WHAT MAKES WORK RESILIENT

The future of work is marked by greater uncertainty, volatility and metamorphosis. A number of different job categories are already being disrupted through a combination of forces driven by technological progress, such as digitalisation, financialisation, global value chains, and new management practices. However, some job categories will be more resilient to these forces than others.

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So which job categories will be the most resilient in the future? This is a burning question for many concerned employees, parents and the rare breed of politicians who think beyond their term in office. The answer depends on evolving market demand and the extent to which existing occupations are insulated from the forces of job disruption. This paper proposes a framework to assess which occupations will be most resilient to the forces of job disruption and evaluate the likely impact on jobs. Building on existing frameworks, it expands on key parameters related to the cognitive elements of work, namely the analytical, creative and social dimensions.

Just over 1/3 of occupations in the United States are likely to be replaced by technology

Based on the Job Resilience Model developed for this paper, it is estimated that just over 1/3 of current occupations in the United States are likely to be largely replaced by technology by 2030. Moreover, 3/4 of US occupations will be at least partially replaced by technology over the same period. Workers most impacted by technological disruption in the shorter term will also be those who are least prepared: those with existing occupations who must suddenly re-skill and pivot to new occupations. This level of job disruption is greater than what we have experienced in the past and generates questions related to policy (e.g., how to support existing workers in re-skilling for new occupations, how to adjust educational systems and support existing workers in re-skilling towards new occupations), business practices and decision (e.g., how to strike the right balance between technology and workers), and individual action (how to best prepare both children and adults for the new world of work).

Technology is a common driver behind the forces impacting existing and new occupations

While there are a number of forces behind the disruption of work, including digitalisation, financialisation, global value chains and new management practices, technology is the most important driver behind all of them. The likelihood of job substitution directly related to technology depends on several factors. David Autor, a Professor of labour economics at MIT, proposes a simple and powerful framework to assess the risk of technological substitution for different occupations. The framework classifies occupation types along two dimensions: manual or cognitive and simple or complex tasks (see Figure 1). The more complex the task – whether it is cognitive or manual – the more difficult it is to automate.

<table>
<thead>
<tr>
<th>Simple tasks</th>
<th>Complex tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual</td>
<td>LOW</td>
</tr>
<tr>
<td>Cognitive</td>
<td>LOW</td>
</tr>
</tbody>
</table>

Source: Autor et al. 2003

2 Autor et al, 2003
3 An extensive body of research highlights the links between routine tasks and the computerisation of jobs. See, for example, Autor, et al 2003, Goos and Manning 2007, and Nedelkoska 2013.
The framework highlights that jobs involving simple cognitive tasks are as much at risk from technological substitution as manual jobs that involve repetitive tasks. It also underscores that manual jobs that involve complex tasks (e.g., electrician or plumber) are more insulated from technological substitution than cognitive jobs that involve simple tasks (e.g., call centre representative).

Four key dimensions drive the resilience of jobs to technology

Building on Autor’s technological substitution framework and extending it to include the dimensions of analytical ability, creativity and social interaction, the technological impact on occupations can be assessed based on the following four dimensions: analytical ability, creativity, manual complexity and social interaction.

- Analytical ability gauges the level of analytical processing and the degree of learning required to perform best for a given occupation. For our purposes, it is measured based on the level and extent of training required for a given occupation as measured by the U.S. Department of Labour Statistics\(^5\).

- Creativity involves the ability to think “out-of-the-box” and find different solutions to problems. When combined with analytical ability, it involves the ability to deal with the unexpected. Moreover, high levels of applied creativity can lead to innovation.

- Manual complexity assesses the extent to which an occupation involves challenging manual tasks, from lowest complexity (e.g., toll booth operator), to highest complexity (e.g., heart surgeon).

- Social interaction is the ability to connect with other human beings using all forms of communication including tone of voice, eye contact and body language. An individual with a high level of social ability is able to read subtle body language, understand and adjust to context as well as demonstrate empathy.

