These are the droids you're looking for

An optimistic vision for artificial intelligence, automation and the future of work

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EXECUTIVE SUMMARY

Artificial intelligence

- Machine learning is the most important area advancing artificial intelligence (AI). It allows more complex problems to be solved than traditional coding and work to be automated more easily.
- AI is real and increasingly used all around us in a wide range of applications, from entertainment to transport, healthcare and office work.

AI's impact on jobs

- There have been widespread concerns about the impact of AI on jobs even before the economic crisis caused by COVID-19. These concerns will only intensify in the challenging period ahead.
- There have been similar concerns about the impact of new technology on jobs for centuries.
- These worries are often driven by the Luddite fallacy: assuming that robots and workers are competing for a fixed number of jobs in a static economy.
- Automation has historically been a force for good and doomsday scenarios have not transpired.
- Some jobs are highly vulnerable to automation from AI. An estimated 30-40 per cent of UK work is at high risk.

- These studies provide a useful directional guide about the scope of automation but are subjective, may not translate into actual job losses, and are unclear on timelines or the net impact on employment.
- The net impact of AI on jobs and the flexibility of the labour market will determine the future outcome. This paper uses a Technological Unemployment Matrix as a framework to guide policymakers.
- The most likely scenario is that AI will support greater prosperity. There is no trend so far towards the doomsday scenarios, and the UK labour market is flexible, with a strong record of delivering high employment. AI will create new jobs, boost productivity and increase purchasing power. There will be some losses to mitigate, with temporary displacement and pockets of unemployment.

Government policies

- Surveying twenty-five governments' policy shows a common blueprint: announcing AI leadership intentions through to publishing an AI strategy and pledging funds for research. These promises are shallow, will have little impact and are unlikely to withstand lobbying.
- Technology progresses faster than regulation, creating a "pacing problem". A regulatory vacuum hinders progress. Estonia's approach, focusing on creating a permissive regulatory environment in which AI can flourish, is instructive.

Potential policy implications

- Vague pronouncements and half measures will not position the UK to lead in AI nor mitigate the potential jobs impact. The UK needs a joined-up and radical programme extending across regulation, research and development, welfare and taxation.
- Technology underpins economic growth. Government should rec-

ognise AI's potential contribution and the importance of fast adoption to improve the UK's competitive position.

- The UK should adopt a "permissionless innovation" regulatory approach for AI leadership. This contrasts with the default government stance of the "precautionary principle".
- Government should set up a £5 million 'Office for removing barriers to Artificial Intelligence' (ORBI) and pass an 'Unleashing Artificial Intelligence Act' (UAI Act). The Office would remove impediments to artificial intelligence and make permissionless innovation the legal default. This approach could be expanded to other areas of regulation.
- Government should not resort to prohibitions, fines, threats, or licensing except in the extreme and with an understanding of the risks. When intervention is genuinely justified, it should support its decisions with cost-benefit analysis.
- Where intervention is needed, government should embrace experimentation and evolution over grand designs. A proportion, around £1 billion of the Department for Work & Pensions' circa £175 billion budget should be used to fund policy experiments to find better solutions for sustained joblessness. This could test policies like Finland's proposal for a lifelong learning voucher scheme.
- Robot taxes should be rejected. They are poorly conceived, would hinder progress, and would be ineffective in a globalised economy.
- A popular policy to protect against the worst AI scenarios is a Universal Basic Income (UBI). The less fashionable Negative Income Tax offers an attractive formulation to achieve this outcome. It would ideally be paired with flatter income taxes.
- The Government should complete experiments and to continue to refine welfare and tax policies to build upon the current system of Universal Credit.

ABOUT THE AUTHOR

James Lawson is a Fellow of the Adam Smith Institute.

He is also a business advisor, supporting executives to transform their operations through AI and digital technologies.

James has been the Chief AI Evangelist at DataRobot, Director of Strategic Markets at WorkFusion, and a consultant on strategy and operations at Deloitte. His clients have included a range of global financial institutions and FTSE 100 companies, as well as the UK Government, City of London and Metropolitan Police.

He read philosophy, politics and economics at Oxford, with a particular focus on events since 1870.

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INTRODUCTION

"For suppose that every tool we had could perform its task, either at our bidding or itself perceiving the need, and if …shuttles in a loom could fly to and fro and a plucker play a lyre of their own accord, then master-craftsmen would have no need of servants nor masters of slaves."

- Aristotle, The Politics

Over the last decade, artificial intelligence (AI) research and development has resurged. This has been driven by the wider adoption of machine learning techniques in business, hardware improvements, and a greater willingness to invest.

Machine learning is increasingly widespread amongst leading technology companies and startups. Simultaneously, the provision of complementary tools has made AI much more useable and beneficial in practice. As Google argued, developing machine learning code is a small part of using AI, as "the required surrounding infrastructure is vast and complex".[1]

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1 Sculley, D, Gary Holt, Daniel Golovin, Eugene Davydov, Todd Phillips, Dietmar Ebner, Vinay Chaudhary, Michael Young, Jean-François Crespo, and Dan Dennison. 2015. "Hidden Technical Debt in Machine Learning Systems."

Computing hardware has become much more powerful at lower cost. For example, graphics cards typically used for video games have very effective processors for AI applications. Chip producer Nvidia claim that recent progress has made it fifty times faster to train an AI neural network.[2] Other processor companies are also prioritising AI applications and investing heavily. Intel has made $117m investments in AI startups in 2019 alone.[3] They are internally building new chips that could be 1,000 times faster for specialized applications.[4] Lower cost servers and cloud infrastructure also make AI easier to deploy for more rudimentary deployments today.

Investment in AI has also increased dramatically. In the last six years, over three thousand AI startups have received venture capital funding, totalling over $66 billion.[5] The pace of funding has been steadily rising. It is estimated it grew 72 per cent in 2018 alone. Despite weakening global markets, 2019 saw the trend continue.

In parallel to these developments, calls for restraint in the development of AI and warnings about the consequences have grown.

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2 Nvidia. 2018. "NVIDIA, Open-Source Ecosystem Accelerate Data Science | NVIDIA Blog." 2018. https://blogs.nvidia.com/blog/2018/10/10/rapids-data-science-open-source-community/?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+nvidiablog+%28The+NVIDIA+Blog%29.

3 Intel. 2019. "Intel Capital Announces $117 Million of New Investments in 14 Disruptive Tech Startups at Annual Global Summit | Intel Newsroom." 2019. https://newsroom.intel.com/news-releases/intel-capital-announces-117-million-new-investments-14-disruptive-tech-startups-annual-global-summit/.

4 Intel. 2019. "Intel's Pohoiki Beach, a 64-Chip Neuromorphic System, Delivers Breakthrough Results in Research Tests | Intel Newsroom." 2019. https://newsroom.intel.com/news/intels-pohoiki-beach-64-chip-neuromorphic-system-delivers-breakthrough-results-research-tests/.

5 Glasner, Joanna. 2019. "AI Companies Raise More Money Across Fewer Rounds – Crunchbase News." 2019. https://news.crunchbase.com/news/ai-companies-raise-more-money-across-fewer-rounds/.

This includes concerns about a full-scale apocalypse driven by AI. Science and technology leaders like Stephen Hawking, Bill Gates and Elon Musk even have warned of an existential threat to humanity.[6] Doomsayers also assert a more imminent threat: AI will bring the collapse of our economic order, driven by mass unemployment. More realistically, f AI is being used to automate work in businesses, under the stated goal of service improvement and cost reduction. This creates a real and broad concern that AI will lead to job losses.

Carl Benedikt Frey and Michael Osborne analysed 702 occupations, finding that 47 per cent of US work was at risk. They claimed that the next decade could produce profound transformation of our labour market[7].

In this context, this report seeks to take stock of the evidence about how AI could affect the labour market and help chart a path forward for government.

The report starts by defining AI and outlining the significance of recent developments (Chapter 1).

It then examines how AI has broad applications, is already changing the way we live, and is not just hype (Chapter 2).

The report then considers the historical context (Chapter 3). Today is far from the first time people have worried about the impact of technology on employment. AI is not the first automating technology. This highlights the central flaw with many past and recent pre-

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6 Catherine Clifford. 2018. "Elon Musk at SXSW: A.I. Is More Dangerous than Nuclear Weapons." CNBC. 2018. https://www.cnbc.com/2018/03/13/elon-musk-at-sxsw-a-i-is-more-dangerous-than-nuclear-weapons.html.

7 Benedikt Frey, Carl, and Michael Osborne. 2013. "The Future of Employment: How susceptible are jobs to computerisation?."

dictions about mass joblessness. The data shows that automation historically did not bring mass unemployment, but instead boosted economic activity and income levels.

Nevertheless, there is still a need to consider how AI could change the nature of the labour market (Chapter 4). There is consensus about the huge scope for automation, albeit a lack of precise forecasts. Job losses because of automation do not necessarily translate to significant unemployment, as it will take time for businesses to adopt AI and new jobs will be created.

What if this time things are different? There are four scenarios governments should consider. The report provides a framework that helps us to understand the possibilities. Overall, policymakers should not panic. AI will most likely be a force for good. Nevertheless, there will be some displacement. There is a role for government policy in helping the losers in this process.

Finally, the report turns its attention to policy. What are governments doing today (Chapter 5)? A survey of many developed countries shows a consistent but limited pattern. Finally, we consider how governments should respond (Chapter 6). The report provides several recommendations, both to change the UK Government's posture towards AI to embrace innovation, and to help mitigate the potential costs of automation. It proposes a radical programme extending across regulation, research and development (R&D), welfare and taxation. These recommendations are guided by the most-likely scenario and an optimistic view of AI. They are also robust even if the doomsayers claims prove to be correct.

1. WHAT IS AI?

"There would be no more need of disputation between two philosophers than between two calculators. For it would suffice for them to take their pencils in their hands and to sit down at the abacus, and say to each other (and if they so wish also to a friend called to help): Let us calculate."

- Gottfried Leibniz

AI is a broad field of study, often confused by conflicting usage of terms. To define AI, start by considering each word in turn. Artificial means made by people. *Artificial* is in contrast with something natural. For example, one might create artificial flowers that resemble flowers found naturally in a field. *Intelligence* means the ability to learn, understand and make judgements based on reason.

At its most basic, artificial intelligence are machines capable of intelligence. This is artificial, in contrast with humans who exhibit natural intelligence.

This is a useful definition to describe the overall field of study. However, this definition struggles in practice because the meaning of intelligence is open to debate, and the level of intelligence that

needs to be demonstrated is unclear.[8] The intelligence also needs to be applied to be proven.

Artificial intelligence traces its roots to at least the 17th century, when mathematician Pascal created some of the first calculators. Pascal's machines could add and subtract two numbers. We have since made significant advances. Calculators have become routine, and are viewed as helpful and useful tools: they are rarely considered artificial intelligence.

As we make advances, the scope of AI is disputed – the 'AI effect'. The 'AI effect' is the tendency to discount any advance in AI as not genuine, especially once the novelty has worn off:

"It's part of the history of the field of artificial intelligence that every time somebody figured out how to make a computer do something—play good checkers, solve simple but relatively informal problems—there was chorus of critics to say, "that's not thinking"[9].

Moreover, consumers rarely purchase AI directly, but use products and services that include AI. The best way for businesses to sell AI applications to customers is to make it so easy and beneficial to use that the recipient need not care about the underlying technology. This reinforces the AI effect.

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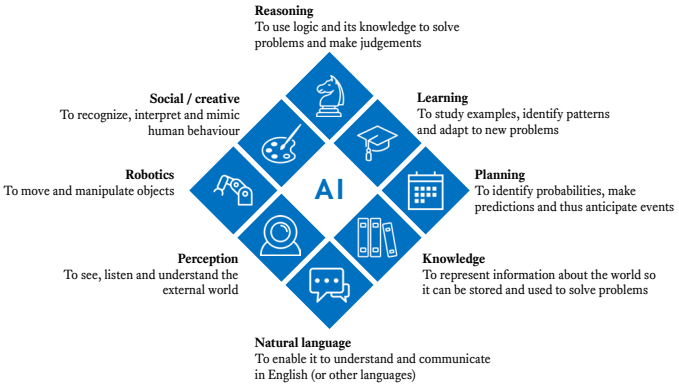
8 The definition of intelligence and associated concepts like knowledge, learning, understanding, judgement, and rationality are all open to extensive philosophical debate. These are not resolved here. For example, Knowledge has been defined by some philosophers as a "justified true belief" since the Enlightenment, and yet this has been challenged since "Is Justified True Belief Knowledge?" (Gettier, 1963). Instead, this paper will focus on examples that would be considered as intelligence in a practical layman or business context without seeking absolute precision.

9 McCorduck, Pamela. 2004. Machines Who Think. A K Peters.

To overcome the AI effect, consider the different aspects of intelligence. Alan Turing's famous Turing Test is helpful. In this test, an interrogator communicates with a computer and person, then attempts to identify the computer. If the computer is indistinguishable, it wins.

For AI to pass the test in most scenarios, a computer would need various capabilities, including resourcing, learning, planning, knowledge, natural language, perception, robotics, and social/creative.

Figure 1: Eight potential AI capabilities



At its most advanced, artificial general intelligence would mean a machine that could demonstrate any intelligence that a human can as well as or better than humans. This does not detract from the advances within, and use of, individual AI capabilities.

It is also possible to go beyond average human intelligence within individual fields – for example, since IBM's Deep Blue in 1997, computers have been world champions of chess.

It seems we have two options if we wish to discuss AI. We can accept

the broadest definition of artificial intelligence. Alternatively, we can counter the AI effect by focusing on the narrow capabilities being developed for today's AI challenges.

MACHINE LEARNING IS THE MOST IMPORTANT TODAY

Machine learning (ML) is the area of AI which has seen greatest progress over the last decade. ML is the underlying technique used to make progress in many of the other capabilities. Today cars are *learning* to perceive the external world (perception), physical machines are *learning* to manipulate objects (robotics) and chatbots are *learning* to understand your questions (natural language) rather than just having the rules manually written for them. This is an important distinction to understand today's developments in AI.

Traditionally, software has been created by writing rules. One or more programmers write explicit instructions for a computer. Each line of code tells the computer a specific calculation or action to take. This is what the Director of AI at Tesla somewhat disparagingly called "Software 1.0". By contrast, the new way of doing things, "Software 2.0", uses learning. Learning is primarily based on data, rather than rules. Data is gathered, cleaned, labelled and interpreted and then the computer builds its own rules. This approach can tackle more complex tasks and is more flexible – learning with new data.

Applying this distinction in practice, consider that chess champion Deep Blue was developed using the first approach. Using brute force rules, it could examine millions of different options in a single turn of chess, planning many moves ahead. This was a costly and difficult undertaking in 1996. Yet, this approach worked well, as chess has clearly-defined rules and boundaries. It did not use machine learn-

ing; as one Deep Blue developer put it, "It is not an artificial intelligence project in any way… we play chess through sheer speed of calculation"[10].

Machine learning brings more than the programming of rules and more computing power, though these are useful too. There are three broad types of machine learning: supervised, unsupervised and reinforcement.

Supervised machine learning is created by having both the inputs and the outputs to a problem. The outputs are usually provided by people or from historic data, hence "supervision" and this is known as training data. Unsupervised machine learning just uses the inputs, and looks independently for patterns. Reinforcement learning also doesn't need the outputs, but is guided by rewards. Good actions are rewarded and the machine attempts to maximise its reward. It becomes smarter as it considers more scenarios. Regardless of type, all three have the benefit of being data-driven, and having the potential to improve over time with more data and more extended learning.

Another area of progress is deep learning, a set of algorithms forming part of the broader machine learning family. These use artificial neural networks, inspired by the workings of a brain, to enhance AI's capabilities further. This area has attracted a lot of hype in recent years, as it strengthens AI's capabilities in processing complex information, like images, audio and video. However, these techniques have yet to be fully adopted by businesses, suggesting there is a gap between research and business adoption.

This distinction between 'Software 1.0' and 'Software 2.0' is subject

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10 Krauthammer, Charles. 1997. "Be Afraid." 1997. https://www.washingtonexaminer.com/weekly-standard/be-afraid-9802.

to debate. Critics of the concept argue they are similar. Both use huge amounts of processing power to complete some form of statistical analysis to make decisions. Yet, however we define our approach, the ability for machines to learn from data opens new possibilities.

In practice, machine learning means we can now automate a greater range of work, more easily, so long as we have data. There has been an exponential increase in data since the digital age began in the 1960s and accelerated in the 2000s. Machine learning is also becoming cheaper and easier to use. As this drives a boom in the use of AI, so our attention has turned to the impact this may have.

1. WHAT IS AI?

"Just as electricity transformed almost everything 100 years ago, today I actually have a hard time thinking of an industry that I don't think AI will transform in the next several years"

Andrew Ng[11]

AI is growing quickly, powered by improvements in machine learning, an abundance of data, more improved hardware, and increased investment. To consider its potential impact on jobs, one needs to determine if the changes AI bring actually matter, or are just hype.

To make this judgement, it helps to consider the latest applications of AI in a few areas of society and to consider how these might progress in the short term.

AI is not just hype. It is having a profound impact across our lives. Its presence extends from the entertainment sector through to transportation, healthcare and office work. AI is a general technology, which can be applied across industries.

