Springer Bio Futures Book, 10 August 2020

Parallels between the Future for MedTech and Agri-Tech, Perspectives Drawing on the British Experience

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1. Introduction

This chapter seeks to draw parallels between, and reveal common insights from, two historically quite distinct, but now increasingly related sectors: medical technology ('MedTech') and agricultural technology ('Agri-Tech'). Previously, others have considered the linkages of these individual sectors with associated industries and economic activities, such as e.g. MedTech and Healthcare or Agri-Tech and Bioscience, but we are not aware of studies concerning prior linkages between the MedTech and Agri-Tech sectors as innovation areas. As an example, we consider the United Kingdom experience and note that, at the time of writing, both the MedTech and Agri-Tech sectors are independently important to the UK economy (BEIS 2017; WLEP n.d.) Furthermore, both have seen significant growth in recent years, (UKRI 2018; WECA 2019) in part as a consequence of driving considerations explored elsewhere in this book. Despite the recent progress, we posit, as a result of our examination of the UK position, that there are likely to be even more dramatic changes ahead and some of these are already underway. We suggest that some of the coming progress will arise from a synergistic combination of the two domains, but even more substantially we see the possibility for knowledge transfer between the two sectors as we detect the emergence of innovations within each sector with much beneficial potential in the other.

Given the urgency in addressing the systemic challenges we face today it is important to start understanding how historically distinct industries are changing and converging towards comparable patterns as they adopt digital technologies. As we show in this chapter, the foundation technologies that enable both MedTech and Agri-Tech are the same. This means these two distinct industries will start showing synergies particularly at the level of business models and data they produce. This poses a considerable opportunity for future thinking from a systems perspective where two of the fundamental industries for human survival, namely agriculture and health, can be brought together to address global challenges.

In this chapter we survey and explore the foundations of the starting linkages between these industries and a set of issues that we have been researching and for which our work is ongoing. We expect to publish that ongoing work in due course. We here provide an overview of key issues and highlights themes and insights emerging from our research thus far.

2. Industry overview

For this chapter we seek, as far as possible, to focus on innovations and from that perspective we seek to establish a set of associated actors driving the process. We consider two related essential questions. Who are the key actors in the innovative system in MedTech and in Agri-Tech in the UK? And, what are the core technologies driving the current waves of innovation in the two sectors? We ask these questions to understand better the future of both sectors, but also the possible scope of cooperation. Can one industry learn from the other? Where is the scope for co-operation and innovation?

Our ongoing research is based on a review of the literature and our initial findings from a series of expert interviews. However, our main purpose in this chapter is context setting and an exploration of the key issues. Both agriculture and health are part of the oldest activities in the history of human civilisation. Today the medical technology sector is known to be one of the most innovative industries. According to Accenture's Disruptability Index, which is studying disruption in 20 industries, healthcare is among the most vulnerable to future disruption (Accenture, 2019). The UK MedTech sector includes organisations developing, producing or selling medical devices. These are all linked to an extensive network of service and supply businesses. The sector is part of the Life Sciences and hence sits alongside the closely-related BioTech sector. The MedTech sector is heavily influenced by medical device regulations and the health economic factors affecting adoption and distribution in key consumer groups such as the UK National Health Service (NHS). The medical devices industry remains central to the MedTech industry and insight into the medical devices industry is crucial when seeking to assess the future of MedTech. The medical devices industry includes technologies from single-use consumables to complex hospital equipment, 'wellbeing' and digital health goods as well as In-Vitro diagnostic products.

The Agricultural Revolution in Britain spanned the mid-seventeenth to the late nineteenth centuries and was underway long before the more famous Industrial Revolution. As industrialisation started to provide more jobs, and as urbanisation took hold, health issues in crowded cities intensified leading to a continuous pressure for innovation in health and medical technologies. In contrast agriculture advanced in bursts of activity when enabling technologies reached a critical mass. From the 1950s onwards the 'green revolution' and the genetic modification of plants led to increased yields and disease and pest resistance opening a new path for agricultural innovation and formation of high growth Agri-corporations. A new wave of innovation in agriculture is today underway with the onset of the fourth industrial revolution. The result is highly intensified precision agriculture, employing sophisticated sensor and data technologies, robotics and AI in order to predict, perform and control agricultural activity. The aim of these developments is to minimise the unpredictability of some deciding factors such as weather, disease, resource scarcity and other natural adverse effects in order to achieve maximal outcomes as well as increased automation and a reduction of reliance on human labour. These enabling technologies increasingly bring agriculture to the fore as a strategic field ready for innovation and disruption and on a par with other innovative industries, such as MedTech.