For each of these four dimensions, a higher level translates into a higher score. The further breakdown of different forms of cognitive ability into analytical, creative and social is particularly important given that a number of non-routine cognitive tasks are beginning to be substituted by technology, contrary to the predictions of Autor’s framework. For instance, Google has recently developed a driverless car that has registered over 1 million km without a single accident caused by the car\(^6\). Such a feat was considered impossible by leading technology experts a decade ago. It is therefore important to pinpoint what types of cognitive tasks are most sensitive to technological substitution.

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4 Frey and Osborne, 2013
5 It is now well established that people with higher levels of education have better job prospects (Pascharpoulos and Pinarios, 2004, OECD 2017); the difference is particularly important between those who have attained upper secondary education and those who have not. On the average, across OECD countries, 84% of adults with tertiary education is employed, which is by about 10 percentage points higher than the employment rate for people with upper secondary and post-secondary non-tertiary education. The employment rate for those who have not completed upper secondary education is 20 percentage points below that for people with upper secondary and post-secondary non-tertiary education.
6 The only accident came when a human driver ran into the rear end of the Google car.
The most resilient jobs will be those that combine the highest levels of analytical ability, creativity, manual complexity and social interaction.

What is more, the combination effect of different dimensions has not been given enough consideration by the existing literature. An occupation that combines all four dimensions of analytical ability, manual skills, social interaction and creativity will be less sensitive to technological substitution relative to one that combines just one or two of these dimensions.

The likely impact of technology on jobs was estimated for more than five hundred different job categories in the United States, taking into account these four dimensions of analytical ability, creativity, manual complexity and social interaction (ACMS indicators).7

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<table>
<thead>
<tr>
<th>Scoring</th>
<th>Analytical (Education and Training or Job Zone)</th>
<th>Creativity</th>
<th>Manual complexity</th>
<th>Social interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Extensive preparation needed (as defined by O*Net)</td>
<td>Very high share of the daily work (e.g., over 60%) dedicated to the development, design or creation of new applications, ideas, relationships, systems or products</td>
<td>Highly complex manual work with unscripted and non-routine movements requiring practice for at least 5 years, requiring to generate or use different sets of rules for combining or grouping things in different ways and the use of precision instruments</td>
<td>Exceptional ability to perceive, understand and respond to all forms of human communication, including tone of voice, eye contact and body language. Excels in reading subtle body language, understanding and adapting to context as well as demonstrating empathy. Multiple levels of communication with different stakeholders with very high frequency</td>
</tr>
<tr>
<td>4</td>
<td>Considerable preparation needed</td>
<td>High share of the daily work (more than 50%) dedicated to the development, design or creation of new applications, ideas, relationships, systems or products</td>
<td>Manual work with unscripted and non-routine movements, requiring to generate or use different sets of rules for combining or grouping things in different ways, with instruments of high/medium complexity to master</td>
<td>Strong ability to perceive, understand and respond to all forms of human communication, including tone of voice, eye contact and body language. Able to read subtle body language, understand and adapt to context as well as demonstrate empathy. Multiple levels of communication with different stakeholders with high frequency</td>
</tr>
<tr>
<td>3</td>
<td>Medium preparation needed</td>
<td>Some share of the work (e.g., 25-50%) dedicated to the development, design or creation of new applications, ideas, relationships, systems or products</td>
<td>Manual work with unscripted and non-routine movements with simple instruments</td>
<td>Some ability to perceive, understand and respond to different forms of human communication, including tone of voice, eye contact and body language. Able to understand and adapt to context as well as demonstrate some empathy. Communication with more than one stakeholder on a regular basis</td>
</tr>
<tr>
<td>2</td>
<td>Some preparation needed</td>
<td>Share of the work (e.g., &lt;25% and &gt;10%) dedicated to the development, design or creation of new applications, ideas, relationships, systems or products</td>
<td>Manual work with scripted and routine movements</td>
<td>Communication is mainly written and oral with a relatively limited frequency</td>
</tr>
<tr>
<td>1</td>
<td>Little or no preparation required</td>
<td>Small share (e.g., 10%) dedicated to the development, design or creation of new applications, ideas, relationships, systems or products</td>
<td>Very limited manual work required</td>
<td>Minimal communication required</td>
</tr>
</tbody>
</table>