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11 Stanford Business. 2017. "Andrew Ng: Why AI Is the New Electricity | Stanford Graduate School of Business." 2017. https://www.gsb.stanford.edu/insights/andrew-ng-why-ai-new-electricity.

AI ALLOWS FOR TAILORING SERVICES TO CUSTOMER NEEDS

Customer experience is paramount in the service sector. Businesses want to ensure customers are satisfied with what they receive. This makes the customer more likely to return for further business or even to spread the word to other potential customers.

A good employee adjusts their approach to each customer. A good product is personalised: compare a bespoke tailored suit with an 'off-the-peg' suit provided in 10 different sizes, or a jacket sold in 'small, medium or large'. The challenge for businesses is that personalised experience requires more effort and higher costs.

The 'holy grail' of customer service is to provide a perfectly tailored offering – bespoke to each individual - at no extra cost. This is where artificial intelligence can prove valuable. Using data about a customer, including their demographics, and their past business history with a firm, it is possible to produce a tailored service.

Since its founding in 2006, Spotify has grown to a nearly $50 billion company and leader in music streaming. In 2015, they debuted the 'Discover Weekly' playlist. This service combines three different types of AI models to determine music you might like.

Firstly, Spotify looks at your preferences (songs you listened to, listen counts, artist pages you have viewed, songs saved in playlists, etc.) and compares this to other users. Using a technique known as "Collaborative Filtering", they can introduce you not only to music you have listened to but also material that other people *like* you listen to. Secondly, Spotify analyses text (lyrics, articles about music, etc.) to determine music that has similarities. Thirdly, Spotify analyses the audio files themselves.

Spotify uses this technology to create a mixtape for its customers, filled with new discoveries and highly-tailored content, each Monday. This contrasts with the hand-selected curator approach used by competitors, who can only create playlists by genre.

Discover Weekly playlists achieved immense success, with customers playing them over a billion times in a matter of months. Spotify soon extended the initiatives to a 'Release Radar' generating playlists for new releases, and 'Daily Mixes,' which provide an endless stream based on a customer's profiles, segmented into different evolving sub-genres.

AI IS MAKING DRIVERLESS VEHICLES A REALITY

At least fifty people died of traffic injuries in the time it takes a typical reader to reach this point in the report. Another is killed every 25 seconds. More than 1.35 million will die on the world's roads every year.[12] Traffic accidents are the leading cause of preventable death amongst young people.

Even in Europe, the safest region in the world, 85,000 lives are lost annually from car accidents. The British are among the safest drivers in the world, but even we lose more than five people every day. Many more sustain injuries (around 50 million globally), suffering adverse health consequences.

According to the World Health Organization, 3 per cent of global GDP is lost due to car deaths and injuries. All this happens despite significant improvements in vehicle safety, the UN's resolution on

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12 WHO. 2018. Global Status Report on Road Safety 2018.

road safety, and the fact that it is preventable.

Artificial intelligence has the potential to ensure that nobody need die on the roads, except perhaps those who choose to follow the practice of manual driving, for leisure or sport. Driverless vehicles could become the norm within our lifetime.

There are different levels of autonomy. The generally accepted set of definitions establish six levels of automotive automation.[13] Tesla cars already come with an autopilot mode, demonstrating 'level 3 - conditional assistance'. This means a Tesla car can take control of itself, but with the expectation that a human driver will intervene when required. The eventual goal is 'level 5 – full automation'. Autonomous vehicles are still under development, and even when implemented, developing countries will take time to catch up but it is now a debate over when this autonomy will be readily available to the public rather than a question of feasibility.

Autonomous vehicles are already safer in many conditions. They have constant 360-degree vision, with no blind spots, as well as ultrasonic sensors and radars. They do not get distracted, tired, or drink alcohol. They can be prevented from straying from the highway code, or breaking speed limits. Advances in driverless cars are already contributing to more general road safety, with features like automatic emergency braking and collision warnings aiding human drivers.

Autonomous cars would bring a wide range of other benefits in addition to improving road safety. Without drivers, the concept of a car

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13 SAE International. 2018. "SAE International Releases Updated Visual Chart for Its 'Levels of Driving Automation' Standard for Self-Driving Vehicles." 2018. https://www.sae.org/news/press-room/2018/12/sae-international-releases-updated-visual-chart-for-its-"levels-of-driving-automation"-standard-for-self-driving-vehicles.

can change to be more pleasant for travellers. It's likely a typical vehicle would have seats facing each other for conversation, whilst others might have beds or office facilities with full internet access. The average motorist spends hundreds of hours driving each year – time they will instead have for work or leisure.

There will be less pressure on inner cities, as people become more willing to commute longer distances, yet still are able to reach work or enjoy evening entertainment. Driverless vehicles also could reduce congestion and emissions by calculating the optimum route and driving approach.

Finally, driverless vehicles will improve access and reduce costs. Eventually, few people will need to own a car, instead paying for journeys per trip, sharing a pool of cars that are utilised more consistently.Accompanied by driverless cars for personal ownership and use, it is no major leap to expect driverless taxis, driverless deliveries and driverless trucking. Tesla promises "one million" robotaxis imminently – a huge influx of competition into the market, and undercutting existing suppliers with a cost target of under $0.18 per mile, compared to $2-3 for Uber and Lyft (and presumably more for most taxis).[14] This extension of driverless technology would surely have a disruptive impact on transportation.

AI IS BEING USED TO IMPROVE HEALTHCARE OUTCOMES

There are a broad range of AI applications in medicine including encouraging healthier behaviour, disease detection, diagnosis, treat-

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14 Tesla. 2019. "Tesla Autonomy Day - YouTube." 2019. https://www.youtube.com/watch?v=Ucp0TTmvqOE.

ment planning, and research for drug discovery.

One UK startup, Babylon Health, has automated the process of diagnosis for issues patients would typically raise with their general practitioner (GP). This is delivered through a chatbot style interface, which uses AI both to understand the patient's responses and to generate additional questions for further data gathering and clarification. This is not a trivial exercise. Patients describe the same symptoms differently, there are billions of combinations of symptoms, and even more options when comparing those symptoms to medical conditions. Whilst there are exceptions, and Babylon also provides a digital platform to video call a real doctor, this approach can help patients with many cases.

Data from Babylon's partnership with the NHS's 111 already shows positive results[15]. In 40 per cent of cases patients were directed towards self-managed outcomes – potentially a huge reduction in pressure on health services dealing with unnecessary cases. This is an effective saving of £10.58 per case, according to the evaluation. In 28 per cent of cases it referred people to a GP and in 21 per cent to Urgent & Emergency care. These outcomes are arguably better than the NHS 111 phone service, where the same proportion are referred to Urgent & Emergency care (i.e. the cases where there is an urgent need), but a much higher proportion are sent to GPs (potentially wasting their time on unnecessary cases). The data suggests the AI was relatively safe and accurate, achieving 90.2 per cent accuracy compared to 73.5-77.5 per cent for nurses and doctors.

Now that computer vision can reach human or superior levels of accuracy, AI can be applied to the assessment of medical images for complex scenarios. This makes it easier to diagnose issues in criti-

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15 Babylon. 2017. "NHS 111 Powered by Babylon Outcomes Evaluation."

cal areas like eye diseases or cancer. Greater speed and accuracy of diagnosis means that more appropriate and timely treatments. This approach is being deployed, or at least tested, for a wide range of conditions. DeepMind and Cancer Research UK Imperial Centre has been working on a diagnosing breast cancer on mammograms.[16] DeepMind has also completed research where they could detect eye conditions and head/neck cancers to a similar standard as experts.[17][18]

Real-time medical data, from basics recorded by phones, through to more precise data from wearables or hospital monitors, combined with AI can also be used to detect when an intervention is required. Apple's 4th generation Apple Watch includes an electrocardiogram, which measures a heart's electrical activity. Using data from this device, researchers have used AI to pre-emptively detect various heart issues[19].

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16 DeepMind. 2018. "Expanding Our Research on Breast Cancer Screening to Japan | DeepMind." 2018. https://deepmind.com/blog/announcements/breast-cancer-screening-japan.

17 Fauw, Jeffrey De, Joseph R. Ledsam, Bernardino Romera-Paredes, Stanislav Nikolov, Nenad Tomasev, Sam Blackwell, Harry Askham, et al. 2018. "Clinically Applicable Deep Learning for Diagnosis and Referral in Retinal Disease." Nature Medicine 24 (9): 1342–50. https://doi.org/10.1038/s41591-018-0107-6.

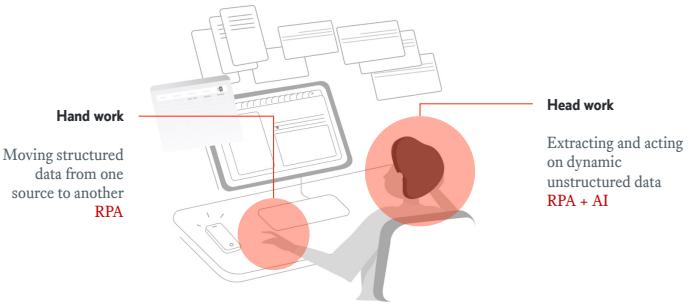
18 Nikolov, Stanislav, Sam Blackwell, Ruheena Mendes, Jeffrey De Fauw, Clemens Meyer, Cían Hughes, Harry Askham, et al. 2018. "Deep Learning to Achieve Clinically Applicable Segmentation of Head and Neck Anatomy for Radiotherapy," September. http://arxiv.org/abs/1809.04430.

19 Green, Eric M., Reinier van Mourik, Charles Wolfus, Stephen B. Heitner, Onur Dur, and Marc J. Semigran. 2019. "Machine Learning Detection of Obstructive Hypertrophic Cardiomyopathy Using a Wearable Biosensor." Npj Digital Medicine 2 (1). https://doi.org/10.1038/s41746-019-0130-0.

AI IS TRANSFORMING THE WORLD OF TRADITIONAL OFFICE WORK

AI is automating mundane manual work and supporting better decision making. Intelligent automation is a new category of software available to businesses.[20] WorkFusion, for example, combines traditional rules-based coding for routine "hand" work, with AI for the more complex "head" work.

FIGURE 2: HAND WORK AND HEAD WORK [21]



A customer deploying WorkFusion can ingest data even with varying sources, formats or languages. The platform has users teach its learning robots how to perform everyday work. The simplest example is the processing of invoices. Invoices are too unstructured and variable for rules or templates to achieve optimal results. With AI, the learning robots would observe how people process the invoices, until they

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20 In the spirit of full disclosure, please note the examples of intelligent automation and predictive analytics provided are those resulting from the author's first-hand experience working for WorkFusion and DataRobot. This report was written in a personal capacity, and the views contained within and any errors made reflect upon the author alone.

21 Reproduced with permission from WorkFusion, Inc.

were good enough to perform the majority of the work themselves.[22]

Taking this concept further, WorkFusion also offers pre-built solutions for complex use cases applicable to many businesses. These solutions delivered a high return on investment due to the speed of implementation and by tackling areas previously dependent upon manual work. The first use case WorkFusion pre-built was to help in the fight against financial crime and money laundering.

Banks have a moral and legal obligation to help prevent crime. Banks frequently have new customers and review their existing clientele. The most performed check is known as a 'negative news' search. A bank analyst will search the customer's name online for any news that might indicate that they are compromised or connected to any unacceptable risk factors – if you have been charged for money laundering offences, the bank does not want you as a customer. This has historically been a highly manual process, but using AI, banks can achieve a 70-80% boost in efficiency – both reducing the cost of doing these checks and allowing their investigations to be more thorough.

AI can also be used to tackle new challenges or to make better predictions to guide the business decision making. DataRobot was a pioneer of "Automated Machine Learning" and has since built a wider AI platform. This makes it easier to create and deploy AI in a business context by automating and accelerating a lot of the data science work. In doing so, DataRobot is helping democratise the use of AI. To

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22 WorkFusion was cited by Martin Ford as a "vivid example of the dramatic impact that white-collar automation is likely to have on organizations … As the workers complete their assigned tasks, WorkFusion's machine learning algorithms continuously look for opportunities to further automate the process … they are simultaneously generating the training data that will gradually lead to their replacement with full automation."See: Ford, Martin. 2015. Rise of the Robots.

date DataRobot has built over 1.5 billion models for over 3,000 companies. Applications include examining the likelihood of a bank loan defaulting, helping insurance companies better manage risks, enabling retailers to understand customer satisfaction, predicting the results of the Wimbledon tennis championships and helping charities better manage water supplies across Africa.

These varied applications of artificial intelligence, from music to transport, healthcare and office work show how AI is not only real, but increasingly used all around us. These examples provide a useful counter to the sceptics who see AI as 'snake oil', or simply a minor extension of personal computing. AI is already being used to tackle huge challenges, and if it can achieve a fraction of its potential, it will have a profound impact on most aspects of our society and economy. AI is not just restricted to the world of academia. It is being successfully deployed today. It is realistic to expect that AI will impact the labour market through automating jobs – the question of how many is addressed next.

3. HAVE WE BEEN HERE BEFORE?

"As the liberty lads o'er the sea
Bought their freedom, and cheaply, with blood,
So we, boys, we
Shall die fighting or live free,
And down with all kings but King Ludd!

- Lord Byron, Song for the Luddites

We are not the first people in history to worry about the impact of technology on jobs. For at least the last two centuries, if not more, there have been warnings that mass unemployment is coming as a result of new technology. There has been a steady stream of doom-mongers who opposed new technology, with sizeable waves of opposition emerging on a cyclical basis at times of great technological change. These concerns have persistently proven exaggerated but risked slowing humanity's progress.

This debate is also reignited during every recession, as people incorrectly link the unemployment caused by an economic dislocation with the prior innovations that were delivered during the boom years. After a historically long period of growth, and with AI currently mak-

ing rapid advances, fears are likely to reach a fever pitch during the current economic crisis.

The impact of COVID-19 on the labour market is still not fully understood, but the outlook is poor. According to the Office of National Statistics, the April unemployment statistics reached 1.3 million.[23][24] However, this hides arguably the true impact of the crisis, with the lockdown leading to a record fall in total weekly hours worked of 175.3 million, or 16.7 per cent. This is the largest fall since estimates began in 1971. Benefit claimants reached 2.3 million in April and the Office for Budget Responsibility forecasts that unemployment could reach 4 million, or 11.6 per cent of the workforce[25]. At the time of publication, nearly 10 million employees are furloughed under the job retention scheme, more than one quarter of the total workforce.[26] Many businesses on the brink of collapse (e.g. in hospitality) in the coming months, the full extent of the crisis has yet to be felt. Despite the clear origins of the crisis, AI and automation could be a scapegoat if the recovery of job opportunities is slow.

Fears about AI's impact on jobs predate the pandemic. In 2019, US Democratic presidential primary candidate Andrew Yang attempted to make automation the top issue of the 2020 election. He warned of unemployment at "levels not seen since the Great Depression", when

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23 BBC. 2020. "Coronavirus: UK Payrolls Shrink by 649,000 Jobs in Lockdown - BBC News." BBC. 2020. https://www.bbc.co.uk/news/business-53427304.

24 BBC. 2020. "Jobless Figures 'not Showing Full Extent of Crisis' - BBC News." BBC. 2020. https://www.bbc.com/news/business-53416207.

25 OBR. 2020. "Fiscal Sustainability Report ." OBR. 2020. https://cdn.obr.uk/OBR_FSR_July_2020.pdf.

26 Statista. 2020. "UK Number of People on Furlough 2020." Statista. 2020. https://www.statista.com/statistics/1116638/uk-number-of-people-on-furlough/.

it peaked at 25 per cent.[27] Yang is inspired by the work of techno-pessimists like Martin Ford, author of *Rise of the Robots: Technology and the Threat of a Jobless Future*. Ford's thesis warns of "devastating" long term unemployment and underemployment as:

> "Virtually every industry in existence is likely to become less labor-intensive as new technology is assimilated into business models—and that transition could happen quite rapidly. At the same time, the new industries that emerge will nearly always incorporate powerful labor-saving technology right from their inception"[28]

The fear of automation is not isolated to a few outlier commentators and politicians. Roughly half of technology experts believe that more jobs will be displaced by AI than created by 2025.[29] In later research, Pew found that over three-quarters (77 per cent) of Americans believe it is at least somewhat realistic to expect robots to occupy many jobs, and about three quarters (regardless of their background) worry about this prospect.[30] In response, many favour restrictive policies to limit change. For example, 85 per cent supported limiting the use of AI only to dirty and dangerous jobs. This general pessimism was reinforced by Pew's latest research showing Americans believe automation has done more harm than good, will take over most work,

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27 Yang2020. 2019. "The Tech 1,000 - Andrew Yang for President." 2019. https://www.yang2020.com/the-tech-1000/.

28 Ford, Martin. 2015. Rise of the Robots.

29 Smith, Aaron, and Janna Anderson. 2014. "AI, Robotics, and the Future of Jobs." https://www.pewinternet.org/wp-content/uploads/sites/9/2014/08/Future-of-AI-Robotics-and-Jobs.pdf.