The British MedTech ecosystem – key actors

The MedTech sector in the UK is moving towards a dynamic and increasingly diverse healthcare procurement environment, with challenges in the form of a new regulatory standards and a highly competitive market. There are around 3,700 medical technology companies operating in the UK (Kent, 2019). The sector accounts for 40% of Life Sciences employment in England (86,000 jobs), however 84% of the businesses are small companies employing less than 50 people (MedTech Landscape

Review, 2019). Around one third of the total turnover comes from small businesses and the rest from companies with turnover of over £50m including UK companies and international corporations. The development of the sector faces a challenge in a form of a gap between a small number of big global corporations and many small and medium sized businesses, including start-ups. In total, the sector employs 127,400 people; 97,600 in core MedTech businesses and 29,800 in Service & Supply businesses. The combined turnover of the sector is £24bn (Office for Life Sciences, 2019).

We note that in the UK, MedTech technology developments are mainly dictated by regulations from the National Institute for Health and Care Excellence (NICE) and purchasing by the National Health Service (NHS) which has a near-monopoly in healthcare procurement. The operation of the NHS and other governmental organisations, such as NICE and the National Institute of Health Research (NIHR) are centralised. The NHS creates a strong centralised network that makes regulation around creation and commercialisation of medical technologies easier. However, it is noteworthy that the NHS, with its significant market power (it accounts for about 80% of expenditure for medical technology (Klein, 2015)), is not perceived to be approachable by the small and medium sized companies and start-ups dominating the MedTech innovation landscape. As a market giant with extremely high bargaining power, the NHS shapes the demand for MedTech innovations focusing mostly on those that appear likely to reduce NHS system costs.

The Medical Research Council (MRC) is the main public body responsible for funding fundamental medical research in the UK. It forms part of the national science base. In addition, the NIHR, as part of the government's Department for Health and Social Care, invests £300 million a year into the infrastructure of clinical trials in the UK, generating what it estimates to be a financial return of £2.4 billion for the British economy (Kent,2019). The MRC has provided the funding for a number of notable medical science breakthroughs, including the structure of DNA. Indeed the research funded by the MRC has resulted in 32 Nobel Prize awards.

Government policy in England is currently strengthening its long-standing emphasis on achieving an impact from innovation in the health and care system, rather than just sponsoring the development of inventions and innovations (MedTech Landscape Review, 2019). However, the presence of science-push remains clearly visible and Great Britain is generally perceived to be one of the best places for digital health and medical technology businesses. Most of medical technology companies in the UK are small to medium sized enterprises (SMEs), that are entitled to research and development (R&D) tax reliefs. Thanks to this they can deduct a high percentage of their qualifying costs from their yearly profit (Kent, 2019).

The NHS has supported and enabled innovations in MedTech through a wide range of collaborations with private and non-profit sectors. Medical technology companies can be found all over the UK, however several regional industrial clusters have developed. Those regions have a high concentration of medical device companies, component suppliers, clinics, and research facilities with a focus on biomed research. Organisations in those clusters benefit not only from the opportunities of joint research and the proximity of experts in different areas (medical, engineering, IT, AI, big data), but often also from collaboration in areas, such as lobbying. In this regard big companies are always privileged as they have higher lobbying power to shape the stream of the governmental funds. At the centre of such medical clusters is the so-called "golden triangle" linking London, Cambridge and Oxford with world-class academic institutions. In particular Cambridge is the UK's MedTech start-up hotspot (Hender, 2016). Being based in the Cambridge cluster allows companies to access talent and resources of world-leading quality. This culture has helped the UK recently to become a world-leader in medical artificial intelligence (AI) and digital transformation of healthcare.

The Agri-Tech ecosystem key actors

Agriculture only contributes less than 1% to the UK economy and its share of employment is 1.45%. Total farming income in 2019 rose by 8.2% to £5.3bn in current price terms and gross output increased by 2.1% to £27.3 bn. The total factor productivity of UK agriculture however, increased by 4% in the last 12 months (DEFRA 2019 and DEFRA 2020). Despite its small contribution to the economy, UK agriculture comprises of a strong ecosystem of actors including university research centres, start-ups, farmers (and farm management businesses), research organisations, and the government through the four Agri-Tech centres (Crop and Soil Health Protection, Animal Productivity Welfare and Health, Engineering and Precision Technologies, and Data Science Analytics and Modelling) as well as grant and funding bodies and catalyst organisations. The ecosystem also contains and is supported by private funding sources (angel investors, venture capital and other forms of private investment), food retailers and business support and consulting organisations and persons.

