INVENTION TO IMPACT

EXPLORING THE KNOWLEDGE EXCHANGE PATHWAYS OF DIGITAL TECHNOLOGIES

November 2023

CONTENTS

FORWARD

Development of entrepreneurs and commercialisation of knowledge are important routes to delivering tangible, real world societal and economic impacts from the university sector that we support. As one example of UK strength, over the last decade investment in UK university spin-outs has increased more than five-fold to £5 billion in 2021. This sustained increase is fuelled by the many mature and emerging commercialisation ecosystems across the country, where universities work with local, national and international partners to create environments where the know-ledge they create, and the people they develop, fuel new products, services and enterprises.

The pathways and approaches needed to do this are not equally mature across all sectors and disciplines. University life sciences in particular has a long history of successful commercialisation, with a history of deep and sustained collaboration between universities and their industrial, investment, public and third sector partners. The 2016 McMillan Review of good practice in technology transfer highlighted that performance, practices and policies necessarily vary in different research/technology spaces, and different exploitation pathways need to be followed.

The diverse family of digital technologies is one such area where distinction considerations must be made, with complex norms, regulation requirements, market expectations and often very fast paced technology development. This broad family contains or closely aligns with four of the five technologies identified as critical to the future of the country in the UK Science and Technology Framework – AI, Future Telecommunications, Semiconductors and Quantum Technologies.

To raise awareness of the diverse modes of commercialisation and entrepreneurship in these tech sector specific domains, we commissioned McIvorStones to provide us with an overview of current practice information from the sector. We identify from this report the need to consider how universities can access the skills and capacity to support scale-up and launch of digital spinouts, including in institutions with lower-volume opportunity pipelines, build their local digital technology ecosystems, and access more patient capital for spinouts working at the techno-logical frontier.

Research England, working as part of UKRI and with other partners, will further explore these and other issues highlighted in the report as part of our ongoing work to support university commercialisation through Higher Education Innovation Funding (HEIF) and the Connecting Capability Fund, and to further best practice across the sector.

Alice Frost

Director of Knowledge Exchange
Research England

ABOUT THE AUTHORS

McIvorStones is a Canada-based public policy consultancy specialising in science, technology, and innovation policy. We work with public sector organizations to explore complex questions, helping them to develop meaningful insights and solutions to achieve their goals.

Charles McIvor is an innovation policy specialist who has developed national strategies and programs related to business innovation, technology transfer, innovation agencies, digital adoption. He has experience with working on critical issues like digital privacy, public procurement, and the future of work.

Ian Stones is a public policy specialist with background in science and technology policy. He has worked on major public projects, including creating national strategies and programs related to artificial intelligence and space systems technologies, and has significant experience building relationships between public and private sector organisations,.

To learn more, write to us at info@mcivorstones.ca.

EXECUTIVE SUMMARY

Turning digital inventions into real-world impact is a relatively new area of work for universities and their technology transfer offices. As digital technologies have evolved and grown in prominence, so to have the needs of universities, founders, investors, and universities' local ecosystems. In helping bring new digital ideas to market, technology transfer offices at universities are navigating a digital revolution, a groundbreaking shift that touches every field, industry, and market.

Universities are critical sources of knowledge and assets that enable new innovations and create economic growth and social impact. They value the public interest and their role as public institutions funded by taxpayers. Through knowledge exchange, universities demonstrate a commitment to seeing out the economic, social, cultural, and public benefits their people, knowledge, and assets can create—be that impact local, national, or global.

The knowledge exchange pathways of life sciences inventions and their applications—in medicine, agriculture, and pharmaceuticals—are well established and understood. **Digital technologies, especially frontier capabilities, such as artificial intelligence (AI), are new and can present unique challenges to founders and university technology transfer offices.** Sometimes, a market for a digital technology does not yet exist, with commercialisation pathways having unclear ends. Digital technologies often have a need for speed, with spinouts needing to bring a viable first product or service offering to market quickly, iterating and trying things out with customers, and possibly failing, but potentially gaining an important first mover advantage.

Certain aspects of knowledge exchange, in particular **problem-solving activities like contracted research or direct hiring, may be more common pathways for digital technologies** moving to market, as compared to licensing new intellectual property (IP) or creating spinout companies. However, problem-solving activities are sometimes addressed separately from commercialisation activities within the structure of university technology transfer offices.