30 Smith, Aaron, and Monica Anderson. 2017. "Automation In Everyday Life." Vol. 4. https://www.pewinternet.org/wp-content/uploads/sites/9/2017/10/PI_2017.10.04_Automation_FINAL.pdf.

and bring more inequality. These fears are mirrored elsewhere, with 30 per cent of respondents in a UK survey saying they thought it was likely that their job would be replaced by AI within 20 years.[31] A more recent study showed that 64 per cent of Britons "want to see more regulation introduced to make AI safer".[32]

MANY ARE GUILTY OF THE LUDDITE FALLACY

The economy is often thought of in static terms. This means people assume that robots and people are competing for a *fixed* number of jobs. Karl Marx wrote that, "The instrument of labour, when it takes the form of a machine, immediately becomes a competitor of the workman himself."[33] The result would be that the worker is "rendered superfluous" or at best, sees wages fall below the value of the work.

This is a somewhat intuitive hypothesis. It suggests that if work that used to be completed manually is now automated, there is less need to employ a person. Moreover, if many positions are automated, this suggests that displacement of existing workers will result in mass unemployment and wage reductions. If large numbers of jobs are at

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31 Sky News. n.d. "How Likely or Unlikely Do You Think It Is That Your Job Will Be Replaced by an Artificially Intelligent Robot or Computer in the next 20 Years?" Sky News. Accessed July 24, 2020. https://interactive.news.sky.com/Robots_Tabs_FULL.pdf.

32 "New Research Reveals How Many Brits Want Greater Regulation of AI." 2020. 2020. https://ebom.com/new-research-reveals-how-many-brits-want-greater-regulation-of-ai/.

33 Marx, Karl. 1867. "Economic Manuscripts: Capital Vol. I — Chapter Fifteen." 1867. https://www.marxists.org/archive/marx/works/1867-c1/ch15.htm#S5.

high risk of automation from AI then the result would be widespread unemployment.

This argument is fundamentally flawed. There is not a limited and static number of jobs. More jobs can – and almost certainly will – be created. There is no finite number of jobs. As old jobs, especially dull and mundane ones are automated, new and better jobs can be created. People can be paid better and do more interesting work. We can use labour resources more efficiently and to generate greater economic value.

Economist David Schloss, in 1891, first debunked the "lump of labour" fallacy. Frederic Bastiat wrote in 1849 of faulty economics resulting from '*What is seen and what is not seen*'. It is common to focus on what we can see today rather than what could exist in the future. Today, it is easy to see how work is being automated but harder to conceive of the new opportunities and future jobs. It's also easier for politicians to blame others (competitor countries, technologies, immigrants, etc.) than to focus on creating an environment that facilitates job creation.

The Luddites were English textile workers who rebelled against mechanisation during the 19th century. They gained infamy by smashing stocking frames, a type of mechanical knitting machine, among other equipment. This was during a period of challenging economic conditions, and they feared competition from machines and less skilled workers. They were ultimately proven deeply wrong, leading to the phrase "Luddite fallacy". "If the Luddite fallacy were true we would all be out of work because productivity has been increasing

for two centuries"[34].

FEARS OF AUTOMATION AND TECHNOLOGY STEM FROM LONG BEFORE THE LUDDITES

Pericles of the Athenian golden age, who launched publicly-funded infrastructure projects, worried in part about unemployment resulting from competition from technology and slaves. Later the Roman emperor Vespasian is said to have paid an engineer for his invention, only to reject its use, declaring "you must let me feed my poor commons"[35]

Automated manufacturing and computers in the 20th century ha echoes of today's AI automation panic. Engineer James Albus proposed in the 1970s that the "economic system is not structured to deal with the implications of a robot revolution" and that automation would "undermine the financial security of virtually every American family".[36] Albus subsequently admitted this "has not been borne out by experience … there is no evidence that automation has increased unemployment … quite the opposite".[37] In the 1980s, historian David Noble warned that automation was a tool of "control and domination", and that with the second industrial revolution,

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34 Tabarrok, Alex. 2003. "Productivity and Unemployment -." Marginal Revolution. https://marginalrevolution.com/marginalrevolution/2003/12/productivity_an.html.

35 Suetonius. 1914. The Lives of the Twelve Caesars. Edited by J.C. Rolfe. Loeb Classical Library. http://penelope.uchicago.edu/Thayer/E/Roman/Texts/Suetonius/12Caesars/Vespasian*.html.

36 Albus, James. 2004. Peoples' Capitalism: The Economics of the Robot Revolution (Online Edition).

37 Ibid.

"the spectre of permanent structural unemployment… has now surfaced for all to see".[38] Economist Jeremy Rifkin wrote "The End of Work" in the 1990s. He argued that the computer revolution would bring us "ever closer to a near-workerless world" which could "spell a death sentence for civilization" unless radical interventions were implemented.[39]

These panics about automation have proven unsubstantiated. Despite economic cycles, productivity issues, and other challenges in developed economies, the overwhelming trend has been a general rise in prosperity. There has been a profound change in the nature of work over the last 200 years, but there has not been mass joblessness. In 1871, around 1 million people in England and Wales were classed as agricultural labourers, a significant proportion of the labour force.[40] Today the number of agricultural labourers is below 100,000 and as the labour force has grown, the share of workers in these occupations has fallen by over 95 per cent.

Deloitte has analysed the last fifteen years of employment data.the UK is amidst a technology-driven shift from low skill routine work to non-routine work. This historic data provides greater perspective to the concerns about so many jobs being susceptible to automation. Whilst 800,000 jobs were lost, the Deloitte analysis suggests 3.5 million new ones were created – with gains outstripping losses more than four times over.[41] Positions such as personal assis-

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38 Noble, David. 2011. Forces of Production: A Social History of Industrial Automation. Transaction Publishers.

39 Rifkin, Jeremy. 1995. The End of Work: The Decline of the Global Labor Force and the Dawn of the Post-Market Era.

40 Deloitte. 2015. "Technology and People: The Great Job-Creating Machine."

41 Deloitte. 2015. "From Brawn to Brains The Impact of Technology on Jobs in the UK."

tants, secretaries and typists saw the greatest decline whilst jobs as care workers, nurses, and in teaching grew dramatically. These were also better jobs, paying around £10,000 more per annum than those they replaced. The benefits were spread across all regions of the UK. Their survey of businesses suggests all these trends will continue, with almost three-quarters of responding firms planning to create more jobs overall. Employers both cite automation as a primary driver of existing headcount reduction while at the same time have plans to increase their overall headcount. A similar study from McKinsey estimated that the computer revolution has created 15.8 million net new jobs in the United States since 1980.[42] There has been no mass unemployment.

Deloitte also completed a wider assessment of technology over the last 150 years. Again, the data shows more jobs have been created than destroyed, that pay has risen, and that the nature of work has improved.[43] Jobs have been transformed from focusing on manual muscle power, towards providing services and knowledge-intensive fields (for example teaching, medical care, and accounting). They recognise the susceptibility towards the Luddite fallacy despite the data, because "the role played by technology in boosting employment often goes overlooked because of its more conspicuous destructive effects". Automation and the displacement of a job is highly visible, often getting headline focus in the affected communities, while new posts and diversification in the forms of employment do not.

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42 McKinsey. 2017. "Five Lessons from History on AI, Automation, and Employment |." 2017. https://www.mckinsey.com/featured-insights/future-of-work/five-lessons-from-history-on-ai-automation-and-employment.

43 Deloitte. 2015. "Technology and People: The Great Job-Creating Machine."

DOOMSAYER WARNINGS OF MASS UNEMPLOYMENT CANNOT BE FALSIFIED

Whenever a prediction of mass unemployment is found wanting by decades of real data, a new doomsayer emerges to tell us that the real revolution is *actually coming now*. Each time we are told that things are actually different, because automation is *more significant*, general and faster than ever before.

There is little dispute that AI will have a significant impact, even that it will automate some forms of work performed manually today. What is much less certain is how quickly it will be adopted, the scale of its impact, and the ability of the wider economy to adapt with the creation of new jobs.

It is possible that this time is *actually* different. However, scrutiny of the long history of inaccurate past predictions of economic distress and doom suggests that the best strategy is to consider all possible scenarios, determine the most likely scenario, and proceed with caution before intervening.

Historically automation has been a force for good, and doomsday scenarios have been proved inaccurate. Caution is still advisable regarding AI to address the possibility of slow wage growth, concentrated losers, and of poor policy decisions.

Automation has proven to be positive, but displacement still comes at a cost. Those whose work is fully or partly automated will hardly relish the prospect of losing their job, even if they later find a better one. It may not be so easy; the search may be hard for some and involves significant change. In some cases, there may even be long term losers.

The period between 1780 and 1840 has been labelled "Engel's

Pause": employment remained high, but displacement caused wage stagnation. The latest data brings this hypothesis into question.[44] It shows a much more substantial and consistent rise in wages throughout the Industrial Revolution.[45] Real wages grew 82 per cent between 1770 and 1860. Regardless, the short-run impact of automation cannot be ignored, particularly if automation's benefits are not evenly distributed and some see slowing wage growth – or worse.

Returning to the era of the Luddites, it is clear that even without a general stagnation, automation can result in some concentrated losers. Consider the invention of the power loom, a key advancement in weaving. First built in 1785, there were soon thousands in use. Their adoption reduced the need for handweaving, causing job losses for this group. The high demand for cloth and the associated earnings of hand weavers arguably accelerated the adoption of power looms. The power looms "in turn, devalued the old skills, so poverty accompanied progress".[46] The Carlton Weavers outside Glasgow were soon rioting. They were driven by their desperate condition. In the long run, or in looking at overall production and sector earnings, this might have been totally misguided but from their individual perspective, it was very much justified, especially at the time.

Public opinion is already sceptical about AI and automation. The possibility of displacement of existing workers and concentrated los-

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44 Allen, Robert C. 2009. "Engels' Pause: Technical Change, Capital Accumulation, and Inequality in the British Industrial Revolution." Explorations in Economic History. https://doi.org/10.1016/j.eeh.2009.04.004.

45 Clark, Gregory. 2005. "The Condition of the Working Class in England, 1209–2004." Journal of Political Economy 113 (6): 1307–40. https://doi.org/10.1086/498123.

46 Allen, Robert C. 2017. "The Hand-Loom Weaver and the Power Loom: A Schumpeterian Perspective Division of Social Science Working Paper Series." http://nyuad.nyu.edu/en/academics/academic-divisions/social-science.html.

ers creates a significant risk. It is likely that there will be intensified political pressure to resist new technology.

This is what Carl Benedikt Frey calls a "Technology Trap" – one of the reasons for stagnation before the Industrial Revolution.

> "The future of AI depends on how we manage the short run. If we seek to understand the challenges ahead rather than glossing over them in the belief that in the long run everyone will come out ahead, we will be in a much better position to shape the outcome… As there has been a populist backlash against globalization, we should be concerned that populists might easily and effectively tap into growing anxiety about automation as well, unless we address it."[47]

A backlash against AI risks restrictive policies, slowing the pace of technological progress and the associated human advancement. This would ultimately make everyone worse off.

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47 Frey, Carl Benedikt. 2019. "The Technology Trap."

3. HOW MANY JOBS COULD BE AUTOMATED?

"It is an era that will be defined by a fundamental shift in the relationship between workers and machines. That shift will ultimately challenge one of our most basic assumptions about technology: that machines are tools that increase the productivity of workers. Instead, machines themselves are turning into workers, and the line between the capability of labor and capital is blurring as never before"

- Martin Ford[48]

MANY JOBS ARE VULNERABLE TO AUTOMATION FROM AI, BUT THERE IS LITTLE CERTAINTY

Several studies have attempted to assess the impact of AI on existing jobs. They suggest that a vast number of jobs are susceptible to automation with current technology or within the coming decades. Perhaps the most famous is the 2013 paper, *The Future of Employment:*

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48 Ford, Martin. 2015. Ibid.

How Susceptible Are Jobs to Computerisation?, in which Oxford academics Dr Carl Benedikt Frey and Professor Michael Osborne concluded that "47 per cent of total US employment is at risk".[49] They also found 19 per cent at medium risk and 33 per cent at low risk. Logistics operations and administrative support are most at risk of automation. There is also a negative correlation between wages and education attainment with the risk of automation, that is, the lowest paid and least skilled are most at risk.

Frey and Osborne estimated the probability of computerisation of 702 jobs using data from the US Department of Labor, which defines the key features of a job. They also held workshops with machine learning researchers from Oxford University's Department of Engineering Sciences to discuss a sample of 70 jobs. They assessed that tasks can be split into those which are routine (following simple rules that can be coded) and non-routine (too complex or hard to understand to be easily coded). Tasks also can be split into those which are manual (physical) or cognitive (knowledge) based.

Automation traditionally has been focused on routine tasks, manual or cognitive. AI extends automation into the non-routine. However, there are various challenges, or bottlenecks, that make automation of non-routine tasks difficult, even with AI. As Frey and Osborne claim:

> "Some inhibiting engineering bottlenecks to computerisation persist. Beyond these bottlenecks, however, we argue that it is largely already technologically possible to automate almost any task"[50]

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49 Benedikt Frey, Carl, and Michael Osborne. 2013. Ibid.

50 Benedikt Frey, Carl, and Michael Osborne. 2013. Ibid.

Table 1. Computerisation bottleneck

Computerisation bottleneck	Variable	Description
Perception and Manipulation	Finger Dexterity	The ability to make precisely coordinated movements of the fingers of one or both hands to grasp, manipulate, or assemble very small objects.
	Manual Dexterity	The ability to quickly move your hand, your hand together with your arm, or your two hands to grasp, manipulate, or assemble objects.
	Cramped Work Space, Awkward Positions	How often does this job require working in cramped work spaces that requires getting into awkward positions?
Creative Intelligence	Originality	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.
	Fine Arts	Knowledge of theory and techniques required to compose, produce, and perform works of music, dance, visual arts, drama, and sculpture.
Social Intelligence	Social Perceptiveness	Being aware of others' reactions and understanding why they react as they do.
	Negotiation	Bringing others together and trying to reconcile differences.
	Persuasion	Persuading others to change their minds or behavior.
	Assisting and Caring for Others	Providing personal assistance, medical attention, emotional support, or other personal care to others such as coworkers, customers, or patients.

Reproduced from The Future of Employment: How Susceptible Are Jobs to Computerisation?

They assume jobs with tasks producing lots of computerisation bottlenecks (like the need to have social perceptiveness or manual dexterity) are less vulnerable to automation. Those jobs which require more routine tasks are more vulnerable to automation.

The Frey-Osborne methodology has been applied to the UK economy, showing that 35 per cent of jobs are at risk.

Deloitte took the underlying methodology, in collaboration with Frey and Osborne, and translated the analysis to the UK job market [51]. They found that 35 per cent of jobs are at high risk over the next twenty years. The inverse relationship between wages and automation risk was high, with jobs paying less than £30,000 five times more susceptible to automation.

These findings provide a useful directional guide about the scope of automation but are subjective, may not translate into job losses, and are unclear on timelines or the net impact on employment. Simply put, a "risk" of automation does not mean the job will be automated and nor does it mean that other jobs will be created like in the past.

Interpretations of the study, like the BBC's, *Will a robot take your job?*, should be treated with some caution.[52] Despite the modelling and data, the study remains quite subjective at its core, with multiple issues that could radically impact the estimates including. There were a number of subjective, and potentially bias assessments involved in deciding what can and cannot be automated and bottle-

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51 Deloitte. 2014. "Agiletown: The Relentless March of Technology and London's Response."

52 BBC. 2015. "Will a Robot Take Your Job? - BBC News." 2015. https://www.bbc.com/news/technology-34066941.

necks. Oxford machine learning researchers may be excessively optimistic, there is ongoing research into issues such as finger dexterity, and, using a different source description of jobs, from the OECD, produces very different results.

Considerable caution is needed, especially as the conclusions of Frey and Osborne's paper and others like it do not necessarily translate directly into job losses.

After decades of stagnating productivity across the developed world, automation could create opportunities for many workers to produce more and at a higher quality. The results suggest that the need for labour input into a particular job might decline significantly where a job is susceptible to automation but it does not follow that the job will be removed altogether. Rather than fewer workers being retained, those employed may produce more, and to a higher standard.

Perhaps more time will be spent on other tasks enabling workers and their employers to improve quality. Leaving simpler work to the AI tools may permit greater focus on the exceptions and validation, improving the overall customer experience and reducing current blockages and obstacles to business. It is also possible that the focus for a job might change altogether, but without this implying the elimination of the post.

The Frey and Osborne study also gives us a limited guide into the timelines involved or how the labour market will react. As Frey and Osborne openly concede, their focus is on the "potential job automatability over some *unspecified* number of years". This paper merely specifies an expectation that those jobs cited are at risk, "perhaps over the next decade or two". The desire to convert their report into a specific headline-grabbing forecast has twisted their findings beyond their original intent. As Frey and Osborne clarified in a follow up

article:

> "Our estimates have often been taken to imply an employment apocalypse. Yet that is not what we intended or suggested. All we showed is that the potential scope of automation is vast, just as it was at the eve of the Second Industrial Revolution, before electricity and the internal combustion engine rendered many of the jobs that existed in 1900 redundant. Had our great grandfathers tried to make a similar assessment by the turn of the twentieth century, they would probably have arrived at a similar figure. Back in 1900, over 40% of the workforce was employed in agriculture. Now it is less than 2%."[53]

The speed at which automation is adopted will depend on a range of factors - not just technology - including the availability of labour, the cost of capital, and political circumstances.In a flexible labour market, new jobs might be created faster than old ones are lost. The relationship between automation (scope and speed) and labour market flexibility ultimately will determine the net impact on employment.