Source: Author’s analysis

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7. The data for various occupations were derived from the U.S. Department of Labour’s O*Net taxonomy of occupations which is the leading source of occupational information in the U.S. covering 1087 standardised occupations. Each occupation has a specific description by level of preparation required, industry, outlook, job family, STEM discipline (e.g., computer sciences, mathematics, engineering, life sciences, geosciences, chemistry) and by career cluster. The database provides additional data on the projected growth (2016-2026), the projected job openings (2016-2026) and the share of job openings in the government. The O*Net program was combined with the data from the Occupational Employment Statistics (OES) program (last update: May 2016), which produces employment and wage estimates annually for over 500 occupations.
Each occupation was scored on all four dimensions using a scale of 1 to 5 with 1 indicating a low level of attainment for the dimension and 5 indicating the highest level of attainment for the dimension. Analytical ability scores were attributed based on the number of years of training required as estimated by the U.S. Department of Labor Statistics. Other dimensions – creativity, manual complexity and social interaction – were evaluated by a team of experts based on the level of correlation with occupational descriptions in the Occupational Outlook Handbook 2018-2019 and a set of criteria as outlined in Box 1 above.

Resilience score was attributed to 1087 standardised detailed occupation categories (8-digit SOC) and then consolidated into over 500 broader operational categories (6-digit SOC) based on the averages of the detailed occupations (see Box 2).

<table>
<thead>
<tr>
<th>Box 2: Job Resilience Calculation Methodology</th>
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<tbody>
<tr>
<td>Consider the Analytical Ability indicator:</td>
</tr>
<tr>
<td>[ AA_i = \frac{\sum_{j=1}^{n} AA_{ij}}{n} ]</td>
</tr>
<tr>
<td>- ( AA_i ) – Analytical Ability indicator of the ( i )-th broad occupation category;</td>
</tr>
<tr>
<td>- ( AA_{ij} ) – Analytical Ability score for the ( j )-th detailed occupation included into the ( i )-th broad occupation category;</td>
</tr>
<tr>
<td>- ( n ) – the number of detailed (8-digit) occupations included into the ( i )-th broad (6-digit) occupation category.</td>
</tr>
</tbody>
</table>

The Resilience Index for the \( i \)-th broad occupation category is calculated as a sum of the Analytical ability, Creativity, Manual complexity and Social interaction (ACMS) indicators:

\[ Resilience_i = AA_i + C_i + M_i + S_i \]

- \( C_i \) – Creativity indicator of the \( i \)-th broad occupation category, it is calculated in the same way as \( AA_i \);
- \( M_i \) – Manual complexity indicator of the \( i \)-th broad occupation category, it is calculated in the same way as \( AA_i \);
- \( S_i \) – Social interaction indicator of the \( i \)-th broad occupation category, it is calculated in the same way as \( AA_i \).

Resilience index ranges between 4 (lowest possible score) and 20 (highest possible score). The higher the score, the least likely is the occupation to be substituted by technology.

For each broad occupation category, the number of job openings is calculated as a sum of job openings of the detailed occupations included in the category. The growth of jobs is calculated using the following formula:

\[ Growth_i = \left( \frac{Emp_{i+}+JO_{i}}{Emp_{i}} \right)^{\frac{1}{m}} - 1, \]

- \( Growth_i \) – the growth rate of the employment for \( i \)-th broad occupation category;
- \( Emp_i \) – estimated total employment rounded to the nearest 10 (excludes self-employed) for \( i \)-th broad occupation category;
- \( JO_i \) – the job openings due to growth and replacement for \( i \)-th broad occupation category;
- \( m \) – the duration of the planning period for job openings.

The substitution rate for \( i \)-th broad occupation category negatively depends on the Job Resilience Index:

\[ SustRate_{i} = 80\% - 10\% \times (Resilience_i - Resilience_{min}) \text{ if } Resilience_i < 12, \text{ and } SustRate_{i} = 0 \text{ if } Resilience_i \geq 12, \]

- \( SustRate_{i} \) – the substitution rate for the \( i \)-th broad occupation category;
- \( Resilience_{min} \) – minimum level of Job Resilience always equal to 4.

The risk of technological substitution and associated substitution rate can be broken down as follows:

- Occupations with a high risk of technological substitution score between 4 and 8 (substitution rate ranges between 40-80%);
- Occupations with a medium risk of technological substitution score between 8.1 and 10 (substitution rate ranges between 20-39%);
- Occupations with a low risk of technological substitution score between 10.1 and 20 (substitution rate ranges between 0-19%).