Universities may inadvertently favour engaging in problem-solving activities with large or global firms, rather than small or medium-sized domestic companies. It takes the same amount of work and administrative input to take on a low-value consultancy

contract as it does a large one, creating unintended barriers for smaller domestic companies. As a result, digital technology knowledge exchange activity may more often favour larger firms over small- and medium-enterprises.

Direct hiring is especially important for digital technology development, as existing companies look to attract the best and brightest researchers. **Universities are experiencing a rise in 'acquihiring'—companies acquiring a spinout for the founders' skills and ideas rather than solely a spinout's IP.** Acquihiring is not limited to global digital firms; even smaller companies, which do not always have the capacity or interest in building long-standing relationships with universities, would prefer to acquire people and their ideas.

Access to the right skills and experience is critical to successfully commercialising digital technologies. **Growing demand for certain skills, like computer science or engineering, comes not only from 'digital' sectors, but from all corners of the economy, creating a competitive market for talent and driving up costs.** Regardless of the sector or technology, most spinouts require access to general business skills and support. Digital technology founders and spinouts are no different, but often have additional and unique needs created by the use of data, including an awareness and access to expertise in fields like ethics, privacy, and data governance. Founders and spinouts do not need to be experts in these issues or even hire expert staff, but need to know where and when they can and should seek help.

Demand for digital skills appears to shift with technology trends; one skillset may be popular and paying a premium in one month, and demand falling away the next. For example, dual ledger and blockchain technology skills do not attract the premiums they did even in 2022. Digital talent clusters remain important, creating stiff competition for universities and spinouts in regions outside these clusters. Universities note that a growth in remote work may be improving access to high-demand talent, with both spinouts and technology transfer offices gaining better access to talent that was previously confined to certain clusters in and around London.

Knowledge creators and spinout founders come from diverse backgrounds, with PhD students and established researchers most likely to engage in commercialisation activities. By comparison, mid-career academics are not always well positioned to pursue commercialisation. Some universities appear to value academic research and publishing more than knowledge exchange activity, including the commercialisation experience of academics, when making promotion and hiring decisions. Mid-career academics must balance competing priorities, like research and teaching, as they look to build their careers and establish themselves in their fields. Incentives that encourage academics to engage in knowledge exchange activities and prevent negative effects on their careers are important for all fields, including digital technologies.

Students are an important source of entrepreneurial activity and skills. Student

enterprise activities are typically treated separately from the formal support of technology transfer offices. Many student enterprises are digital-first companies, as these businesses often have lower barriers to entry. Engaging students in knowledge exchange activities may be an under-tapped pathway for bringing university digital knowledge and assets to market.

Universities often see t**rade secrets and copyright, combined with effective first mover advantage, as more valuable approaches to securing IP and gaining a competitive advantage as compared with seeking patent protections.** It can be difficult to determine or prove violation of software or other digital application patents, especially for capabilities like AI that can have opaque background inputs. In other jurisdictions, namely the United States (U.S.), more permissive digital patenting regimes may exist, whereas in the United Kingdom (U.K.), the patenting of digital technologies—in particular software and related capabilities—is more restricted, limiting the use of these protections.

The collaborative nature of developing software can create challenges for technology transfer offices when determining the origin and ownership structures of new IP. Software development is collaborative and new applications can combine code and contributions from multiple sources, especially in early research stages. Technology transfer offices must work to establish a clear and auditable chain to demonstrate IP ownership. A lack of clear ownership can prevent a university from commercialising new software or reduce the value of the underlying IP.

Investment in digital technology ebbs and flows with technology trends and fads, as both private and public sector investors have been seen to jump into blockchain and fintech start-ups one day, and into AI-enabled ventures the next. Universities view that what investors focus on when valuing digital technologies are sometimes steered by trends and hype, often prioritising flashy use cases. Technology transfer offices must navigate demands from public and private investors who can be more focused on bigger hi-tech issues than smaller more mundane problems where the most impact can be. For example, helping local businesses use software to better manage manufacturing parts inventories or to schedule maintenance services can have better payoffs for a university's community than focusing solely on transformational applications in the hopes they will change how we live or work.