The Cambridge Hub, located in East of England is the example of a lively and expanding Agri-Tech ecosystem where all the above mentioned elements are working together creating a rapidly growing Agri-Tech scene in the region. Given the central role of farmers in an Agri-Tech ecosystem and the fact that farms are dispersed around the countryside Agri-TechEast (renamed as Agri-TechE in 2020, as it goes national due to its strong success), a catalyst organisation, has had a central role in initiating and shaping this cluster in the east of England. The University of Cambridge, the University of East Anglia and the University of Bedfordshire all have agriculture and technology research groups that work in various specialist areas of Agri-Tech. NIAB (the National Institute for Agricultural Botany) is a leading UK centre for plant science, crop evaluation and agronomy with its headquarters in Cambridge. Also the region has a long history in farming and there are a considerable number of farms of varying sizes spanning arable, pastoral and mixed operations.

In 2018, the UK government officially announced support for the development of a £500 million ($650 million) Agri-Tech Cluster, to be located on the edge of the university town of Cambridge. The project aims to develop a 553-acre commercial park to house the new cluster. The park will provide working space for up to 4,000 people, spread across one million sq/ft of commercial properties as well as land for field trials, demonstration plots and access to up to 25,000 acres of additional crop and technology trial areas through 'established local partnerships' with farmers (Ag Funder Network 2018 and Cambridgeshire Live 2018). Together with the already established strength of the ecosystem in the area this places Cambridge to lead the nascent Agri-Tech industry in the UK.

Agri-Tech Industry and Policy in the UK

In July 2013 the UK government published the "A UK Strategy for Agricultural Technologies". The report aimed at building a capability to feed a growing population without damaging the natural environment through connecting basic research and applied sciences in order to create modern systems that allow farmers to access Agri-Tech expertise and innovations (HM Gov 2013). Embedded in the strategy was the development of relevant skills to carry out ideas from laboratory to farms. Industry was placed at the helm of the strategy working in partnership with public and third sectors, in particular by identifying opportunities for development and co-investment. The strategy was the first recognition of Agri-Tech as a sector encompassing agricultural research and the full supply chain from seeds food processing and packing and retail, encompassing both arable and livestock agriculture. The adoption and establishment of the Agri-Tech strategy by the government in 2013 was a timely response to the rapid rise of the adoption of digital technologies in agriculture, as well as the expansion of agricultural markets due to a rising population, growth of emerging economies and increasing scarcity of the fundamental factors for agriculture namely, land, water and energy. Furthermore, the strategy lead to the UK government investing £90M in setting up four key Agricultural Technology Centres or Agri-Tech Centres (Agri-Tech Centres n.d.), to foster collaboration between the Agri-Food sector, government and academia:

- Agri EPI Centre- Centre for precision agriculture and engineering
- Agrimetrics– Centre of excellence for big data across the agri-food sector
- CHAP- Centre for innovation in crop health and protection
- CIEL – Centre for innovation excellence in livestock

Another development towards fostering the Agri-Tech ecosystem and shaping regional communities was the foundation of a number of Agri-Tech Hubs including the afore-mentioned Agri-Tech East in 2014, based in Cambridge UK aimed at bringing people together farmers, scientist, engineers and other players in the industry including logistics and retail identify challenges and opportunities and form multidisciplinary collaborations to address the UK growth requirements in agriculture and food production. The organisation has been highly successful in building a strong tie between different players in the ecosystem. Another organisation, The Ceres Agri-Tech Knowledge Exchange Partnership, funded by a £4.78m budget from the Connecting Capability Fund, Research England, was also established in 2018 as a partnership between Cambridge University, the University of East Anglia, Hertfordshire University, the University of Lincoln and the University of Reading. These universities are collaborating with the John Innes Centre in Norwich, Cambridge-based NIAB and Rothamsted Research Institute to augment their joint commercialisation expertise. Furthermore, as noted earlier, there is backing for establishing a dedicated Agri-Tech cluster near Cambridge including a research and development park which will lead to the region becoming the industry lead nationally and potentially internationally.

All these developments occur along the backdrop of Brexit which will lead to a new bill to shape the post Brexit UK agriculture policy. This will see the UK exiting the Common Agriculture Policy (CAP) with a "public money for public goods" agenda. The policy is a series of 'Scheme' targeted at the protection of the environment and countryside, conservation of livestock while being accessible to farmers, growers and other players in the value chain.

The latest data available on the size of Agri-Tech sector in the UK also goes back to 2013 which saw a contribution of £14.3bn to the UK gross value-added income and employed more than half million people. A growth rate of 16% was reported for the sector between 2008 and 2013. With some subsectors showing growth of over 20%.