A wide range of competing estimates have emerged. Their main value is in reminding us to treat predictions with caution and appreciate the limits of modelling.

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53 Frey, Carl Benedikt, and Michael Osborne. 2018. "Automation and the Future of Work –… | Oxford Martin School." 2018. https://www.oxfordmartin.ox.ac.uk/blog/automation-and-the-future-of-work-understanding-the-numbers/.

Table 2. Job loss estimates

Source	Jobs at high risk automation by 2030s	Study scope	Comments
Frey and Osborne[54]	47%	US	Modelled based on expert workshop bottlenecks to computerisation, and tasks across 702 jobs. Didn't commit to a timeline and not a prediction per se
Haldane (Bank of England)[55]	35%	UK	Bank calculations using same approach as Frey and Osborne
Bowles (Bruegel)[56]	54%	EU	Applying the Frey-Osborne methodology, but mapped across to the EU labour market and data
Deloitte	35%	UK	Applying the Frey-Osborne methodology, but mapped across to the UK labour market and data
Forrester[57]	9%	US	Study focusing on relatively short time horizon, by 2025. Will also create c2% more new jobs in the automation economy
Gartner[58]	1.80m	US / World	2,300,000 jobs will be created over three years

54 Benedikt Frey, Carl, and Michael Osborne. 2013. Ibid.

55 Haldane, Andrew. 2015. "Labour's Share."

56 Bowles, Jeremy. 2014. "Chart of the Week: 54% of EU Jobs at Risk of Computerisation." 2014. https://bruegel.org/2014/07/chart-of-the-week-54-of-eu-jobs-at-risk-of-computerisation/.

57 Forrester. 2017. "Predictions 2018: Automation Alters The Global Workforce." 2017. https://www.forrester.com/report/Predictions+2018+Automation+Alters+The+Global+Workforce/-/E-RES139991.

58 Gartner. 2017. "Gartner Says By 2020, Artificial Intelligence Will Create More Jobs Than It Eliminates." 2017. https://www.gartner.com/en/newsroom/press-releases/2017-12-13-gartner-says-by-2020-artificial-intelligence-will-create-more-jobs-than-it-eliminates.

Lawrence M Roberts C King L (IPPR)[59]	33%	UK	Timeline unclear. 33% of wages in the UK, using the Frey and Osborne approach but focusing on wages not jobs
Arntz, Gregory and Zierahn (OECD)[60]	9%	OECD	10% estimate for the UK. Follows similar approach to Frey and Osborne but with more focus at task level. Major difference because even in high risk jobs, workers perform some tasks that are hard to automate.
OECD Nedelkoska, Quintini (OECD)[61]	14%	OECD	Another 32% of jobs have a risk of between 50 and 70%.
PWC[62]	30%	UK	Analysis also covered other countries suggesting 38% of jobs at high risk of automation in USA, 35% in Germany, and 21% in Japan. PWC analysis builds upon the Frey and Osborne analysis
World Economic Forum [63]	7.1m	15 country	Study focusing on short time horizon, by 2020

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59 Lawrence, Mathew, Carys Roberts, and Loren King. 2017. "IPPR Commission on Economic Justice Managing Automation Employment, Inequality and Ethics in the Digital Age." www.ippr.org/cej.

60 Arntz, M, T Gregory, and U Zierahn. 2016. "The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis." OECD Social. https://doi.org/10.1787/5jlz9h56dvq7-en.

61 Nedelkoska, Ljubica, and Glenda Quintini. 2018. "Automation, Skills Use and Training." https://doi.org/10.1787/2e2f4eea-en.

62 PWC. 2017. "Will Robots Steal Our Jobs? The Potential Impact of Automation on the UK and Other Major Economies."

63 WEF. 2016. "The Future of Jobs Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution."

World Economic Forum[64]	75m	World	Study focusing on short time horizon, by 2022. 75 million figure is extrapolated from a sample of 15 companies. WEF also extrapolates creation of 133 million new jobs

These studies show how changes in input data and methodology tweaks can produce radically different results – a good reason to treat predictions with caution. The majority of these estimates draw heavily upon the same methodology or model, simply mapping the results across to a different data set. Those that differ most are the two OECD-affiliated studies. These suggest that the number of jobs at high risk of automation is much lower, between 9 per cent and 14 per cent, rather than 47 per cent[65].

Both studies use an OECD data set on jobs and skills, rather than the US Department of Labor data. Arntz, Gregory and Zierahn argue that one difference is they aren't limited to considering whole jobs, but have greater focus on the tasks within a job and thus the variabilities between people doing the same job, including across companies. They also consider other factors like demographics, including "gender, education, competences, income, sector, firm-size"[66]. It is unclear if all these factors genuinely enhance the analysis – would AI's impact on the same job vary significantly by gender?

Whilst the Nedelkoska and Quintini study's headline high risk figure is much lower, they do find that another 32 per cent of jobs have

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64 WEF. 2018. "The Future of Jobs Report 2018 Insight Report Centre for the New Economy and Society."

65 Arntz, M, T Gregory, and U Zierahn. 2016.Ibid.;Nedelkoska, Ljubica, and Glenda Quintini. 2018.Ibid.

66 Arntz, M, T Gregory, and U Zierahn. 2016.Ibid.

an automation risk of between 50 per cent and 70 per cent. For these jobs, there might be significant disruption, or a reduction in head-count associated as productivity boosts enable more to be done with fewer people. Overall, they find the average job has 48 per cent chance of being automated. They also re-run their model, using data from the UK skills survey, getting radically different results – only 3% of UK jobs are at high risk of automation, compared to their main study figures of 12% for the UK or 14% across the OECD.[67] They also find different types of jobs to be at higher risk, particularly "middle-skilled" jobs as opposed to the low-skilled jobs highlighted in other studies. Again, this highlights the sensitivities of input data and model assumptions.

The studies estimate job automation of 30-40%, but the real impact on employment is unknown. Policy makers should remain open minded about the impact.

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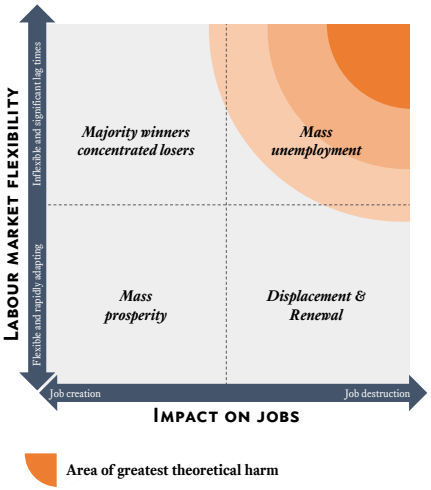
67 Nedelkoska, Ljubica, and Glenda Quintini. 2018.Ibid.

A TECHNOLOGICAL UNEMPLOYMENT MATRIX PROVIDES A USEFUL FRAMEWORK FOR POLICY MAKERS AND BUSINESSES TO CONSIDER SCENARIOS

A prudent policy agenda should consider the full range of possibilities, including the worst fears of AI sceptics. There are two useful axes or spectrums to consider.

Figure 3. Technological Unemployment compass: harm



What impact will AI have on the total number of jobs? What will be the net impact? At one end of that spectrum, AI will primarily be an enabling technology, supporting people to do their jobs more effectively. Even if lots of work is automated, AI would create more jobs to compensate overall. At the other end of the spectrum, AI will primarily be a replacing technology, removing the need for people altogether. Some new jobs might be created, but it would destroy many more.

The other axis or spectrum to consider is the flexibility of the labour market. This is the speed at which labour markets adapt to changes in society, and ultimately the creation or loss of jobs. In a highly flexible labour market, there are few impediments for employers and employees, allowing a quicker response. If new jobs are created quickly and are easily accessible, the unemployed won't suffer for long. By comparison, in an inflexible labour market, it might take years to get back into work. Overreaching unions or excessive regulations would limit the market's ability to create new opportunities for the recently-unemployed.

The faster the pace of change relative to labour market flexibility, the greater the potential imbalance. If the scope of AI's impact is huge, causing many jobs to be lost, but this happens slowly over many decades in a highly responsive labour market, then unemployment should remain negligible. By comparison, even if AI's impact is much more restricted, with only a few small sectors experiencing job losses, if this happens suddenly and in an inflexible labour market, there would be concentrated losses. In the worst-case scenario that pervades much of public discourse, AI will automate most work and the market won't respond, resulting in mass unemployment.

THERE ARE A NUMBER OF POTENTIAL TECHNOLOGICAL UNEMPLOYMENT SCENARIOS CAUSED BY AI

Overall, this leaves us with four high level scenarios to consider. Whilst the reality may be somewhere in the middle ground, considering these cases provides a useful guide for policy.

Table 3. AI impact scenarios

Scenario name	AI impact on jobs	Labour market flexibility	Results summary
Mass unemployment	High	Low	Majority of jobs lost and there is an inflexible labour market, with significant lag times. Majority of the population unemployed, with insufficient new opportunities to compensate. Mass unemployment is sustained. New concentrated elite class may emerge. Substantial risk of extreme politics or revolution unless harm mitigated.
Displacement & renewal	High	High	Majority of jobs lost but there is a flexible labour market, which rapidly adapts. Labour market adapts more quickly than the pace of change. Many jobs as we know them today are lost, causing temporary displacement. Most people transition to modified roles with their existing employers or move to new opportunities before being harmed. Unemployment is short lived for those most directly affected. Displacement likely to cause unrest even if rapidly addressed. Political conflict between those who recognise the benefits and embrace change, against technophobes and those who reject flexible labour markets by default.

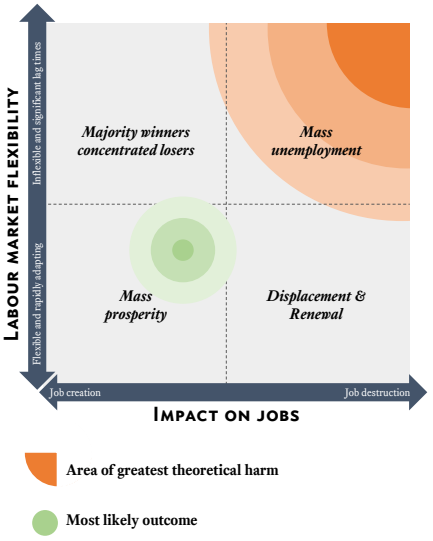
Mass prosperity	Low	High	AI is primarily an enabler for greater productivity in existing jobs and a net creator of jobs. Simultaneously the labour market is flexible, which rapidly adapts. Demand for human work significantly outstrips losses. People can make full use of these new opportunities, to get better jobs, leading to greater fulfilment and prosperity. Likely strong and sustained political majority for flexible labour markets and adoption of further technology. Risk of bad policies remain though, as other events can undermine stability.
Majority winners concentrated losers	Low	Low	AI is primarily an enabler for greater productivity in existing jobs or even a creator of new jobs. But the labour market is inflexible, with significant lag times. Those who lose their jobs will struggle to find new work. This will likely be concentrated into particular industries and associated geographical regions, with fears they will be left behind. Unless mitigated, concentrated losses result in strong campaigns against AI, against the dispersed majority who benefit but are less passionate. High risk of policies that limit overall prosperity.

Government policy should not be based on unfounded panic, but a recognition of probabilities across the many possible scenarios. Those claiming certainty about the future of AI are unjustified, and should have more humility about their ability to predict the future.

Philip Tetlock, a professor of political science at the Wharton School of Business is one of the world experts on forecasting. From 1984 to

2003 he tested 284 experts from government, economics and wider academia. On the 28,000 predictions they made, they were roughly as accurate as a "dart-throwing chimpanzee"[68]. In the case of AI, predictions are particularly challenging (compared to - say - predicting the next Prime Minister or the winner of the 2022 soccer World Cup). The scope of prediction is vast, and AI is a new technology changing our very economy and society.

Figure 4. Technological Unemployment compass: Most likely outcome



The most likely scenario based on the full range of evidence is that AI will be a force for increased prosperity, but with some pockets of concentrated losers and temporary displacements that will need to be mitigated. This is shown not only by the historic trends (see Chapter 3) but also the latest data.

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68 Tetlock, Philip E., and Dan Gardner. 2015. Superforecasting: The Art and Science of Prediction.

THE SPEED AND SCALE OF AI'S IMPACT COULD EASILY BE EXAGGERATED AND SHOULD BE PUT IN PERSPECTIVE OF PAST REVOLUTIONS

The emergence of new technology usually is met with hostility and even panic. Past doomsday scenarios of sustained mass unemployment have not been fulfilled (see Chapter 3).

The observation that we tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run has also been true before in AI. As a field it has experienced "hype cycles" before and been through an "AI winter" where it became clear that the bold predictions weren't grounded in reality – disillusion saw funding and projects cancelled through the 1970s and 1980s.

There is also a risk that we overestimate and celebrate the advances of the twenty-first century. Whilst AI is a profound general technology that will transform jobs across industries, is it much more significant than what came before? Consider the agricultural revolution, steam power, mechanised textiles, the creation of the iron industry, the move to machine tools/manufacturing and other changes from the first industrial revolution. Yet, for all of the industrial revolution's social challenges and sceptics at the time, it didn't bring about mass unemployment. Instead the industrial revolution enabled an unprecedented rise in prosperity.

The same comparison can be drawn from other big technological advancements. The Technological Revolution or Second Industrial Revolution was a period of further rapid industrialisation through the 19th Century and early 20th Century. It brought further advances in manufacturing, the mass production of steel, railroads, electrification, petrol, early automobiles, fertilizer, and telecommunications.

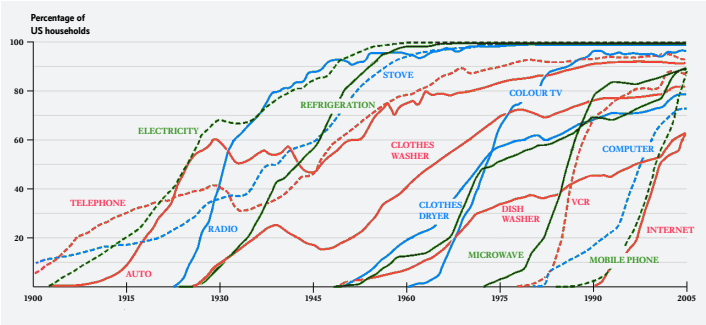
It was then followed by the Digital Revolution or Third Industrial Revolution, with personal computers and the internet. Over the last century, agricultural labour has declined by 95 per cent. In the last three decades alone, leather working has declined as an occupation by 82 per cent. Does the supposed Fourth Industrial Revolution match those which came before?

This is not to say that AI will not bring a similar or greater level or change. Automation of 30-40 per cent of work would be huge. Rather, it helps put AI in perspective. It also reminds us that past industrial revolutions enabled massive increases in general prosperity. They didn't bring about the sustained mass unemployment or disruption feared by critics.

THE IMPACT OF TECHNOLOGY ON JOBS IN RECENT YEARS IS NOT TRENDING TOWARDS THE DOOMSDAY SCENARIOS

AI has been impacting our lives for a decades. The internet reached 1 billion users in 2005. Personal computers emerged in the 1970s and reached ubiquity in the developed world in the 90s. Yet despite all of this technological progress, throughout the period of 1980-2019 we haven't seen signs of major technological unemployment, let alone mass unemployment. .

Figure 5. Consumption Spreads faster today



Source: Cox, Michael, and Richard Alm[69]

The pace of change may have accelerated, a key premise for the doomsayers as to why this time will be different, yet this hasn't made the difference. Perhaps the technologies we're adopting more quickly aren't as significant as those that came before, like steam, electricity or the telephone. It's also possible that there is a significant lag time or the impact is graduated.

EMPLOYMENT IN THE UK HAS REMAINED HIGH AND HAS BEEN RESISTANT TO SUDDEN MASS TECHNOLOGICAL UNEMPLOYMENT

Over the last fifty years, there have been periods of raised unemployment. However, the rises that have occurred in unemployment are generally well attributed to other factors, including business cycles,

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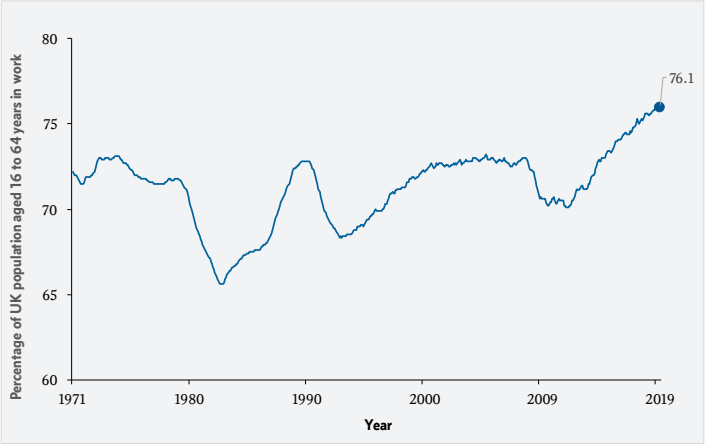
69 Cox, Michael, and Richard Alm. 2008. "You Are What You Spend - The New York Times." New York Times. 2008. https://www.nytimes.com/2008/02/10/opinion/10cox.html.

monetary policy and labour market inflexibility.