Source: Author’s analysis

7. The US Department of Labor/Employment and Training Administration (USDOL/ETA) provides 5 levels of “Job Zone”. Occupations are grouped into one of the five categories based on levels of education, experience, and training necessary to perform the occupation (One: little or no preparation required to 5: extensive preparation required).
8. The 2018-2019 Occupational Outlook Handbook (OCH) includes information about 675 detailed occupations in 325 occupational profiles and is available online. The profiles include the latest U.S. Bureau of Labor Statistics (BLS) projections, a future job outlook, work activities, wages, as well as education and training requirements.
9. Several limitations to these substitution estimates should be highlighted:
   • The model focuses on the likely substitution of existing occupations, and the model does not take into account the emergence of new occupations;
   • The estimated impact on the volume of jobs is based on the breakdown of jobs as recorded by United States Department of Labour Statistics in May 2016;
   • The analysis is focused on the U.S. job market. However, the basic trends of technology substitution should be applicable to other advanced industrial nations;
   • The Resilience scoring depends on a degree of expert interpretation.
Based on the model results, just over one third (37%) of American jobs in the United States are at risk of substitution from technology by 2030. More than three quarters of all listed job occupations by the U.S. Department of Labour are at a high or medium risk of at least partial substitution by 2030.

**Classifying job categories into typologies allows a first assessment of an occupation’s vulnerability**

The model also allows the identification of job typologies with different degrees of risk from technological substitution depending on how you combine the dimensions. Different job typologies are summarised below, including the estimated Resilience score and with examples of occupations.

<table>
<thead>
<tr>
<th>Job typologies</th>
<th>Resilience score</th>
<th>Description</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACMS</td>
<td>15+</td>
<td>Occupations that combine all four dimensions of analytical ability, creativity, social interaction and manual complexity</td>
<td>Doctor, Nurse Anesthetist, Practitioner, Pediatrician, Legislator, Construction Manager</td>
</tr>
<tr>
<td>ACM</td>
<td>12-16</td>
<td>Occupations that combine a high level of analytical ability, creativity and a degree of manual complexity but less social interaction</td>
<td>Mechanical, Chemical, Electrical Engineer, Archeologist, Material scientist</td>
</tr>
<tr>
<td>ACS</td>
<td>12-16</td>
<td>Occupations that combine a high level of analytical ability, creativity and social interaction but less manual complexity</td>
<td>Psychologist, Lawyer, Judge, Marriage Counsellor</td>
</tr>
<tr>
<td>AMS</td>
<td>12-17</td>
<td>Occupations that combine a high level of analytical ability, manual complexity and social interaction but less creativity</td>
<td>Physical Medicine and Rehabilitation Physician, Dentist</td>
</tr>
<tr>
<td>MS</td>
<td>10-14</td>
<td>Occupations that combine manual complexity with social interaction</td>
<td>Fitness teacher, Sport competitor, Food preparation and serving, Musician</td>
</tr>
<tr>
<td>AC</td>
<td>10-14</td>
<td>Occupations that combine high analytical ability with creativity but less manual complexity and social interaction</td>
<td>Historian, Architect, Transportation planner, Technical and copy writer</td>
</tr>
<tr>
<td>AM</td>
<td>7-11</td>
<td>Occupations that combine high analytical ability with manual complexity but less social interaction or creativity</td>
<td>Fuel Cell Technician</td>
</tr>
<tr>
<td>AS</td>
<td>10-14</td>
<td>Occupations that combine high analytical ability with social interaction but less manual complexity and creativity</td>
<td>University teacher, Education Administrator</td>
</tr>
<tr>
<td>A</td>
<td>7-11</td>
<td>Occupations that require high analytical ability but less creativity, social interaction or manual complexity</td>
<td>Financial analyst, Computer programmer, Airline pilot, Radiologist, Accountant, Statistician Librarian</td>
</tr>
<tr>
<td>M</td>
<td>7-11</td>
<td>Occupations that require high manual activity but less analytical, creative and social ability</td>
<td>Plumber, Electrician, Housekeeper, Painter, Security guard, Taxi driver</td>
</tr>
<tr>
<td>S</td>
<td>7-11</td>
<td>Occupations that require high social activity but less analytical, creative or manual ability</td>
<td>Receptionist</td>
</tr>
<tr>
<td>C</td>
<td>7-11</td>
<td>Occupations that require a high level of creativity but less analytical, social or manual ability</td>
<td>Artist</td>
</tr>
</tbody>
</table>