In general, universities have access to robust ecosystems of investors interested in digital technologies, as well as access to many digital-specific accelerators. There appears to be some variation in the availability of investors in digital technologies outside of London, with **more limited access to larger investment firms beyond the Oxford–Cambridge–London, 'Golden Triangle'.** However, most universities have access to strong pools of angel investors, including in the North East and South West.

Investors in digital technology spinouts expect faster returns than investors in other sectors, particularly when compared with life sciences, and are often looking for quick exits through public offerings or acquisitions. Such aggressive return timelines can be achievable for some digital technologies, like software applications and other capabilities with lower costs to scale. But other 'deep' technologies and spinouts working at the frontiers of scientific discovery and commercial application often require more patient, long-term capital, and investor interest.

In addressing equity arrangements, universities recognise a need for greater flexibility when working with digital spinouts. Ventures often rely on founders' passion and drive to make a business successful, with underlying IP not always having the same relative value as for other technologies, such as in life sciences. Anyone can bring a successful drug to market, particularly with the right institutional backing, but **digital technologies do not always have clearcut applications or pathways to market**. Some universities note that 'founder-friendly' approaches to issues like equity are necessary to enable the long-term success of these companies.

In one notable case, a university expressed a digital-specific and founder-friendly philosophy and approach to equity, noting that it takes lower stakes in digital spinouts to future proof founders equity shares though follow-on rounds of investment. Multiple rounds of investment are a particular feature of digital start-up growth. To support the success of its ventures through these future rounds, the university pursues equity stakes that will not create barriers to future investment and company growth.

Smaller **institutions appear to have insufficient deal flow in digital technologies, whether as spinouts or licensing deals, to justify dedicating programs and employees to focus on them**. In some cases, universities describe "leaving IP on the shelf", without the time or people to commercialise it. Almost all technology transfer offices have their own digital skills gaps. Even the largest research-intensive universities can struggle to attract or retain the experienced and skilled people they need to help guide digital spinouts or best licence IP. Several universities describe wanting access to skills and capacity to support scale-up and launch of digital firms. Many are interested in gaining access to shared or collective support for digital companies that would take the pressure off of individual universities in helping digital spinouts navigate their journeys.

A university's geography and ecosystem play a role in its ability to access people, investors, and businesses with which to collaborate. Generally, in the Golden Triangle, universities have this access, whereas as for universities in the North, Midlands or the South West this can be a challenge. **University objectives and strategies in the Golden Triangle are global in nature**, believing the impact of their research has the potential to change the world. **In the North, Midlands, and South West, universities share a stronger focus on driving local and regional impact**. This is not to say that institutions in these regions do not

pursue or cannot achieve global impact, but that they often prioritise creating jobs in their local economy and positioning the university at the centre of a strong local ecosystem. The primary focus of these institutions is often on how they can help local industries and businesses identify, use, and monetize data and digital tools. They have a strong focus on social enterprise and building relationships with public and community organisations, including National Health Service (NHS) trusts or government agencies like the Met Office.

Regulatory regimes, particularly related to data and privacy, can greatly affect the success and potential of digital spinouts. When and how data can be used for commercial purposes is a noted barrier to firm growth. Many universities note that available data sources, such as those used to train models can only be used for research. A lack of clarity around data access and rights to usage can deter investors in digital technology spinouts.

Digital spinouts must often address layers of stacked regulatory requirements. They must deal with data, privacy, trust, or other issues, while also often contending with regulations designed for specific sectors, such as for financial services or medical devices. Universities identify that national security restrictions are a growing and important consideration when commercialising digital technologies, not as a barrier, but as a key issue to address when licensing IP to an existing company or securing investment in spinout ventures.

This report has sought to explore the pathways digital technologies take from universities to market, but there are questions this report has identified that can be further investigated. The following represent key issues for future exploration, which we believe would help Research England and others to further identify how universities and public funders can work together to grow their impact for the benefit of the economy and society:

- pathways for digital hardware (e.g., semi-conductors or quantum technologies), which may have less well understood knowledge exchange pathways than software;
- university support for student-led start-ups in the context of knowledge exchange activity;
- the effects of regulatory frameworks for data and emerging technologies like artificial intelligence on university knowledge exchange;
- the skills composition of technology transfer offices and how shared pools of skills and experiences could augment them;
- the U.K. patent regime, assessing if it meets the needs of digital technology creators when international competitors can secure protections for certain software assets;
- the growth and impact outcomes of digital technology spinouts who receive funding from university investment funds; and
- the technologies universities could use to better support technology transfer offices.