Although traditional agriculture still dominates the industry, emerging technologies are increasingly gaining acceptance in the agriculture sector and account for a third of Agri-Tech output with the technology component in agriculture showing the fastest growth between now and 2030. High-tech agriculture is currently dominated by precision farming and engineering which is worth over £1bn to the UK economy and employs 21,000 people.

3. Strategies for innovation and the technologies driving innovation

In our discussions with sectoral experts we sought to explore the extent to which strategy is shaped by the flow of money. In addition, we were keen to determine how government industrial strategy informs decisions as to where government funding is allocated. We also sought to explore the extent to which trickle-down funding in Agri-Tech and MedTech impacts on the balance of technologies developed. In addition, we considered whether there is a fundamental difference between the Agri-Tech and MedTech sectors arising from the shape of the market in each case.

MedTech technologies driving innovations

The MedTech market in UK is characterized by faster innovation and adoption (compared to biopharma), but it is still slow when compared to other markets of nonmedical technologies. New products are fuelled by new technology and unmet market need. Many companies use the new technology as part of their core business some experiment with new approaches to find ways of creating added values. The industry is in a development stage, under pressure to scale new technologies.

We note that:

- 75% of healthcare businesses are currently rolling out AI and machine learning technologies (Taylor, 2020);
- Healthcare is the next tech frontier however the industry needs to demonstrate success to convince investors;
- Brexit (EU-UK alignment) and Covid-19 will shape the future of MedTech in UK.

The core technologies driving innovations in Medtch in the UK include:

Artificial Intelligence (AI), Big Data, extended reality and quantum computers. These technologies are expected to become the foundation for next-generation products and services. Healthcare is adopting social, mobile, analytics and cloud technologies. However, most healthcare providers are in early stages of the digital transformation. AI has a great number of emerging use cases in healthcare. It is changing the way patients interact with doctors and is supporting the personalised healthcare e.g. AI can identify diseases using speech, facial features, retina scans, or X-rays. AI might also be used in contact centres, for payment activities, medical chart reviews and it can help patients take part in self-service activities. British start-up Lancor Scientific opened a laboratory to push for 90% accuracy for cancer screening with the use of AI. It has developed a device that the company claims is able to early detect cervical cancer at 90% accuracy and which can also be used for several other types of cancers. The afore-mentioned technologies are expected to push each other further forward and these combinations might have a game-changing impact on healthcare. The UK government, being a big supporter of AI and especially the use of AI in healthcare, took some steps to address and shape a future increasingly driven by AI. Among them is creation of a national strategy: ‘Artificial Intelligence Sector Deal’ in 2019, and the Life Sciences Industrial Strategy with the aspiration for the UK to apply £10 billion data set to domestic purposes. It has also supported the AI in healthcare by launching the national Artificial Intelligence Lab, to help the diffusion of technologies across the NHS. In 2018 the UK business secretary Greg Clark announced five new centres of excellence for digital pathology and imaging, including radiology using AI medical advances. Among them is the Pathology Image Data Lake for Analytics, Knowledge and Education (PathLAKE), in Coventry that will use NHS pathology data to ‘drive economic growth in health related AI’ and the London Medical Imaging and Artificial Intelligence Cenre for Value based healthcare that will use AI in medical imaging and related clinical data for faster and earlier diagnosis and automating expensive and time consuming manual reporting (MedTech Innovation News, 2019). Inward investment into AI increased in the UK by 17% in 2019 (more than in the whole of the rest of Europe). The UK is ranked third in the Global AI Index, following China and US. It is placed first in 'Operating Environment' measure of the index that focuses on the regulatory context and public opinion (Global AI Index n.d.)

Robotics, Automation, 3D printing – We note the rise of a human + machine collaborative workforce, where individuals are empowered by their skillsets and knowledge and new capabilities are delivered by technology. One example might be 'surgeon robots' that can perform complex surgeries with minimal supervision. Robots can collect blood samples, support patients (nurse and patient care robots) and that can carry out diagnostic procedures. Surgical robotics is another area where UK companies are at the forefront. CMR Surgical is using the Versius surgical robotics system, transforming keyhole surgery minimising the learning curve for the procedure, shortening it from two or three years to weeks. This also helps the surgeon to stay seated, reducing the operator's physical burden and hence the possibility of surgical errors due to exhaustion. Robotics can be expected to change the face of healthcare in the future.