Figure 5. Employment rate highest in 2019 since 1971



Source: ONS[70]

Since the 90s the level of unemployment generally has remained at healthy lows. Indeed, as the digital revolution and AI's march has accelerated, employment has hit all-time highs.

Even if there is a lag time or if AI's most displacing applications have yet to be applied, there remains cause for optimism. The UK has a relatively flexible labour market. The World Economic Forum rated the UK's labour market the 6th most "efficient" in the world, behind only Switzerland, Singapore, United States, Hong Kong, and New Zealand. This means the economy should be able to respond rela-

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70 ONS. 2019. "Labour Market Overview, UK: September 2019." 2019. https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/bulletins/uklabourmarket/september2019.

tively quickly to unemployment, creating new opportunities[71].

NEW JOBS ARE BEING CREATED, INCLUDING SOME WE CANNOT EVEN IMAGINE TODAY

Improvements in productivity allow employers to lower prices, boost wages, make investments, increase leisure time and perks, and ultimately take home higher profits. The resulting boost in demand creates new opportunities for work (as happened during previous technology revolutions, see Chapter 3).

Over the last thirty-five years, productivity growth has created more jobs than it destroyed.[72] Automation has reduced jobs in some industries, but the positive spill over into the wider economy so far appears to have been comfortably greater.

New technologies also directly create new jobs, as people can deliver goods and services that were previously impossible or never imagined. We are now seeing the creation of many such jobs, from drone pilots to crypto speculators and 3d printing technicians.

Drivers using Uber or other ride-hailing apps like Lyft, Viavan, Bolt and Kapten didn't use to exist. Whilst this has put pressure on traditional minicabs and taxis, the overall number of drivers has increased. Uber now has 3.9 million drivers globally, facilitating 14

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71 WEF. 2017. "Global Competitiveness Index 2017-2018."

72 Autor, David, and Anna Salomons. 2017. "Does Productivity Growth Threaten Employment?"

million trips daily.[73]

In 2007, Apple released the first iPhone, with Google's Android following shortly after. Since then millions of apps have been published, both by large companies and lone creators. This has created huge demand for app developers, with over twenty million registered for Apple's iOS alone.[74] While not all of these will be app developers as their primary occupation, millions are active developers.[75] By extension there has also been a huge rise in demand for others who contribute to the creation of new digital services, like UX (user experience) designers and data scientists.

Social media and digital marketing are new fields of employment. A decade ago, nobody would have considered a job as a 'Social Media Manager' or as an 'Influencer'. An influencer is an individual who has gained a sizeable following on social media, sometimes just with a niche audience. They can be paid thousands of pounds to share sponsored content.

The digital age has also seen the rise of new artistic and creative professions. Many work as independent 'content creators' of various forms, as the ability to reach a large audience and make a living has been democratised. Over three million 'streamers' share live footage of their video gaming on platforms like Twitch, most for pleas-

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73 Uber. n.d. "Company Information." Accessed September 17, 2019. https://www.uber.com/en-PK/newsroom/company-info/.

74 Lunden, Ingrid. 2018. "App Store Hits 20M Registered Developers and $100B in Revenues, 500M Visitors per Week | TechCrunch." Tech Crunch. 2018. https://techcrunch.com/2018/06/04/app-store-hits-20m-registered-developers-at-100b-in-revenues-500m-visitors-per-week/.

75 Statista. 2018. "Global Developers per App Store 2017." 2018. https://www.statista.com/statistics/276437/developers-per-appstore/.

ure, but for some as a full-time profession.[76] Others work as bloggers, vloggers, and podcasters, competing with the traditional industries of formal newspapers, television and radio.

The AI era similarly will create new jobs. It's hard to predict what form these will take, but Accenture proposed three major categories, trainers, explainers and sustainers[77]. These would include jobs like training AI to understand the meaning of human communication (including challenges like detecting sarcasm), explaining why an AI entity made a decision and determining whether it should be used for future particular customer cases, and sustaining the use of AI in a company by evaluating its performance and promoting it to colleagues.

LABOUR MARKET PRODUCTIVITY IS A MAJOR ISSUE, BUT AI SHOULD HELP NOT HINDER

As Paul Krugman famously wrote, "Productivity isn't everything, but in the long run, it is almost everything. A country's ability to improve its standard of living over time depends almost entirely on its ability to raise its output per worker."[78] This is not just a hypothesis, but supported by empirical data. One study examining the period 1973-2016 found (despite recent complexities), "substantial evidence of linkage between productivity and compensation", with a one percentage point boost in productivity associated with a 0.7 to one per-

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76 TwitchTracker. 2019. "Twitch Statistics & Charts · TwitchTracker." 2019. https://twitchtracker.com/statistics.

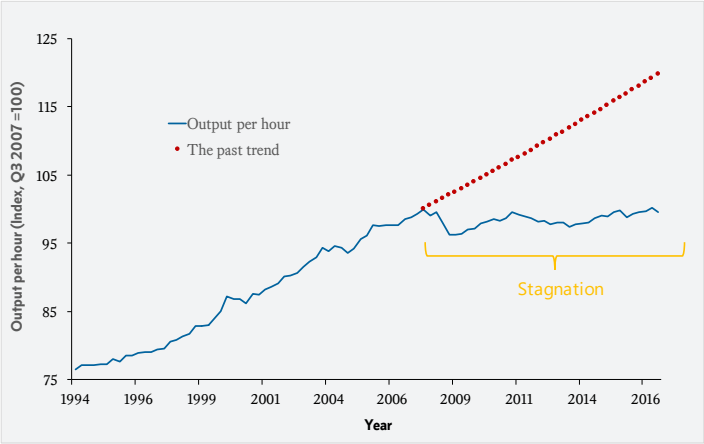
77 Wilson, James, Paul Daugherty, and Nicola Morini-Bianzino. 2017. "The Jobs That Artificial Intelligence Will Create." 2017. https://sloanreview.mit.edu/article/will-ai-create-as-many-jobs-as-it-eliminates/.

78 Krugman, Paul. 1997. The Age of Diminished Expectations.

centage point boost in average compensation growth.[79] In earlier periods the link was arguably even closer.

The most concerning dimension of UK labour markets is productivity, an issue which AI ought to help address. Productivity is the amount of output a worker can generate per hour of work. Over the last decade the UK has faced what the ONS termed a 'productivity puzzle' – i.e. stagnation.

Figure 6. The productivity challange



Productivity is not only a driver of overall output growth, but of increased wages. With productivity stagnant, there may still be a high volume of employment opportunities but real pay is motionless and many even will suffer real declines in earnings. This alone can be a cause of great popular disquiet, with immigrants and technology serving as the default scapegoats.

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79 Stansbury Lawrence H Summers, Anna M, Jared Bernstein, Josh Bivens, John Coglianese, Jason Furman, Larry Katz, Robert Lawrence, et al. 2017. "NBER WORKING PAPER SERIES PRODUCTIVITY AND PAY: IS THE LINK BROKEN? Thanks To." http://www.nber.org/papers/w24165.

Technology enables workers to create greater output with the same set of inputs and in the same amount of time. AI should thus increase productivity in aggregate. Stagnant productivity today suggests there are other issues to address, and in this context, AI is more likely to help than to hinder.

The need for technologically driven productivity gains from AI and automation are also important in the context of the West's aging population. By 2050 projections show one in four people in the UK will be aged over 65 years.[80] Even adjusting for increasing economic activity in later life, economic dependency will continue to rise. A decreasing share of the population will need to produce more output per worker if prosperity is to continue and grow.

TECHNOLOGY IS BOOSTING OUR PURCHASING POWER

Even if the new opportunities emerge relatively rapidly, there remains a worry that the new work might be worse – with wage stagnation for those most impacted, or even declines in real terms. This is intuitive if the demand for manual labour decreases, all things being equal, wages ought to fall. However, this is too simplistic: absolute wages are only part of the equation determining personal welfare and one also needs to consider purchasing power.

With AI, new products and services will emerge that we never imagined before, and others will be produced more cheaply, improving standards of living. The same wage, thus, will be able to purchase more goods and services.

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80 Krugman, Paul. 1997. The Age of Diminished Expectations.

For example, AI powered medical care that prevents debilitating illness or death, which previously might not have been possible at all, or only for the richest few. Also consider AI powered transport, democratising chauffeuring. Previously this was a luxury good only enjoyed by those wealthy enough to employ personal staff, or professionals regularly taking taxis on an expense account, but with AI it could be accessible to all.

As Matt Ridley vividly summarises in the *Rational Optimist*, there is a huge transformative power of technology, specialisation and exchange that means the average person today lives better than the elites of the past:

> "The Sun King had dinner each night alone. He chose from forty dishes, served on gold and silver plate. It took a staggering 498 people to prepare each meal.
>
> [Consider the average person] You are far from poor, but in relative terms, you are immeasurably poorer than Louis was. Where he was the richest of the rich in the world's richest city, you have no servants, no palace, no carriage, no kingdom. … Yet consider this. The cornucopia that greets you as you enter the supermarket dwarfs anything that Louis XIV ever experienced (and it is probably less likely to contain salmonella)…. You may have no chefs, but you can decide on a whim to choose between scores of nearby bistros, or Italian, Chinese, Japanese or Indian restaurants, in each of which a team of skilled chefs is waiting to serve your family at less than an hour's notice. … you have far, far more than 498 servants at your immediate beck and

call."[81]

This same effect can be felt well beyond food, as we receive goods and services from across the globe. AI will extend our range of choices even further. In doing so, it means that even if a salary grows slowly, or declines, AI is still likely to enable greater actual purchasing power.

All things considered; aggregate prosperity, thus, is likely to increase. Whilst the effect on purchasing power is perhaps unrecognised, hard to objectively quantify, and ought to be monitored closely in all scenarios, it is all too frequently ignored altogether.

A UNIQUE REVOLUTION, WITH TASK ENCROACHMENT LEADING TO NOT ENOUGH WORK?

The latest and perhaps most interesting pessimistic analysis is Daniel Susskind's, *A World Without Work*. His argument provides a more measured analysis of AI, sidestepping many of the mistakes made by others, whilst still reaching worrying conclusions. Susskind's argument is that we should not expect a "big bang, but a gradual withering" of jobs.[82] He believes there will not be enough work left to "provide everyone who wants it with traditional well-paid employment".[83] This is "not a world without any work at all, as some predict, but a world without enough work", despite the title of his book.[84] He is less

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81 Ridley, Matt. 2010. Rational Optimist: How Prosperity Evolves.

82 Susskind, Daniel. 2020. A World Without Work.

83 Ibid.

84 Ibid.

reliant on dramatic predictions but hinges his argument upon the unrelenting march of "task encroachment".

Task encroachment is "where machines take on more and more tasks that were once performed by people".[85] AI is increasingly capable at performing manual, cognitive, and even affective/emotive work. Even conservative economists and technology optimists don't disagree that task encroachment is happening, at most debating the speed at which it is happening.

Susskind acknowledges that technology has displaced workers before, but that it also increased demand for their work elsewhere. Historically this "complementing effect" of new demand was greater than the "substitution effect" of automation removing work. This is why past automation worries were misplaced.

Susskind's argument is that task encroachment means that the substitution effect will outpace the complementing effect. Task encroachment will exacerbate frictional unemployment caused by a "mismatch of skills, a mismatch of identity, and a mismatch of place".[86] It isn't just the unemployment rate to worry about, but the underlying participation rate. He accepts that workers could gain skills, think differently or move to reduce frictional unemployment, but these frictions are hard to resolve.

Task encroachment will also exacerbate structural unemployment according to Susskind. Historically automation boosted productivity, grew the economy and created new opportunities to compensate with more work. This can "only continue to raise the demand for human workers if they remain better placed to do those tasks than

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85 Ibid.

86 Ibid.

a machine", which Susskind believes will no longer be the case.[87] He challenges the "superiority assumption" that humans remain the best choice for new work. Even if this process takes a long time, Susskind is thus convinced we will enter a world without enough work.

Susskind's argument gives us reason to consider the real possibility of a more extreme scenario. However, prudent government policy remains to consider all the scenarios, and to wait for data to show that his hypotheses are materialising before taking similarly extreme action.

Susskind's argument relies on an assumption or belief that AI's capabilities are reaching a tipping point where task encroachment is more potent than ever before. He is guilty of his own "superiority assumption", that AI will become the best choice for new work. This is arguably not borne out by current AI capabilities.

Susskind cites many examples of AI's progress in automating ever more complex work but these aren't sufficient to carry us to a tipping point where the task encroachment is sufficient to break historic economic forces without a leap of faith. There are still limits to the substitution effect, and a complimenting effect and proximity or inevitability of this tipping point is far from clear. The onus is on the pessimists to convincingly demonstrate the fundamentals have changed this time.

To confidently make this leap of faith requires one to believe we will soon reach the singularity (the point at which technological growth becomes uncontrollable) or at least we develop something approaching Artificial General Intelligence (AI that demonstrates any intelli-

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87 Ibid.

gence that a human can as well as or better than humans). Some AI researchers believe the singularity is near, but this is far from a consensus, with many reasons to believe we won't reach it in our lifetimes (which we need not digress upon here). In short, Susskind is perhaps both too optimistic about AI and too pessimistic about humans.

DOOMSDAY MASS UNEMPLOYMENT IS UNLIKELY BUT THE THREAT OF DISPLACEMENT IS REAL

Even if the labour market adapts quickly relative to the pace of job losses, generally boosting prosperity, some will lose.

The displacement effect is likely to cause some disquiet, economically, socially and politically. Consider workers who join a reliable industry. These employees could expect an extended career path and steadily rising wages, with greater experience and promotions. If AI changes the nature of their role or forces them to move, they may lose even if they quickly find a new opportunity. Perhaps they enjoyed their old role, or don't want to learn new skills. Whilst AI will likely eliminate much mundane work in favour of more interesting tasks, this may not always be the case or appealing to all. Not everyone would want to move jobs without being forced to do so by the loss of their old role. Unless the new role brings a higher salary or other benefits, the effect isn't necessarily neutral or positive for those affected.

Concentrated losses will likely prompt the greatest backlash. Not everyone will be so fortunate as to just modest and brief displacement, even in a flexible labour market and a world where AI creates many opportunities. For those who become unemployed after AI replaces their jobs, and then struggle to find new work, there is a

clear loss. This is likely to be concentrated in specific industries and regions, particularly for those workers who have been dedicated to a specific role for many years or even decades. Their skill set is not necessarily transferable, and if traditionally it would be, the other opportunities to which they once would have moved may have been automated as well.

Consider the scenario that autonomous driving is successfully implemented. If reliable automated trucks emerge suddenly and rapidly, undercutting the cost of traditional truckers by 90 per cent, surely the vast majority will soon be unemployed? There are over 300,000 HGV drivers in the UK today[88] and over 3.5 million in the United States[89]. How easily will these workers find new roles? It is likely the most obvious adjacent markets, from last-mile delivery to taxis, will undergo similar automation. This leaves the only option for an unemployed trucker to be to migrate into another industry altogether. This isn't likely to be a pleasant or easy experience and may also entail retraining. Thus, a group of AI losers might form suddenly, with little appreciation from such groups for the aggregate macro benefits of embracing AI.

Addressing the plight of these potential groups of AI losers, whilst maximising overall innovation and prosperity, should be the focus of political attention. This scenario is much more likely to occur than the doomsday scenario of mass unemployment, and is likely to occur sooner. There is a delicate balance to be struck in this process.

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88 DfT. 2017. "Domestic Road Freight Activity Increases to Record Highs in 2016." 2017. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/627597/domestic-road-freight-statistics-2016.pdf.

89 US Census Bureau. 2019. "America Keeps on Truckin'." 2019. https://www.census.gov/library/stories/2019/06/america-keeps-on-trucking.html.

There is a high risk that a vocal minority can change policy for the worse. Concentrated but small interest groups are overrepresented in political debate compared with the diffuse majority, directing policy as a result.

Whilst the advance of artificial intelligence should promote overall prosperity, including for the "losers" in the long run, the short run costs may become an obstacle. This is the central insight of Carl Benedikt Frey's latest work, *The Technology Trap*: "If technology fails to lift all boats in the coming years, broad acceptance of technological change cannot be taken for granted"[90]. There is a substantial risk of mainstream politics losing further credibility and bad policy decisions.

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90 Frey, Carl Benedikt. 2019. Ibid.

5. WHAT ARE GOVERNMENTS DOING?

"A revolution in AI technology is already emerging. If we act now, we can lead it from the front. But if we 'wait and see' other countries will seize the advantage. Together, we can make the UK a global leader in this technology that will change all our lives."

AI Sector Deal, HM Government

Government responses to AI have been neither inspiring nor alarming. Across the developed world governments have been welcoming to artificial intelligence, at least in theory. Over the last few years, most OECD countries have released strategies (or similar policy guidance), committed new funding streams and proposed policies to support AI. Surveying across countries shows several common themes. It is remarkable how alike government responses have been.

