industries increase the demand for services in the local economy and, therefore, create indirect jobs. This multiplier effect is higher for skilled jobs, which is the case of technology industries. Goos, Konings and Vandeweyer (2015) estimate for Europe that every job in the high-tech industry — which includes both manufacturing and knowledge-intensive services — creates five additional low-tech jobs in the region where the industry is located[17]. The same estimate is found by Moretti (2010) for an approximation of the US high tech sector[18]. These figures, together with the fact that technological advances create increasingly skilled jobs, suggest that the size of the local multiplier will play a key role in the future of employment.

A race between two forces

As technological advances automate existing jobs and introduce new tasks for humans — and indirect jobs — at the same time, the net effect on the labour market will depend on the race between these two forces. If automation outpaces job creation, the concerns of "technological unemployment" will materialize.

The two forces have been more or less balanced so far. To explain this fact, Acemoglu and Restrepo (2016) argue that automation and the creation of new tasks are not independent from each other. Since automation of existing jobs reduces labour demand and tends to reduce the cost of labour, it also makes the creation of new complex tasks for humans more profitable relative to further automation. This 'price effect' would act as a stabilizing force that tends over time to self-correct the labour shedding caused by technology.

However, if there is a change in the innovation possibilities frontier — i.e. the technology for creating new technologies — that makes automation-related innovations easier than creating new tasks, then Acemoglu and Restrepo predict that the economy will settle in a new equilibrium with a greater share of tasks performed by capital and worse prospects for labour. Following this reasoning, the future of employment would depend on whether the combination of ever-increasing computing power, artificial intelligence and the "Internet of Things" give rise or not to a fundamental shift in the innovation possibilities frontier.

14: Acemoglu, D., & Restrepo, P. (2016). The Race Between Machine and Man: Implications of Technology for Growth, Factor Shares and Employment. *NBER Working Papers*, No. 22252.
15: Lin, J. (2011). Technological Adaptation, Cities, and New Work. *Review of Economics and Statistics*, 93 (2), 554–574.
16: Berger, T., & Frey, C. B. (2015). Industrial Renewal in the 21st Century: Evidence from U.S. Cities. *Regional Studies*, forthcoming.
17: Goos, M., Konings, J., & Vandeweyer, M. (2015), Employment Growth in Europe: The Roles of Innovation, Local Job Multipliers and Institutions. *Utrecht School of Economics Discussion Paper Series*, Vol. 15, No. 10
18: Moretti, E. (2010). Local Multipliers. *American Economic Review* 100(2): 373-77.

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