Digital medicine, the Internet of Medical Things (IoMT) – The growing number of connected medical devices and smartphones that are able to generate, collect, analyse and transmit data create the IoMT a complex, connected infrastructure. It includes the medical devices but also, data, software, health systems and services. According to Deloitte the IoMT will transform the the role of MedTech in healthcare: improving drug management, diagnosis and treatment, disease management, remote monitoring of chronic diseases, enhancing patient experience and decreasing costs (Deloitte, 2018). Solutions based on connected devices can help reduce health care costs by reducing hospital re-admissions, lowering medication non-adherence, and increasing wellness. IoMT can also engage and empower patients and their carers to improve self-management.

The Topol Review published in 2019 presented a digital future for the NHS stressing the latest technologies across the themes of genomics, digital medicine and AI and robotics identified digital healthcare technologies that will impact on the NHS from 2020-2040: telemedicine, smartphone apps, sensors and wearables for diagnostics and remote monitoring, automated image interpretations (AI), interventional and rehabilitative robotics (Bolland, 2019). The digitization of the patient experience has been given a huge additional boost by the COVID-19 pandemic leading to a rapid virtualization of the patient experience seeking medical advice from their primary care physician.

Applications

In the UK the NHS, in common with many other health systems around the world, is looking for solutions that will enable earlier diagnosis of disease, address unmet needs in mental health, offer new solutions to cancer and rare diseases, and for complex multi-morbid patients (MedTech Landscape Review, 2019). Three new innovations have been recognized and announced by the NHS and are recommended to become mandatory across the health service (Taylor, 2020). They include:

- **HeartFlow Analysis** - non-invasive test that helps clinicians understand the severity of coronary heart disease by using artificial intelligence (AI), leveraging deep learning and highly trained analysts, HeartFlow creates a 3D digital model of a patient's arteries to help clinicians understand the location and severity of blockages. The HeartFlow Analysis has the highest diagnostic performance compared to other non-invasive tests, and can reduce the need for additional tests and deliver cost savings. It has many benefits for patients as it gives diagnostic clarity, reduces additional visits and exposure to radiation. The estimated cost savings for NHS are £9.1m every year (Millar, 2019). These savings are result of avoiding expensive unnecessary procedures and focusing on those who really need it. The technology was recommended by NICE in 2017 and now is used in more than 40 hospitals across NHS.

- **SecurAcath –** A device to secure catheters, associated with low incidence of catheter-associated complications. It improves stability and decreases infection risk for patients with a peripherally inserted central catheter (Fig.2). SecurAcath was one of four technologies centrally funded by the NHS under the Innovation Technology Payment (ITP) programme (over 250 medical technologies applied for the program). It helps to reduce time taken to care and treat dressing changes.
- **Placental growth factor (PIGF) test** that quickly predicts the risk of pre-eclampsia in pregnancy. The main benefit is a reduction in monitoring that allows pregnant women to spend less time in hospital. PlGF-based testing has been recommended for use by NICE Diagnostic Guidance (DG23) and Clinical Guidance (NG133) and is supported by the NHS Accelerated Access Collaborative and Innovation and Technology Payment (ITP) programme. The test became even more important recently as it helped to keep women out of hospital during the COVID-19 pandemic.

Agri-Tech Technologies and their Applications

The Agri-Tech industry has very similar digital drivers to those seen in other industries. These are based on a number of core technologies listed below:

Data and AI: at the heart of the data revolution is the increased storage capacity (cloud) and computational power which together enable the rapid processing of large quantities of data. This is increasingly augmented by machine learning, namely mathematical models that enable the creation of algorithms that find and apply patterns in data (Hao, 2017). The quality and accuracy of data is key to a useful and successful AI system. Hence when it comes to using advanced systems, the old adage of "garbage in garbage out" still stands and hence it becomes highly important to generate and use quality data. In agriculture data sources are mainly from sensors in the field, satellite data, and economic and historic datasets on produce.

Internet of Things (IoT): IoT is an umbrella term for a series of technologies that work together to enable dispersed hardware to communicate with each other using internet protocols and with a central data storage and processing centre. An IoT system requires a robust architecture that enables sensors, hubs and data processing centres to work in combination supported by a robust data relay network. The main application of an IoT system in farming is in enabling precision agriculture by integrating sensors and monitoring solutions into existing infrastructure and processes to generate data from agriculture activities or, in the case of animal husbandry, data related to each individual animal's health and physical condition. This data generated directly from the farm, possibly in combination with external data leads to an optimisation of processes, better management of resources, and continuous monitoring of plant and animal health which will enable timely intervention leading to prevention of loss of harvest or animal products.

Robotics: robots are specially designed hardware that can operate using advance AI systems using data generated from the farm as well as other external data required for fulfilling a specific task such as harvesting fruit or selectively taking out weeds without impacting the crops - leading to highly reduced use or, indeed in some cases, no use of harmful chemicals. Robots are designed around fulfilling a specific task and their intelligence depends on AI, IoT networks that they are part of and data that feed these systems.