The common government blueprint on AI has followed 5 steps:

1. Announce publicly that the country will be "a leader" in AI
2. Publish an AI Strategy or similar report, to show "commitment" to AI
3. Recommend undisputable ideal outcomes like fostering innovation, having high employment, improving infrastructure, being a good place for business and supporting communities
4. Pledge to spend millions over a 3-5 year horizon, though this may not actually be budgeted for or ratified, with about 50 per cent directed toward research, with the rest funding wider projects and new quangos or special purpose bodies
5. Pledge to examine and produce thought leadership on the ethical and regulatory implications of AI

The table below shows a sample of AI policies across twenty-five countries.[91]

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91 There are several overviews of government AI strategies. Two sources which proved useful to point in the right direction, summarise highlights and/or validate my understanding included: "An Overview of National AI Strategies | Medium." n.d. Accessed July 26, 2020. https://medium.com/politics-ai/an-overview-of-national-ai-strategies-2a70ec6edfd."AI as a National Strategy: Will the Race Continue as Before?" n.d. Accessed July 26, 2020. https://members.tortoisemedia.com/2020/05/07/200505-ai-as-a-national-strategy/content.html."The Global AI Index - Tortoise." n.d. Accessed July 26, 2020. https://www.tortoisemedia.com/intelligence/ai/.

Table 4. AI policies by countries

Scenario name	AI impact on jobs
Australia	• AU$30m investment to support development of AI in 2018-19 budget • Digital Economy Strategy launched in 2018 with four focus areas: people, services, digital assets and enabling environment.
Canada	• 'Pan-Canadian Artificial Intelligence Strategy' published in 2017, committing C$125m investment in AI • Main focus on research and talent
China	• Public ambition to be #1 global leader on AI • Published 'A Next Generation Artificial Intelligence Development Plan' in 2017 • Plan parity on AI by 2020, leadership in some areas by 2025 and primary by 2030 • Published 'Three-Year Action Plan to Promote the Development of New-Generation Artificial Intelligence Industry' • Baidu, Alibaba and Tencent guided by government to lead in different segments
Denmark	• Published Digital Strategy • Ongoing funding of DKK 75-125m annually for digital initiatives
Estonia	• AI strategy published in 2019 • Liberal attitude to regulation adjusting current legislation and leaning towards permissiveness • One of the first countries to allow autonomous vehicles by amending its Traffic Act • Creating general liability legislation on AI to enable faster adoption, rather than waiting for specific regulation
Finland	• Created steering group in 2017 on AI • Published 'Finland's Age of Artificial Intelligence' • Published 'Work in the Age of Artificial Intelligence' • Created Finnish Centre for AI, partnering with universities • Strong focus on labour market flexibility and skills. Proposed a lifelong skills voucher scheme.

France	• Published AI Strategy, 'AI for humanity' in 2018 • €1.5 billion commitment, of which half is for research • Creation of "European DARPA" • Public lab on the transformation of work to "test tools support professional transitions" for those affected by automation • Testing new funding methods for vocational training • Completed surveys into policies for innovation and AI in other countries
Germany	• Published AI strategy in 2018 • €500m in 2019 budget, and €3billion total commitment to implement strategy • Proposed creation of 100+ AI professorships • Proposed establishment AI observatory
Israel	• Israel Innovation Authority has called for an AI Strategy to be created in its 2018 Innovation Report
India	• Published AI strategy discussion paper in 2018 • Policy focus on research through Centres of Research Excellence (COREs) and International Centres for Transformational AI (ICTAIs)
Italy	• Published AI White Paper • Significant focus on AI within government itself • Proposed creation of National Competence Centre
Japan	• Published AI strategy in 2017 and set up Strategic Council for AI • Proposed a range of high-level policies to develop AI communities, promote research, harmonise regulation and expand training
Kenya	• Created a taskforce in 2018 on AI
Malaysia	• Announced National AI framework in 2017
Mexico	• Published White Paper in 2018 • Full AI Strategy pending
New Zealand	• Released a report in 2018, Artificial Intelligence: Shaping a Future New Zealand
Poland	• Created a roundtable on the creation of a strategy in 2018

Russia	• Public statements on AI's importance and indication of AI Arms Race, including that "whoever becomes the leader in this sphere will become the ruler of the world" • Hosted government conference on AI in 2018
Singapore	• Published 'AI Singapore' in 2017. • S$150 million committed to building AI capabilities, focusing on research, experiments and apprenticeships. • Advisory Council on Ethics created in 2018
South Korea	• Announced 1 trillion won investment in AI research spread over 5 years in 2016, prompted by AlphaGo • Will fund projects in R&D challenge, similar to DARPA • Commitment increased in 2018, with funding for graduate schools and training
Sweden	• Published 'National Approach for Artificial Intelligence' in 2018 as a high level guide, but not a strategy or policy document • Launching AI initiatives around training and projects
Taiwan	• Published four-year AI Action Plan in 2018 • Annual commitment of NT$10 billion, primarily for research • Will fund projects in R&D challenge similar to DARPA • Building AI International Innovation Hub
UAE	• AI Strategy published in 2017 • First country to create a Ministry of Artificial Intelligence
UK	• Published AI Sector Deal in 2018, as part of wider Industrial Strategy • £1bn for development of AI, of which c£300m is private sector investment and £300m is new government funding • Expansion of Alan Turing Institute • Launch of Centre for Data Ethics and Innovation • Launch of Office for Artificial Intelligence • House of Lords called for Global Summit
USA	Obama Administration published a series of AI Strategy papers; followed by Trump Administration 2018 AI summit AI Select Committee created Identified focus on removing regulatory barriers to innovation AI R&D rising in a public and classified context Range of 'big tech' companies providing AI leadership but in contrast to China, competition in many areas

The consistent 5 step approach is encouraging in that it shows governments are at least thinking about AI, but it leaves a lot unanswered. The danger is that without substantial well-developed policies, bad ideas will emerge in practice. Supporting technological progress is very easy at this surface level. Everyone wants to be "a leader," but not everyone can actually lead by definition. Funding some research in partnership with universities and creating quangos that facilitate networking or publish interesting research is intuitively beneficial. But the actual measurable impact is unclear and these initiatives come with an opportunity cost: something else could have been funded.

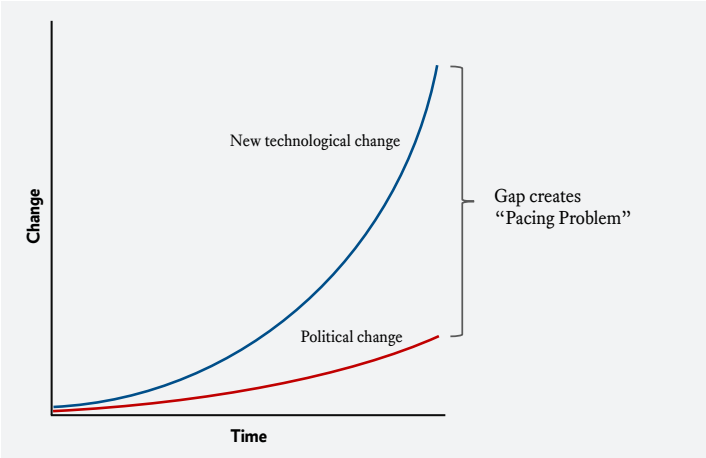
There is little evidence that further state funding into similar initiatives will produce a return on investment. The UK's relatively strong AI performance is not readily attributable to these initiatives. These initiatives are neither necessary nor sufficient for the flourishing of AI, so while they make for nice gestures, they do not move-the-needle. The primary benefit is perhaps cultural; it provides official backing that AI is a force for good and to be encouraged.

An AI Strategy doesn't alter the fundamentals that make a difference, except at the margins, from the regulatory environment to labour market flexibility and incentives for entrepreneurs. This surface level commitment to AI is also not very robust; it is unlikely to hold up against any public hysteria about jobs or the opposition of concentrated interest groups.

When one looks below the surface at the actual applications of AI, support from governments is more confused. Take driverless vehicles again, an area in which the UK Government has been relatively supportive. The 2015 Report, *The Pathway to Driverless Cars* said the

technology offered "major potential benefits"[92] and that they could be tested on public roads, with a Code of Practice published shortly after. Yet the regulatory framework remains unclear around liabilities in the case of a collision, the highway code does not permit driverless cars outside the context of testing, and safety standards are still being defined. Testing is only permitted "providing a test driver is present". We have yet to proactively legalise 'level-5' fully autonomous cars on our roads, though government expressed support in 2019[93]. These are all obstacles to more rapid and general use of driverless cars. Given this is an application of AI that the government has recognised and supported since at least 2015, if not earlier, more could be done to facilitate progress in a timely manner.

Figure 7. Pace of change



The response to driverless cars, despite being relatively supportive in

92 Department for Transport. 2015. "The Pathway to Driverless Cars Summary Report and Action Plan." www.gov.uk/dft.

93 "Government Moves Forward on Advanced Trials for Self-Driving Vehicles - GOV.UK." 2019. 2019. https://www.gov.uk/government/news/government-moves-forward-on-advanced-trials-for-self-driving-vehicles.

the UK, demonstrates that technological change is outpacing governments. This pacing problem is what Larry Downes has called *The Law of Disruption*. The gap between technological and political change creates a regulatory vacuum. This vacuum can hinder innovation and result in the creation of bad policies due to panic.

This is where the Estonian approach is particularly interesting. Their government had investigated creating a general law on AI to cover liabilities regardless of sector or application:

> "Cross-sector approaches can minimise the time it otherwise takes to establish regulations for each individual sector (e.g. drones, IoT devices, etc.). With a holistic approach, Estonia can use these technologies more quickly, and hopes to reap the benefits faster. In addition, such an approach is also user-friendly, with fewer and simpler laws facilitating the end-user's engagement with these systems."[94]

Whilst the final conclusion of the e-Estonian Council was "there is no need for a unified AI law", their overall approach remains the same, and is one of general permissiveness.[95]

The pacing problem forces entrepreneurs to operate with legal and regulatory uncertainty. In areas that are already highly regulated, this will typically hinder the rate of progress. Innovation will push beyond the boundaries of law, and sometimes innovation should wait for policy change. In areas that are new or not highly regulated, inno-

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94 European Commission. 2018. "The European Artificial Intelligence Landscape." 2018. https://ec.europa.eu/digital-single-market/en/news/european-artificial-intelligence-landscape.

95 e-estonia. 2019. "Estonia Accelerates Artificial Intelligence Development — e-Estonia." 2019. https://e-estonia.com/estonia-accelerates-artificial-intelligence/.

vation can proceed more freely despite the pacing problem, but there is a risk of panic and overreaction later. Addressing this issue, perhaps inspired by the Estonian approach, would do more for AI progress than the typical AI strategy.

5. WHAT SHOULD GOVERNMENT DO?

"In the department of economy, an act, a habit, an institution, a law, gives birth not only to an effect, but to a series of effects. Of these effects, the first only is immediate; it manifests itself simultaneously with its cause — it is seen. The others unfold in succession — they are not seen … the bad economist pursues a small present good, which will be followed by a great evil to come, while the true economist pursues a great good to come, — at the risk of a small present evil."

- Frederic Bastiat (That Which is Seen, and That Which is Not Seen)

Technology underpins economic growth – government should recognise AI's potential contribution

In caring about wellbeing and human flourishing, supporting growth is vital. AI will enable further growth, so long as government allows its adoption rather than hindering through a panicked response to an unlikely scenario.

Without rehashing the debate, it is worth noting the huge transformative power of growth for general prosperity. Consider that the compounding effect means that growth of 2.5 per cent per year would

result in a doubling of output in twenty-eight years. People forget how growth has been and how it is a radical deviation from the historical norm of stagnant economies, poverty and squalor.

FIGURE 8. WORLD GDP

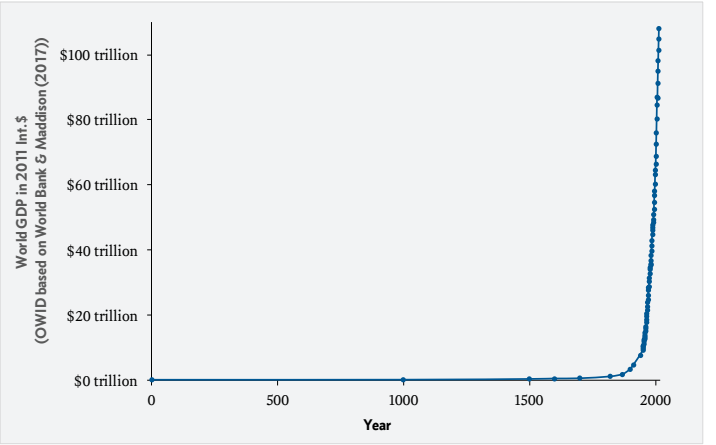
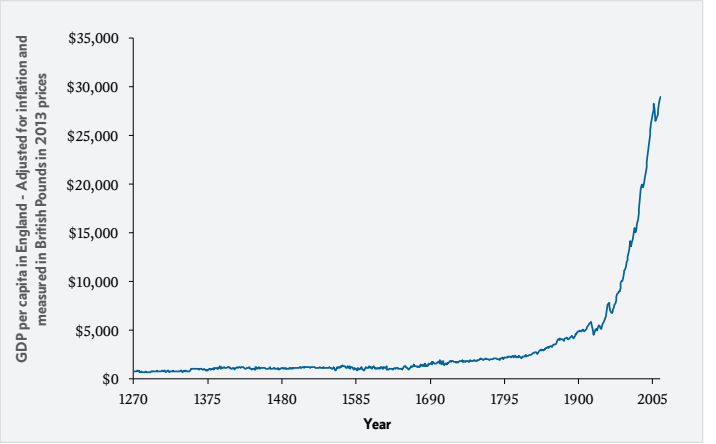


FIGURE 9. GDP PER CAPITA IN ENGLAND



According to polling by Russ Roberts, US journalists think stand-

ards of living have increased by 50 per cent since 1900.[96] But actually the real standard of living has increased by a factor of five to seven in the United States[97], with the UK seeing similar progress. This translates into huge improvements in prosperity, for example, average life expectancy has doubled in the UK since the 1800s.[98] About sixty per cent of spending is now on goods and services that didn't even exist back then.[99]

It also extends to the world of work; we don't have to work as hard and have more leisure time. In the 1800s a worker would labour between 2,800 and 3,300 hours per year, but today their hours are closer to 1,400 to 2,000.[100]

Technological progress is a core driving force behind economic growth. It was the primary driver of US growth since 1960 and the main factor explaining differences in wages across countries. The exact mechanisms of growth are still contested and differ across eco-

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96 Cowen, Tyler. 2018. Stubborn Attachments : A Vision for a Society of Free, Prosperous, and Responsible Individuals.

97 Ibid.

98 ONS. 2015. "How Has Life Expectancy Changed over Time? - Office for National Statistics." 2015. https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/lifeexpectancies/articles/howhaslifeexpectancychangedovertime/2015-09-09.

99 Gordon, Robert. 2016. The Rise and the Fall of American Growth. Princeton University Press.

100 Cowen, Tyler. 2018. Ibid.

nomic growth theories, but technology is critical.[101][102][103]

Innovation is arguably slowing in many areas and AI is being hailed as one of the ripest areas of technological progress today. Governments should recognize its potential contribution to prosperity.

FASTER ADOPTION OF TECHNOLOGY ENABLES GREATER COMPARATIVE ECONOMIC GROWTH

The differing rates of technology adoption and innovation across countries are important too; some countries do better than others. A recent study showed that "changes in the pattern of technology diffusion account for 80 per cent of the Great Income Divergence between rich and poor countries since 1820".[104] This finding has also been supported by earlier research by the US Department of Commerce, which found innovation was vital to producing high paying jobs. They concluded that innovation is the primary driver of increases in real wages and that preventing it would result in lower wages. Comparing countries, 75 per cent of differences in income were arguably explained by innovation-driven productivity

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101 Freeman, Chris, and Luc Soete. 1997. The Economics of Industrial Innovation. Third Edition.

102 Hall, Robert E, and Charles I Jones. 1999. "Why Do Some Countries Produce So Much More Output Per Worker Than Others?" Source: The Quarterly Journal of Economics. Vol. 114.

103 Jorgenson, Dale, Mun Ho, Jon Samuels, and Kevin Stiroh. 2007. "Industry Origins of the American Productivity Resurgence." Economic Systems Research. https://doi.org/10.1080/09535310701571885.

104 Comin, Diego A, and Martí Mestieri Ferrer. 2013. "If Technology Has Arrived Everywhere, Why Has Income Diverged?" NBER. http://www.nber.org/papers/w19010.

differentials.[105][106][107]

So, if the UK seeks to do well out of artificial intelligence, it would be better to be a leader than a follower. In a globalised and competitive world, there are significant benefits to being the pioneer. Entrepreneurs who successfully introduce new products and services gain huge rewards. The countries that facilitate these entrepreneurs also benefit greatly, with new jobs and increased productivity prompted by innovation.

Global dynamics also limit the efficacy of some government policies. Blocking or hindering artificial intelligence in the UK, to negate the risk of mass unemployment, is credible. If we were to take such a route, innovation would continue apace elsewhere. There is also no guarantee this strategy will protect jobs, as more productive nations (powered by AI) would then offer goods and services at a lower price and higher quality. There is also a risk of 'brain drain'. If our entrepreneurs and scientists find that public or political attitudes hinder their work, they will look to do their business elsewhere.