INTRODUCTION

British universities have a long history developing and bringing new technologies successfully to market, particularly pharmaceutical drugs and medical devices. Over two decades ago, universities adapted to encourage more diverse sources of commercial innovation by bringing research from non-science disciplines to market, especially from the arts and humanities, and enhancing their collaborations with the business community.[1] Today, the rapid growth and maturation of digital technologies, especially those derived from research in computer sciences like artificial intelligence (AI), presents universities with new opportunities and challenges.

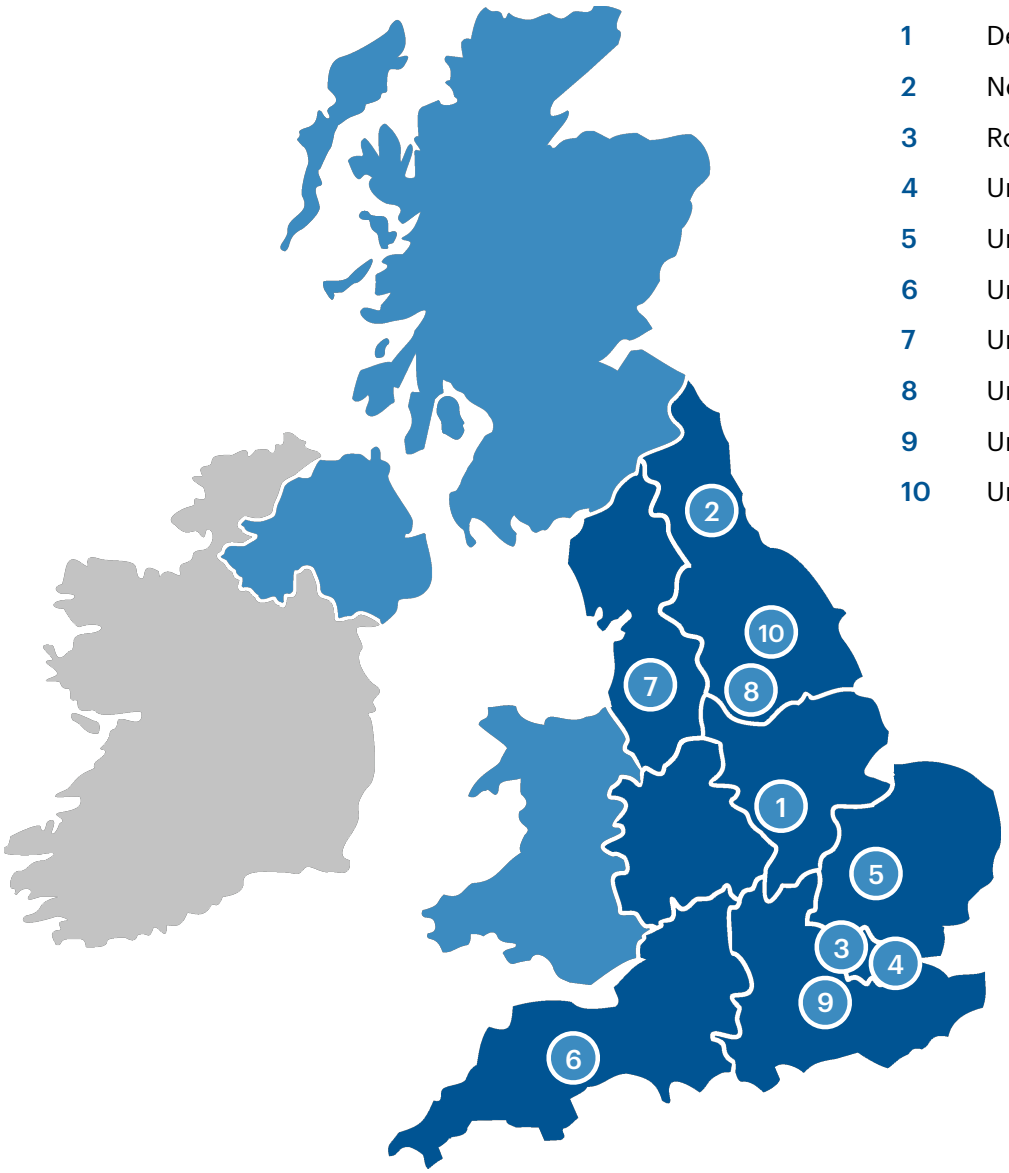
In this context, Research England commissioned this study and report to explore the pathways digital technologies take from universities to the market. In addressing this task, we examine what makes digital technologies unique, the processes universities use to commercialise them, and the enablers and barriers that affect their path to market. We hope this work helps underscore the often complex and varied considerations and contexts universities work with and within to transform digital inventions into socially and economically impactful innovations.