In case of Agri-Tech applications, practically drones are small flying robots carrying a camera or other devices/sensors and photographing, filming or charting a designated area. Drones also perform their tasks based on a combination of technologies used in IoT systems, and AI modes and data technologies very similar to those seen in traditional robotic applications. The main difference being that drones are usually a mode of data collection whereas robots are more often machines/devices designed to take action based on data and AI decision systems inputs.

Other innovations in Agri-Tech are based on new ways of combining the above-mentioned technologies to fulfil new applications and solutions. For example, hydroponics is the cultivation of plants without the use of soil. In general plants are set in an inert growing media and supplied with nutrients, oxygen and water through liquids (hydroponics) or vapours (aeroponics). These technologies are currently most suitable for flowers, salads, herbs and some vegetables and are tried out in demonstrator projects at some scale. However, considerable further development is required in order to enable these technologies reach scales that are economic for a variety of crops. One advantage of these systems is that they can be built and run indoors using artificial light. In some cases crops can be stacked on top of each other creating "vertical farms". Most of the technologies behind these systems, apart from the nutrients that go into the hydroponics water and aeroponics vapours are all operated, monitored and adjusted using AI and IoT core technologies.

Key applications

The above-mentioned technologies converge in a number of ways to enable three main areas of application:

- Precision agriculture: this is when IoT and data from the field (machinery as well as soil and crop condition) are combined with other data sources such as weather, satellites and drones to inform the timing, location and amount of water, fertiliser or pesticides needed. This has a considerable impact not only on the cost of managing a field, but also minimises negative impacts on the environment by reducing water, fertiliser and pesticide use.
- Labour replacement: robots are increasingly becoming accepted in agriculture mainly because farm labour is in short supply and both the pandemic and Brexit have been seen in 2020 to exacerbate these shortages because so far most of the seasonal farm work has been carried out in the UK by seasonal migrant workers (Byrne 2018). Furthermore, robots can apply any intervention with high precision and continuously. Two start-ups we interviewed for this research, are developing precision solutions to routine agricultural work:
    - Ubiqutek (Rootwave) has developed a device that can kill weeds using an electric current and can be applied to each single week leaving crops intact.
    - Small Robot Company is developing small and flexible robots that can manoeuvre easily in a farm environment and can carry different tools for specific tasks.

It is not surprising that both companies are collaborating with each other in developing a weed zapping robot that can carry out this task without getting tired. There are also other forms of automation aimed at specific tasks in a farm such as continuous cleaning of animal sheds and even herding in the field which are being tested using specifically designed robots.

Animal health: IoT systems have been also deployed in animal husbandry with sensors continuously monitoring mainly the body temperature of each individual animal in the herd, notifying any changes through the systems. This enables the farmer to address any health issues before they present as visible symptoms and hence reduce risk of infecting the rest of the animals in the herd. A farm which benefits from the ability to run most of its routine daily tasks and timely data reports for decision making and prediction of required interventions in the near future is a so called "connected farm". It can gain economic advantage by reducing costs, reduce its environment footprint by minimising use of water, fertilisers and pesticides and other sources of environmental damage. Technologically the creation of such farms is quite possible today. Apart from capital cost for the technology infrastructure other challenges such as old and rigid business models and policy which currently does not allow for rapid adoption of new technology in farming and hence hampers the commercialisation of new technology. Start-ups are the main supply of new technology and innovation to this industry (Beauhurst, 2018). However, in Agri-Tech there is a not enough domain expertise in the start-up ecosystem. Most founders are engineers, data scientists or from other technical fields mainly with an urban life background. Investors too are not familiar with the challenges and opportunities of the industry and are not willing to risk larger sums of investment in the industry. Furthermore, there are risks associated with changing weather patterns as well as the impending consequences of climate change namely floods, heat waves, and drought.

It is important to emphasise that the field of Agri-Tech is in its early days and the rate of innovation using the above-mentioned core technologies i.e. AI, IoT and robotics is rapidly growing, and many innovations are yet to emerge. However, as with new field of innovation there will be also a so-called selection pressure and only a few innovations will become dominant technologies that will capture a maximal market share. Apart from the enhanced rate of adoption, the interoperability of these technologies, as well as adaptation to diversity of agricultural settings, are all important factors. Furthermore, the level of funding and support to a nascent start-up (and the technology it commercialises) and numerous other nuanced factors can play a determining role in the success or failure of a new technology as its promoters seek to survive in the competition to establish the dominant design.