A FRAMEWORK FOR GOOD AI POLICY

Three principles provide the best framework for AI policy, given the uncertainty and range of impact:

1. Governments should embrace a 'proactionary principle' or 'per-

105 Hall, Robert E, and Charles I Jones. 1999. Ibid.

106 Basu, Susanto, and John G Fernald. 2009. "What Do We Know (And Not Know) About Potential Output?"

107 U.S. Department of Commerce. 2010. "Patent Reform: Unleashing Innovation, Promoting Economic Growth, and Producing High-Paying Jobs." https://doi.org/10.2139/ssrn.10583.

missionless innovation,' in contrast to the typical precautionary principle.
2. They should favour interventions supported by cost-benefit analysis, combining empirical data and a consideration for 'unseen' consequences.
3. Lastly, they should embrace experimentation and evolution over grand designs and top-down planning.

PERMISSIONLESS INNOVATION TO FACILITATE ARTIFICIAL INTELLIGENCE INNOVATION

The precautionary principle is the default guide for legislators when faced by uncertainty. This principle guides us to anticipate the potential harm from an action before it occurs, and to implement preventative measures. It also implies that the proponent of an activity needs to establish that it will not cause harm before proceeding. Applied to AI this approach quickly leads one down a path of either outlawing applications, or other interventions which penalise innovation like robot taxes. This approach may help avoid worst-case scenarios, but as AI innovation will likely progress elsewhere, even this is questionable.

What is certain is that the precautionary approach will ensure best-case scenarios do not happen. A precautionary approach ensures that a country will not be an AI leader and will lose many potential benefits to those who move faster. There will be fewer entrepreneurs and many lost opportunities. There will be less economic growth. There will be fewer improvements in productivity, goods and services. Average real wage growth will be reduced.

By comparison, under permissionless innovation, artificial intelligence would be exempt from regulations and restrictions until a gen-

uine proven need for intervention. Intervention would only be undertaken when it is clearly needed to avoid serious harm. It favours permitting innovation by default, even if this comes with risks. It clarifies for entrepreneurs that they can experiment with artificial intelligence and challenge the status quo. If problems occur, they can and should be addressed promptly.

The Industrial Revolution and many of our powerful innovations since have emerged in an environment of effective permissionless innovation. Where intervention was required, it was primarily derived through common law, custom and judicial precedent established through court cases. Under tort law, people seek compensation for harms. Under contract law, businesses and customers established mutually beneficial agreements. Where statues were required, they were highly targeted and generally followed the innovation, rather than preceding it in the name of precaution. Cultural pressure, self-regulation and insurance markets were also important checks against harm.

Permissionless innovation also has had great success since; it is not a relic of a past age where we ought to have regulated but were just too incompetent. Consider the adoption and use of the internet, which was originally highly restrictive. The 1982 MIT handbook on its predecessor ARPAnet stated:

> "It is considered illegal to use the ARPAnet for anything which is not in direct support of government business... Sending electronic mail over the ARPAnet for commercial profit or political purposes is both antisocial and illegal. By sending such messages, you can offend many people, and it is possible to get MIT in serious trouble with the government agencies which

> manage the ARPAnet."[108]

However, in the 1990s the Clinton administration opened the internet up to the public. The 1996 Communications Decency Act (part of the Telecommunications Act) and 1997 Framework for Global Electronic Commerce put in place relatively permissionless foundations.

Importantly, Section 230 of the 1996 CDA stated that:

> "No provider or user of an interactive computer service shall be treated as the publisher or speaker of any information provided by another information content provider"

This section protects internet companies from liability for content provided by their users – crucial for any online communications, forums, or social networks.[109] Without this protection, the costs when challenged would be prohibitively high for the existence of many online firms. Likewise, the Framework for Global Electronic Commerce explicitly called for a "minimalist" approach, an internet with "self-regulation" that was "market driven" and free of "undue restrictions".[110]

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108 Thierer, Adam. 2016. Permissionless Innovation The Continuing Case for Comprehensive Technological Freedom Revised and Expanded Edition. Mercatus Center at George Mason University.

109 Electronic Frontier Foundation. n.d. "Section 230 of the Communications Decency Act." Accessed September 18, 2019. https://www.eff.org/issues/cda230.

110 Clinton Whitehouse. 1997. "Framework for Global Electronic Commerce." 1997. https://clintonwhitehouse4.archives.gov/WH/New/Commerce/read.html.

CREDIBLE COMMITMENT TO 'PERMISSIONLESS INNOVATION' IS NEEDED FOR ARTIFICIAL INTELLIGENCE LEADERSHIP

Applying permissionless innovation to artificial intelligence would create an environment ripe for genuine progress and leadership. To do this, the Government should create a £5 million independent 'Office for Removing Barriers to Artificial Intelligence' (ORBAI) and pass an 'Unleashing Artificial Intelligence Act' (UAI Act).

This new institution would complement the recently created Office for Artificial Intelligence (a joint BEIS-DCMS unit) responsible for overseeing implementation of the AI and Data Grand Challenge. The Office for Artificial Intelligence, thus far, has been granted limited powers and arguably lacks the independence to push for more radical change. It focuses on the implementation of the UK's existing AI Strategy. ORBAI would also complement the Centre for Data Ethics and Innovation, whose role is to develop the "right governance regime for data-driven technologies".[111] A laudable aim but one that risks being captured by precautionary thinking rather than truly promoting innovation.

A similar approach could be applied, in combination or separately, for other red tape that creates impediments to key innovations driving future economic growth. Red tape is excessive regulation that goes beyond the 'minimal necessary regulation', that is as few rules as possible that are necessary to achieve certain objectives like protecting safety.

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111 "Centre for Data Ethics and Innovation - GOV.UK." n.d. Accessed July 25, 2020. https://www.gov.uk/government/organisations/centre-for-data-ethics-and-innovation.

This policy has some parallels to past "one-in, two-out" commitments, like under the Coalition Government in 2013 and recent calls for a 'Brexit red tape challenge'. However, "one-in, two-out" policies have historically failed to stop an increase in red tape, as they lacked the teeth to proactively remove regulations. At best governments slowed the march of new red tape, but failed to keep to the "two-out" side of the bargain.

Government should conduct a 'bonfire' of red tape, following a specific review of impediments to AI across industries. The purpose of ORBAI would be to provide ongoing independent and authoritative analysis of barriers to artificial intelligence, both current and resulting from emerging legislation. This is especially important in arenas that are already highly regulated, where AI will be prevented or hindered by default.

The commitment to permissionless innovation for artificial intelligence should be publicly articulated by the Government, making it the policy default. This is especially important in those arenas which are new and where regulatory ambiguity may impede artificial intelligence.

Commitment to AI leadership requires full consideration of all obstacles, not just regulation. Another significant obstacle is access to global talent. Recommendations ought to include measures to support the immigration of entrepreneurs and specialists, particularly as the UK reevaluates these policies in the light of Brexit.

The UAI Act would provide a statutory basis for the ORBAI, like that of the National Audit Office or Office for Budget Responsibility. In creating the Act, the Government also would seek to provide a general AI law, inspired by the initiatives in Estonia to limit liabilities or otherwise provide a permissive regulatory environment. If a gen-

eral AI law proves too challenging, obvious barriers and growth areas should be the immediate focus. The Government should reconsider the role of common law as an evolutionary mechanism to manage emergent technologies, as opposed to rushing towards statutory legislation. The general ethos of any statutory legislation should be to enable permissionless innovation by default, removing impediments and limiting liabilities.

DO NOT REGULATE AI INTO OBLIVION WITH PROHIBITIONS, FINES, THREATS AND LICENSING

When a new application of AI emerges, it will be all tempting to aggressively intervene when there are the first visible signs of some potential harm. Novelty can breed fear. This fear does not justify intervention alone.

Any harm should not be considered in isolation. Policymakers tend to have an imperfect understanding of the cutting-edge technologies, including the benefits they bring. Regulators need to look not only at areas of damage but at the net impacts, and to consider the origin of damage. The harm may in fact be an adverse impact stemming from the pre-AI status quo.

Rushing to prevent harm sends a strong negative signal to innovators. Their innovation could suddenly be singled out for state restriction. It is unclear whether an investment will be allowed to continue or even assisted if there are even slight negative consequences from its development. This risks undermining investment and innovation. Governments must avoid supporting AI in policy discussions, but hindering it in practice. A good regulatory environment requires clarity, stability, and gradual evolution.

Even when robust intervention seems appropriate to remove harm, like a prohibition or fine, the real impact is often different. Just because a government prohibits something, does not mean it goes away. The application may continue, but now in an unregulated or underground fashion. This can criminalise people performing victimless crimes, if they are even worthy of being called crimes. Prohibitions also attract criminals who may enter the market to make a profit from the risk they take on by providing the same application or service, despite its illegality. The result can easily be that usage experiences face little decline, whilst harm rises. Any attempt to regulate AI should be considered carefully, with both the costs and benefits of policy change carefully assessed before action is taken.

CONDUCT COST-BENEFIT ANALYSIS ON INTERVENTIONS

Completing cost-benefit analysis provides an additional hurdle against bad decision making. When an issue emerges from artificial intelligence, it may cause panic, but this does not necessarily justify a legislative response. A rare incident should be considered in context. The 'unseen' costs of a policy should also be considered.

Consider a future with driverless vehicles, in which they are 99 per cent safer than human drivers. Even in this scenario, there will still be some accidents, even deaths. The wise response to the first accident should not to ban driverless cars, or to punish the individual passenger in the offending vehicle. The accident and legislative response should be considered in the context of the overall increase in safety that has been achieved, which is a sizeable net benefit, and the huge cost that would follow intervention.

The ethics of AI are challenging, but practical solutions should be

sought. Consider variants of the 'trolley-problem' – how should one react should a driverless car kill a child, a grandmother, or two middle aged convicts? Interesting work is being completed to help determine the answer. In 2014 MIT researchers created an online experiment called the Moral Machine, to test public attitudes with 40 million decisions, across 233 countries and territories[112]. The research showed that attitudes vary significantly, particularly across different cultures. In practice, government shouldn't become paralysed by these hypothetical events, edge cases and rare incidents of actual harm. Instead the Government should encourage emergent solutions: contracts, insurance and self-regulation can provide a solid foundation.

DO NOT PICK WINNERS AND HOLD PUBLIC R&D TO THE SAME STANDARDS AS PRIVATE INVESTORS

Government has a poor history in making investment decisions. The lessons of the past caution against a policy of state investment in artificial intelligence companies or attempting to lead through subsidies.

This is well demonstrated by the UK's period of greatest intervention in businesses through nationalisation and industrial policies. Between 1960-75 nationalised industries saw average returns of 1.1 per cent per annum, compared with 2.7 per cent per annum for all manufacturing industries.[113] Through 1950-79 nationalised compa-

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112 Awad, Edmond, Sohan Dsouza, Richard Kim, Jonathan Schulz, Joseph Henrich, Azim Shariff, Jean François Bonnefon, and Iyad Rahwan. 2018. "The Moral Machine Experiment." Nature 563 (7729): 59–64. https://doi.org/10.1038/s41586-018-0637-6.

113 Dunkerley, J, and P Hare. 1991. "Nationalized Industries." In The British Economy since 1945.

nies saw slower increases in labour productivity than in the wider British economy and in the same industries in other countries.[114] In 1975 the UK Government set up a National Enterprise Board to invest in companies. By 1978 it had reported a loss of £40m on £1.4bn of investment.[115] Similar organisations in Europe suffered even worse performance.[116] The failure of big mission-orientated projects like the Concorde Aircraft and Advanced Gas-Cooled Reactor further cemented scepticism in government-led R&D.[117]

Even seeking a small return on investment, it is hard to beat the market. The root problem is that politicians and bureaucrats lack the information required to make good investment decisions. They are prejudiced by political considerations, not simply good business outcomes. They usually lack the specialised skills and profit motives of a professional entrepreneur or investor. Their actions can even hinder development, with entrepreneurs manipulating subsidies and rent-seeking. There is little reason in theory or practice to believe that a government can pick innovative winners better than the market.

Picking winners fell out of favour in most developed countries based on the failures of the post-war era. However, it is gaining misguided

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114 Hannah, Leslie. 2004. "A Failed Experiment: The State Ownership of Industry." In The Cambridge Economic History of Modern Britain: Volume III: Structural Change and Growth, 1939-2000, 84–111. Cambridge University Press. https://doi.org/10.1017/CHOL9780521820387.005.

115 Grylls, M, and J Redwood. 1980. "National Enterprise Board: A Case for Euthanasia." Centre for Policy Studies.

116 Burton, John. 1983. "Picking Losers...? The Political Economy of Industrial Policy — Institute of Economic Affairs." The Institute of Economic Affairs. https://iea.org.uk/publications/research/picking-losers-the-political-economy-of-industrial-policy.

117 Henderson, P. D. 1977. "Two British Errors: Their Probable Size and Some Possible Lessons." Oxford Economic Papers. Oxford University Press. https://doi.org/10.2307/2662657.

appeal in the field of AI, inspired by China. Much of China's AI efforts are centralised around three companies, Alibaba, Baidu and Tencent. As Amy Webb has argued, "they have to follow the leadership of the Chinese government". This has the apparent advantage that they can focus independently on different fields (avoiding competitive duplication), but in practice this represents a state facilitated reduction in competition. This will discourage innovation overall, even if it seemingly achieves some great milestones, with positive headlines. China's AI motives are also quite different in that they reflect the government attitude towards privacy, freedom of speech, and other human rights. This is not a model for the UK to follow.

This is not to say government should never support innovation. Positive spillovers from innovation and clusters of investment mean the private sector could carry out insufficient research and development.[118][119][120][121] The original inventor or first-mover entrepreneur doesn't always gain all the rewards. Innovations also combine in unpredictable ways. However, government support needs to be well directed to assist innovation, and to avoid government failure or misdirection of resources.

The UK currently spends less on R&D than other developed coun-

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118 Nicholson, R, CM Cunningham, and P Gummett. 1991. "Science and Technology in the United Kingdom."

119 Nadiri, M. Ishaq. 1993. "Innovations and Technological Spillovers." National Bureau of Economic Research Working Paper Series. National Bureau of Economic Research. https://doi.org/10.3386/w4423.

120 Martin, Ben R., Af Hicks, Keith Pavitt, Jacqueline Senker, Margaret L. Sharp, and Nick von Tunzelmann. 1996. "The Relationship between Publicly Funded Basic Research and Economic Performance."

121 Acs, Zoltan J, A E Pontus, Braunerhjelm Ae, David B Audretsch Ae, and Bo Carlsson. 2008. "The Knowledge Spillover Theory of Entrepreneurship." https://doi.org/10.1007/s11187-008-9157-3.

tries like the United States or Germany – both in the private sector and public sector. What the government spends is primarily directed towards universities. Here incentives focus more on academic success than practical applications.[122][123][124] Outside of universities, funding through bodies like the Industrial Strategy Challenge Fund are somewhat politicised; there is a high risk of government failure. There is also a risk that government R&D spending may not be complementary to private sector R&D but substitute or 'crowd it out', though the empirical data is unclear and remains open to debate.[125]

It has recently become fashionable to discuss following a public R&D model inspired by the United States Defense Advanced Research Projects Agency (DARPA). This was set up to launch high risk but high gain research in the wake of the Soviet Union's launch of Sputnik into space. It has been praised for contributions to GPS, the internet, personal computing, lasers, and rockets.

Similar models have been used elsewhere, with Japan's Strategic Innovation Promotion Program (SIP) and other emerging DARPA-style proposals abroad providing inspiration and caution. France, South Korea and Taiwan have discussed the creation of DARPA type

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122 Azoulay, Pierre, Joshua S. Graff Zivin, and Gustavo Manso. 2011. "Incentives and Creativity: Evidence from the Academic Life Sciences." RAND Journal of Economics 42 (3): 527–54. https://doi.org/10.1111/j.1756-2171.2011.00140.x.

123 Gans, Joshua, and Fiona E Murray. 2011. "Funding Scientific Knowledge: Selection, Disclosure and the Public-Private Portfolio."

124 Cowen, Tyler, and Alex Tabarrok. 2016. "A Skeptical View of the National Science Foundation's Role in Economic Research." Journal of Economic Perspectives 30: 235–48. https://doi.org/10.1257/jep.30.3.235.

125 David, Paul A., Bronwyn H. Hall, and Andrew A. Toole. 2000. "Is Public R&D a Complement or Substitute for Private R&D? A Review of the Econometric Evidence." Research Policy 29 (4–5): 497–529. https://doi.org/10.1016/S0048-7333(99)00087-6.

organisations as part of their AI Strategy and associated government proposals. France's proposals were treated with some scepticism, but helped prompt the creation of the Joint European Disruptive Initiative (JEDI).

The ARPA model has significant risks though. Its focus has traditionally been in the military domain, where concentrated funding and research was needed for particular military objectives, regardless of the economic return on investment. Whilst some of these projects happened to have positive side effects for society, as would most R&D projects, there was an opportunity cost. There is limited research talent and funding available. These resources might have had an even bigger impact for society had they not been distracted towards military applications. It's easy to focus on their societal successes whilst ignoring the unseen lost innovations.