Source: Author’s analysis

10. Based on breakdown of number of jobs by occupation as recorded by the U.S. Department of Labor Statistics.
11. Includes all occupations with a high or medium risk of technological substitution.
By breaking down occupations according to ACMS typologies, it is possible to have a first assessment of their degree of vulnerability to technological substitution as well as the main rationale for that vulnerability. Thus, occupations that combine two or fewer ACMS dimensions will be relatively more vulnerable to technological substitution.

Examples of occupations most at risk include: financial analysts (A), radiologists (A), librarians (A), receptionists (S), cooks and waiters and related occupations (MS).

By contrast, occupations that combine at least three ACMS dimensions will be more likely to demonstrate greater resilience. These include management occupations (ACMS), healthcare practitioners (ACMS), engineers (ACM) and social scientists (ACS).

It should be noted that occupations with a single ACMS dimension still can be resilient to technological substitution. For instance, many occupational categories involving complex manual tasks such as housekeepers, plumbers or electricians, are largely insulated from the threat of technology.

As we have seen above, the most resilient jobs involve a combination of four parameters: (1) Analytical ability; (2) Manual complexity; (3) Social interaction and (4) Creativity. By considering both an index of job resilience to technology (Resilience Index) and the job growth potential, occupations can be categorised into different quadrants to help guide job seekers and policy makers in their resource allocation (see Figure 2 below).

The Job Resilience Matrix demonstrates that some occupations may have a low Job Resilience Index but still generate opportunities for employment because of the large volume of jobs and the high growth rate. This is the case for waiters / waitresses, fast food workers or cashiers (bottom right hand side of the matrix).

12. The job growth potential is based on the Bureau of Labor Statistics 2016-2026 employment projections. Future jobs are calculated as a sum of current employment (2016) and "Projected Job Openings", which represent job openings due to growth and replacement in the period 2016-2026.
Occupations may also have a high Job Resilience Index but still offer limited opportunities because of low overall volume and low growth. This is the case for judges, magistrates and other judicial workers (top left hand part of the matrix). Occupations with a low Job Resilience Index score and low growth offer the least promising opportunities for employment: secretary and administrative assistance or office clerks in the bottom left of the matrix are cases in point. Occupations that enjoy a high score on the Job Resilience Index and a high growth rate will be the most resilient. Examples include childcare workers, barbers, actors, producers, physicians and surgeons and psychologists (top right hand corner of the matrix).

Many new jobs will still be created in the future to partially compensate for technological substitution of the least resilient existing occupations

While a number of existing jobs will be disrupted by the disruptive forces of technology, many new jobs will also be created. Science and technology will transform existing sectors but also generate the development of new sectors with great employment potential such as nanochemistry and quantum computing. The convergence of different fields – such as nanotechnology, biotechnology, information technology, big data and cognitive science – will also generate employment opportunities.

Armed with greater insight on what makes work more resilient, policy makers, business leaders and individuals must take appropriate action

Taking into account the four dimensions of work resilience – analytical ability, creativity, manual complexity and social interaction – it is estimated more than 1/3 one third of existing occupations in the United States are at risk of being largely eliminated by 2030. What is more, over 3/4 of occupations are at a medium to high risk of at least partial technological substitution. Of course, over this time the magic of creative destruction will continue to create new occupations within existing and new sectors, many of which cannot be predicted today (who would have thought just a few years ago that data scientists would become one of the occupations in highest demand?)

In order to avoid widening skill gaps accelerated by the emergence of new occupations, the evolution of jobs categories must be closely monitored and individual training customised and responsive to accelerated shifts in labour market demands. Policy makers and business leaders must take action to strengthen workforce skills in the four dimensions of resilience and propose ways to adapt education and training systems so that they become more relevant, flexible and responsive to future job requirements.
References


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