4. Challenges

MedTech

As introduced earlier, there are a set of concerns driving forward a series of innovations, including: Big Data, AI, precision healthcare, and the Internet of Medical Things. These considerations lead us to ask: how will UK developments be shaped by the departure from EU? Is there scope for closer cooperation with US and, for example, the Middle East?

Concerning Big Data and Artificial Intelligence in MedTech: we suggest that data collection and application is the key to greater levels of automation and more sophisticated AI. With developments in AI outpacing even the nimblest regulators, the key question for the UK is whether future-proofed frameworks can be built which will allow technologies to be deployed in real world settings. The European Medical Device Regulation (MDR) aims to support innovations, but at the same time to guarantee high quality and robust safety standards for medical devices produced in EU or imported into Europe. In May 2020 a new MDR came into force in the EU. That was just months before the end of the Brexit implementation period, but for now the U.K. remains subject to this EU law. However, the future depends on the ongoing EU-UK "future relationship" negotiations.

There are many problems regarding the data:

- Lack of standardisation - the available medical data is a mixture of structure, semi-structured and unstructured data
- How to handle big data

- Privacy and security issues
- Data transfer and speed limitation
- Reliability of data storage

There is a need for International partnerships and joined-up approaches, so as to harness properly the data underpinning much of current MedTech innovation. It is important to leverage the power of such data. If UK innovation is to achieve global impact then matching to, and helping shape, international standards will be key concerns. Existing technologies use different frameworks and standards. They store information in a way that does not allow other systems to see, understand and use it. It is crucial to develop standards to improve accessibility, utility and scalability of healthcare data. These challenges and opportunities sit in a context where consumer trust has been damaged. Increasingly consumers (patients) do not trust companies to be able to safely collect and use data. In the spring of 2020 as the COVID-19 pandemic took hold, there was much interest around the world in the potential for smart phone technology to assist with the tracking and tracing of epidemiological contacts. This in turn led to much debate concerning user privacy and a ground breaking collaboration between Apple and Alphabet (parent of Google) in the development of a highly-private protocol open to both iPhone and Android smartphone users. At the time of writing (August 2020) however such smartphone-based techniques have so far largely failed to gain significant traction in Europe or North America. The concerns around the alternative approaches often promoted by governments including holding personal information in central databases, reminds us that a cultural shift is needed if trust is to be restored. Perhaps the Apple-Alphabet COVID-19 collaboration is a first example of such a cultural shift. We posit, based on that recent experience and other indications, that there is a need for better understanding of such 'trust issues' on the part of MedTech companies. We suggest that they can improve healthcare only if they access and utilise data responsibly. In that regard perhaps collaborations with academic institutions can help, as long as public trust in the socially beneficial role of academic institutions is also maintained.

Agri-Tech:

There are obvious global challenges to agriculture in general, namely:

- Population growth increasing the pressure on agriculture for intensification and increased yields
- Rapid urbanisation and reduction of arable land as well as labour willing and able to work in agriculture, leading to labour shortage
- Increased frequency and duration of adverse weather conditions due to climate change reducing the chance of reliable outcomes
- Social and economic pressure to reduce the carbon footprint of the industry
- Need to address legacy, policy, attitudes, entrenched interests and resistance to change
- Retreat of globalisation and increased emphasis on self-sufficiency

Furthermore, in the context of Brexit, the UK potentially faces an uncertain future due to a number of factors such as a loss, or weakening, of research partnerships built over decades with European institutions, the impact of trade negotiations on prices through possible tariffs and the potential loss of international political influence. This picture, although troubling, does not necessarily lead to a bleak future for Agri-Tech industry in the UK. In contrast the above-mentioned pressures have the potential to increase the support and attention to the industry and to favour the acceleration of automation and the diversification of agricultural products to replace imports (e.g. via urban hydroponic vertical farming). With its strong research and innovation base the UK is well placed to face these challenges.

The Covid-19 pandemic has considerably increased the immediacy of these pressures. For example, we have seen that unemployment is exacerbated due to global lockdown of countries to combat the pandemic. These events lead to acceleration of the drive for automation and also potentially reduces barriers to adoption by showing how a sudden unexpected event at national or global scale can suddenly disrupt the old models of the industry.

Discussion and conclusions

The innovation process in MedTech is much more complex and regulated when compared to Agri-Tech. It is characterised by high R&D costs, short product life cycle and it requires very sophisticated knowledge, expertise and resources. The UK is leading the charge among its European counterparts when it comes to embracing AI, robotics, and generally accelerating the digital transformation of healthcare.