For publicly funded R&D that does occur, ARPA's culture may provide some useful lessons on reducing waste and improving the return on investment. Any public R&D should have minimal political interference and focus on practical applications, not academic citations. Contributions should be welcomed on a competitive basis. Prizes should be awarded at key milestones and after completion, rather than granting large funding before any progress has been made. The overall ethos should mirror that of private sector startups, embracing a 'lean startup' philosophy or iterative development methodology, accepting fast failures rather than focusing on extended expensive vanity projects.[126] [127] Programs should be decentralised and focus on making incremental 'diffusion-orientated' progress, rather than

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126 Cowen, Tyler, and Alex Tabarrok. 2016. Ibid.

127 Fuchs, Erica, Anna P Goldstein, and Michael Kearney. 2018. Funding Breakthrough Research: Promises and Challenges of the "ARPA Model."

concentrated in grand 'mission-orientated' initiatives.[128] Program Managers should have a high degree of independence, with recruitment focusing on leading talent from the private sector and academia, on a fixed-term basis. These refinements would support a stronger culture of risk-taking entrepreneurship which might otherwise be rare in government.

EMBRACE EXPERIMENTATION AND EVOLUTION OVER GRAND DESIGNS

There will be areas where government feels the need to step in, either due to a clear risk of harm or due to concentrated pockets of unemployment. Government should act with humility and restraint. Policymakers are unlikely to have a full understanding of the technology, its costs and benefits, nor can forecast future developments. Even when the type of intervention seems clear, perhaps licensing to restrict usage or retraining to support reemployment, effective implementation may be challenging.

The Government should set aside £1 billion of the Department for Work & Pensions c£175 billion budget, to enable policy experiments. Across the country, these should seek to target joblessness more effectively in an age of artificial intelligence and automation. This could be nded by identifying current ineffective programmes for joblessness and efficiencies in other welfare spending. The long term aim should be for the £1 billion to generate a measurable return on investment, with more effective programmes and a reduction in long term benefit costs as people return to work.

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128 Ergas, Henry. 1987. "The Importance of Technology Policy." In Economic Policy and Technological Performance. Cambridge University Press. https://doi.org/10.1017/cbo9780511559938.005.

There is already a vast structure of benefits, in particular Universal Credit, which is replacing the Jobseeker's Allowance, as well as other in-work benefits such as the Working Tax Credit, Housing Benefit and Child Tax Credit. This provides for a safety net for those who are unemployed. They must seek work, and are incentivised to return to work. Under Universal Credit, payments taper off as a person returns to work, helping reduce the steep cliff edge that trapped some people in unemployment. There are some opportunities to gain work experience and vocational training.

The UK has a safety net in place which allows for traditional responses to unemployment - visit the Jobcentre, do community service, speak to the Jobcentre support staff. The £1 billion of experimentation would allow the Government to try more radical approaches, with randomised controlled trials and other pilots. These would likely involve a range of nudges (influencing decision making through positive reinforcement), re-education and re-location schemes, and even cash payments to encourage entrepreneurship.

Policies such as the lifelong-learning voucher scheme suggested in Finland's AI Strategy are worth testing. These would allow workers to update their skills while maintaining choice by using the full plethora of educational providers to support. It's not yet clear whether such a scheme would make a measurable difference for getting the unemployed back into work or how best it would be formulated. This type of data and experience is lacking. Delivered effectively, such insights will then help inform policy makers and guide future policy to tackle any concentrated pockets of unemployment. It also ought to save DWP money overall, as more effective work discovery would reduce the need to pay out benefits.

The spirit of experimentation precludes this paper from providing

a comprehensive or restricted list of policies to test to enhance the effectiveness of the UK's welfare system. However, novel (and not so novel) ideas across developed welfare systems can be grouped into several buckets: payments, education, personalization, and partnerships.

TABLE 5. WELFARE IDEAS

WELFARE IDEAS	DESCRIPTION
Payments	
Wage Insurance	Compensation for taking a lower-paying job, providing an incentive to return to work more quickly and avoid lengthy unemployment. The longer one is unemployed the harder it becomes to return. Gives more time to find a similar or higher paying role reducing frictional unemployment. Wage insurance can take many forms - it may be graduated, time bound or require some employee contributions.
Re-employment bonuses	Bonus payments for finding a new job quickly, again incentivising a faster return to work like a Wage Insurance, with the same intentions. Bonuses can be focused on a time period but this can cause perverse incentives or further discourage those who miss the bonus window.
Income support	Longer term support similar to Wage Insurance or Re-employment bonuses, provided to those where there is limited/no expectation that they will return to past earnings or who are working part-time whilst retraining, completing on-the-job-training or working as an apprentice.
Mobility assistance	Providing support when there is a mismatch between workers and their location. This may be particularly relevant if automation is concentrated within a particular industry with geographical implications.
Housing refinancing	Support to "underwater" negative equity borrowers to refinance or sell their homes enabling greater flexibility and mobility. Could also be complemented by waiving stamp duty for those who qualify.

Disolaction/ adjustment benefit	A general package of benefits/payments to support those losing their jobs in areas deemed to have been particularly impacted by AI. This could include access to job search support, relocations/training grants, wage insurance and other measures.
Workplace Benefit protection	Maintaining access to services received whilst they were employed. This is particularly relevant in countries in which workers are reliant upon employment-based health insurance, but can also be translated to other workplace benefits.
Small business support	Providing assistance (usually primarily financial) to unemployed workers who want to start their own businesses. Small business loans are typically considered higher risk by financial institutions so funding is challenging to raise. High risk remains even if government is more generous, so applications processes / access restrictions based on business case are key areas for testing
Education	
Nano degrees / micro-credentials	First popularised by Massive Open Online Courses (MooCs) these provide a potential model for highly focused education that is flexible and cost effective. Leading online platforms provide courses that can be completed in 4-8 weeks, with exams or practical testing providing a gateway to more formal qualifications. Critics challenge that these programmes are less thorough and may not have as lasting an impact as classroom or "real-world" training.
Life-long learning vouchers	Universal voucher based access to approved education and training packages for life, regardless of employment status, encouraging the workforce to continue proactively re-skilling on a life-long basis to reduce unemployment risk, increase flexibility, and/or boost productivity.
Work-based learning	Facilitating easy access to learning in a workplace, either for existing employees, or through hands-on apprenticeships for those more likely to learn for practical experience than a classroom.
Employability	Support and training that is focused on employability rather than actual workplace skills. This includes re-building trust in the supporting institutions and employers, which may have been damaged by past negative experience. It could also focus on softer skills and maximising opportunities with existing

Personalization	
Tech enabled solutions	Greater use of online and digital channels to research, find, and apply for opportunities as is increasingly popular in a private sector context. Enhancing information signals to improve matching. Building upon Universal Jobmatch service (now rebranded as 'Find a Job').
Personalized pathways	Conducting in depth assessments of individual needs then providing a tailored package of support and interventions. This helps allocate different services like counselling, mentoring, training, placements based on individual needs and preferences. Pre-defined paths or playbooks could be developed for common challenging scenarios.
Risk assessments	Completing risk assessments for new claimants to identify other challenges which may hinder their return to work or which may have encouraged their exit from the workforce, enabling more tailored support and interventions.
Youth targeting	The costs of unemployment are typically higher for young people, with a longer term impact. Measures here would be segmented for younger workers.
Family-based policies	Dual-earner families are typical. Whilst this may lessen the impact of an individual becoming unemployed, it can hinder re-entry to work, e.g. if moving is required, do both look for new work? Policies might adjust benefits and support based on household situations rather than at an individual level.
Partnerships	
Community service	Creating placements in the charitable sector that are party/fully funded, providing more opportunities for apprenticeship style education.
Apprentice-ships	Partnering with private sector organizations willing to take on apprentices, potentially with preferential or subsidised salaries.
Community colleges	Partnering with local education to enhance and tailor training to local industries and circumstances.
Work-sharing	Working with the private sector to offer work with reduced hours rather than laying off workers. This might be partnered with partial benefits to top up individual incomes.

ROBOT TAXES ARE A BAD IDEA

Robot taxes have started to gain celebrity proponents like Bill Gates:

> "Right now, the human worker who does, say, $50,000 worth of work in a factory, that income is taxed and you get income tax, social security tax, all those things. If a robot comes in to do the same thing, you'd think that we'd tax the robot at a similar level … Some of it can come on the profits that are generated by the labor-saving efficiency there. Some of it can come directly in some type of robot tax"[129]

Their rationale is simple. If AI results in job losses without replacement, the number of taxpayers decreases. This could reduce tax revenue, reducing the government's ability to support a growing number of unemployed. Moreover, people pay taxes but robots do not – this gives robots unfair tax advantages.

Despite this narrative, robot taxes are deeply flawed. Defining robots and what gets taxed is nearly impossible. In a factory, you could start by counting the number of physical robots, but how would one determine the tax paid by each different automation in a fair way? In software, you could count the number of software robots, if they closely emulate a person's workflow, but what if they do not? In most cases, automating software does not replace entire jobs, but individual tasks. Some of an individual's tasks can be automated without an entire job disappearing.

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129 Delaney, Kevin. 2017. "Bill Gates: The Robot That Takes Your Job Should Pay Taxes." Quartz. 2017. https://qz.com/911968/bill-gates-the-robot-that-takes-your-job-should-pay-taxes/.

It is unclear where a robot starts and ends. For example, when Apple introduces a new AI powered feature to improve the quality of iPhone cameras, it would be very challenging to determine how much additional tax needs to be paid. Similarly, it is unclear how much tax should be paid by an AI that examines a patient's retinal scan to identify eye diseases or by an AI used to determine a customer's likelihood of default when being granted a loan. It seems nearly impossible to objectively and fairly calculate the hypothetical wage a robot would have earned if it had been a worker instead. The lack of boundaries makes the robot tax near impossible to implement in practice. Moreover, AI and robots should not be especially singled out compared to other technologies that can automate work or enhance decision making.

Adam Smith proposed useful maxims for good taxation in the Wealth of Nations: proportionality, certainty, convenience and economy. A robot tax would perform poorly against all of these. An ideal tax is targeted at an activity that we want to discourage;technological advancement is no such activity.

Even if a robot tax could be administered efficiently and fairly, it approaches the potential challenge of innovation and mass unemployment from the wrong perspective. Taxes discourage activity. Discouraging the use of robots would limit gains in productivity and overall output, making us all worse off. Instead, it would be better to embrace higher output, and if necessary, redistribute afterwards once we are wealthier through more general increases in revenue.

The tax would also suffer under global competition. Companies using technological advancement might leave the UK for countries with more favourable tax regimes, meaning a robot tax would raise little revenue and result in fewer jobs in the UK. This will limit the effectiveness of robot taxes in compensating for automation, and enhances

the case for finding 'post-hoc' solutions – i.e. providing support to those who lose out rather than sporadically penalising some innovators.

A UNIVERSAL BASIC INCOME OR NEGATIVE INCOME TAX COULD BE IMPLEMENTED INSURE AGAINST THE WORST AI SCENARIOS

It is not within the scope of this paper to redesign the welfare and taxation system, but these policies are examined briefly.

A universal basic income (UBI) is an ambitious and radical change to welfare. It is the idea of providing a cash payment from the government to all citizens. Andrew Yang made the UBI the signature policy of his 2020 Democratic Party presidential campaign. He called it a "Freedom Dividend". Yang proposed a $1,000 monthly UBI for every American over the age of 18 years.

The UBI has support across the political divide, including many 'free-market' proponents. The rationale is that the UBI is an opportunity to simplify the welfare system, replacing all other programmes. An additional benefit is that it avoids the poverty trap. Other welfare systems can encourage people to remain on welfare due to the costs of transitioning to work.

The problem with a UBI is that it is extremely expensive. Consider that Yang's proposal for $1,000 per month per American would cost $3.9 trillion. That is more than the entire government revenue of the USA in 2018 of $3.3 trillion, and 95 per cent of current expendi-

ture.[130] It is around four times as much as is spent on Social Security today, leaving a gap of $2.9 trillion. Adding in the USA's large deficit, to balance the budget with Yang's UBI would require more doubling tax revenues to $7 trillion. In the UK, an equivalent policy would be a UBI of around £850 monthly, a total cost of around £670 billion. This is six times the current education budget, four times the health budget and twice the current social protection budget. It makes up almost the entirety of all central government spending. It would entail substantial new taxes.

The negative income tax (NIT) is essentially the same policy, but better delivered and at a lower cost. A NIT is a welfare system in which, depending on income, some pay tax, others pay no tax, and those earning the least receive an income top up. This approach retains the core benefits of a UBI. The welfare trap is reduced by removing the cliff edge between receiving benefits and not receiving benefits on entry into the workplace – it all depends on your income, and it always pays more to work. A UBI and NIT are basically the same policy, administered differently. The current system of Universal Credit is not that dissimilar to a Negative Income Tax, making a NIT the most logical extension and easier to implement.

A well configured negative income tax could be combined with a flat tax, and the abolition/reduction of other benefits (perhaps except for disability and needs specific benefits). This could give the unemployed coverage but more free-choice, whilst giving workers incentives for higher earnings and to stay within the system (rather than resorting to legal tax avoidance or illegal tax evasion).

The two most common concerns about a UBI/NIT beyond cost

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130 Congressional Budget Office. 2019. "The Federal Budget in 2018." https://www.cbo.gov/system/files/2019-06/55342-2018-budget.pdf.

include ensuring benefits are appropriate for different needs and providing benefits paid by hardworking taxpayers, with no obligations in return. The former concerns might be addressed by covering all citizens including children (so families receive more) and supplementing the benefits of those with special needs. The latter concerns might be addressed by placing conditions on recipients receipt or use of the funds.

The biggest challenge with a NIT was recognised by Milton Friedman in his proposals. There is significant risk that any UBI/NIT could spiral in cost and complexity over time:

> "It establishes a system under which taxes are imposed on some to pay subsidies to others. And presumably, these others have a vote. There is always the danger that instead of being an arrangement under which the great majority tax themselves willingly to help an unfortunate minority, it will be converted into one under which a majority imposes taxes for its own benefit on an unwilling minority."[131]

Depoliticising the negative income tax level, with an independent body calculating the level based on a predefined rule might help in theory. However, it probably isn't desirable or feasible to outsource such a significant portion of government spending.

Overall the NIT provides a compelling safety net for a potential world without enough work, particularly when paired with a wider transformation of taxation and welfare, worthy of serious assessment.

If data begins to show a trend towards the more extreme unemploy-

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131 Friedman, Milton. 2002. Capitalism and Freedom: Fortieth Anniversary Edition. University of Chicago Press.

ment scenarios, the Government should set up a Flat Welfare & Tax Commission. Its brief would be to test the NIT through pilots and experiments, define an overhauled welfare and tax system that builds upon Universal Credit, and create legislation to enable its implementation.

A well-defined welfare system is the best defence available against the AI automation pessimists who ask, "what if this time is different?". The innovation maximising solution is to embrace AI and reap its benefits, but mitigate losses.

CONCLUSION

AI is real and increasingly all around us. With machine learning, more complex problems are being solved, and more work can be automated easily. An estimated 30-40 per cent of UK work is at high risk of automation. At the same time, technological progress is key to growth and increased overall prosperity is the most likely scenario as AI develops. We should embrace AI whilst protecting the short-term losers.

The quality of most AI discourse so far has been poor. Politicians are uninformed about AI, and many commentators are uninformed about good policy. Many proposals have been limited to high level political platitudes. They propose nice outcomes without a substantive step to achieve them. The worst policies are unduly optimistic about politicians and unduly pessimistic about AI, hindering or blocking progress.

AI could contribute to no less than a 4th Industrial Revolution. The UK is well placed to benefit immensely. Aside from the United States and China, whose funding clout is unparalleled, the UK could become an established world leader in AI.

Woolly pronouncements and half measures will not suffice to position the UK to lead in AI or mitigate the potential impact on jobs. A

radical programme is needed across regulation, R&D, welfare and taxation.

This report recommends a path forward that would better position the UK. It starts with a recognition of AI's potential contribution and the importance of fast adoption. It requires adopting a regulatory stance of "permissionless innovation", in contrast to the default government stance of the "precautionary principle".

To make this credible, the Government should set up a £5m 'Office for Removing Barriers to Artificial Intelligence' (ORBI) and pass an 'Unleashing Artificial Intelligence Act' (UAI Act). This would remove impediments to Artificial Intelligence and make permissionless innovation the legal default.

To be consistent and maintain its credible commitment to AI, the Government should not resort to prohibitions, fines, threats or licensing except in the extreme and with an understanding of the risks. When intervening is genuinely justified, decisions would be supported with cost-benefit analysis.

Where intervention is needed, the Government will need to embrace experimentation and evolution over grand designs. £1 billion of the Department for Work & Pensions c£175billion budget should be redirected to enable policy experiments to better tackle sustained joblessness.

Robot taxes are one the popular policy proposals today for mitigating the impact of AI – they should be avoided. Robot taxes are poorly conceived, would hinder progress, and would be ineffective in a globalised economy.

Another popular policy to protect against the worst AI scenarios is

a Universal Basic Income. However, the less fashionable Negative Income Tax is the best formulation to achieve the desired outcome.

The Negative Income Tax stands on its own merits to both enhance and simplify welfare. It would ideally be paired with a flat income tax. The Government should set up a Flat Welfare & Tax Commission if the worst case unemployment scenarios emerge in reality.

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