The UK has the largest number of researchers and professional engineers educated in the biological sciences at some of the world's leading universities. This includes Cambridge University, an institution located at the heart of Europe's leading technology cluster. When looking at both industries we find that it is the people, and their unmatched expertise, that are the driving factors for innovation in the UK. Being based in the UK, particularly in the Cambridge cluster or more widely in the 'golden triangle' allows companies to access talent and resources of world-leading quality.

When looking at similarities we noticed that both Medtech and Agri-Tech are technologically linked through their foundational technologies. As mentioned earlier, data and AI, the IoT and robotics underpin the majority of innovations in both industries. The outputs of all these technologies converge via data (including its generation, transfer, aggregation and analysis) for insight and decision support. Robotics will also find considerable transferable technology and skills in both sectors.

Agri-Tech benefits from a less complex stakeholder landscape regarding data. It is spared some of the difficulties seen in MedTech – a sector burdened with trust issues in relation to patient data and its privacy and security. In contrast to the MedTech experience a considerable amount of Agri-Tech data is already traded on different websites serving as market-places. Internal farm data, although possibly owned by the farm owner, finds its full use and applicability when it is combined with other data and even with data from other farms; hence there is an increased incentive for data sharing. In contrast medical data, is highly prized and is a subject of competitive intelligence as well as strict privacy requirements concerning patients.

We have noticed that the British innovation landscape in Medtech is diverse and developing dynamically, looking for opportunities of cooperation and synergistic results. However, at the same time the associated centralised systems are slow in adopting, as they are focused mainly on cutting costs. These Medtech contextual realities might restrain promising innovations and slow down the commercialisation processes. As a result, many British MedTech start-ups scale-up through internationalisation and are selling their products to foreign markets, particularly the U.S.

In contrast Agri-Tech in the UK is not hindered by a centralised organising structure and hence has a reasonable opportunity to thrive in both national and international markets. The challenges for Agri-Tech are mainly its low level of prominence as a tech sector, both for tech talent and for investors. However, through organisations such as AgritechE and government-backed schemes such as the Ceres

Agritech Knowledge Exchange Partnership and the Cambridge Agritech Cluster, the industry is gaining support and attention as source for innovation and growth.

As the reality, dimension and severity of global challenges such as climate change, population pressure and resource limitation become more evident, both agriculture and healthcare come into the zone of concern for policy makers and business leaders alike. It is evident that the solutions which brought the agricultural revolution and advances in health care are not sufficient to address the scale and scope of the challenges we will imminently face. Both Agri-Tech and MedTech can play a considerable role, at the global and national level, to address these challenges at the systems level. Climate, food and health are key to navigating the world through 21^{st} century.

In light of COVID-19 pandemic, the MedTech industry comes into focus as it has the potential to be a strong contributor in solutions to challenges posed to both the global community and the UK through the pandemic. Agriculture however, is also strongly impacted by the pandemic in the UK mainly due to its dependence on seasonal workers who are not able to travel to the UK as before. Furthermore, both industries will be impacted by Brexit when it is expected to come into full force in January 2021. Initially it appears that MedTech would be more exposed to a hard Brexit due to changes in regulation and compliance which will hamper medical certification of UK MedTech products in the EU and other countries that use EU standards. This will impact MedTech start-ups mainly because European markets sometimes were much easier to navigate than the complex monopoly of NHS in the UK medical market. Furthermore lack of access to EU will take away the opportunity to scale-up using EU standard regulations accelerating start-ups moving into the US market and developing their goods under FDA regulations.

In contrast Agri-Tech is less burdened by stringent validation and regulatory requirements and has the scope to expand significantly in the UK. Nevertheless, the challenge of navigating the export landscape will remain.

MedTech and Agri-Tech can have a convergence point in animal health and “quantified-self” health monitoring in humans. Both MedTech and animal husbandry Agri-tech are based on measuring a series of health indicators via sensors to send early warning signals for prevention and early treatment. Such synergies may be useful in new innovations for epidemiological control in pandemics in the near and distant future.

Both MedTech and Agri-Tech play a central role in addressing global systemic challenges, such as food production and health provision and the management are both already under pressure due to population growth and climate change.

Who are the key actors in the innovative system in MedTech and in Agri-Tech in UK? And, what are the core technologies driving the current waves of innovation in the two sectors? We ask these questions to better understand the future of both sectors but also possible scope of cooperation. Can one industry learn from the other? Where is the scope for cooperation and innovation? Despite the ideas explored in this chapter, these questions remain pertinent. More research is needed if the full benefits of the synergies between the fast moving sectors of MedTech and Agri-Tech are to be made real. This work, and indeed this entire book, forms merely part of a work in progress. It is far too soon to know where this journey will end, but it is already proving interesting and provocative.

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