METHODOLOGY

Building on existing reviews of knowledge exchange practice, a literature review was undertaken, which informed semi-structured interviews with ten university technology transfer offices or equivalents, PraxisAuril—the national professional association for knowledge exchange practitioners, the Department for Science, Innovation and Technology, and Research England. The following report presents key findings and trends identified by these interviews. As our findings reflect the experiences of a select number of universities and their technology transfer offices, they may not be universally applicable across all U.K. universities. Participating institutions sometimes reported diverging points of view on the same issues, reflecting these contextual and diverse experiences.

The technology transfer offices interviewed represent a broad sample of university types, sizes, expertise, and knowledge exchange experience, from research-intensive, to design and arts intensive, to teaching and skills-focused institutions. They represent regions across England, from the North East and the Midlands to London and the South West.[2] Some offices interviewed operate directly within a university while others are independent university-owned entities, such as UCL Business and Cambridge Enterprise. Individual technology transfer officers have unique academic and entrepreneurial backgrounds, which shape their lived experiences and how they approach their work. The diversity of these participants provides a picture of the knowledge exchange of digital technologies across England.

PARTICIPATING UNIVERSITIES



1 De Montfort University
2 Newcastle University
3 Royal College of Art
4 University College London
5 University of Cambridge
6 University of Exeter
7 University of Salford
8 University of Sheffield
9 University of Surrey
10 University of York

UNDERSTANDING KNOWLEDGE EXCHANGE

Universities follow many pathways to generate impact from their research. We use McMillan's (2016) categories of university **knowledge exchange**, which also include community-based activities and public space and people-based activities, focusing on the two areas of activity most relevant to digital technologies:

- **Commercialisation** activities, including the process by which universities transform ideas created by research into commercial or social applications through licensing IP, spinning-out new companies, and patenting, activities also known as technology transfer.
- **Problem-solving** activities, including working with existing companies through consulting, contracted research, joint research, and the creation of physical facilities.[3]

While working from these categories, this paper does not seek to fully explore the many nuances of university knowledge exchange activity, which McMillan (2016), Oxford Insights & Cambridge Econometrics (2022), and Ulrichsen (2023), among others, discuss in greater detail. In general, business engagement, including seeking out, engaging and working with businesses and securing licensing opportunities forms the majority of university knowledge exchange activity.

Though both commercialisation and problem-solving work typically fall within the scope of university technology transfer offices, some only engage in and consider commercialisation activities within their mandates, while other areas of the university facilitate problem-solving activities. This separation may be more prevalent among larger universities or where the technology transfer office is a subsidiary to its university.

Our scope of inquiry also includes university support for student commercialisation and entrepreneurship activities, which weigh heavily towards digital technology endeavours; these functions also often exist outside the mandates of technology transfer offices. While this study and report focus on the knowledge exchange pathways of digital technologies, our findings also provide lessons which are applicable to understanding university knowledge exchange activities in general.

The formalisation of knowledge exchange processes and functions is relatively new and today universities must balance these

activities with teaching and research. Driving impact from research through knowledge exchange has grown in importance and, as PraxisAuril notes, it is no longer an afterthought for universities—it is an important function of their impact. As knowledge exchange has grown in importance, how universities approach these activities has evolved.

Research England and other national research funding bodies have implemented measures to benefit the U.K. economy and society, including dedicated funding for knowledge exchange activity through the £260 million Higher Education Innovation Funding (HEIF).[4] The HEIF supports and incentivises providers to work with business, public and third sector organisations, community bodies and the wider public, to exchange knowledge and increase the economic and societal benefit from their work. Other measures have been implemented to assess the impact of research and how knowledge emerging from Higher Education Providers (HEPs) is used for the benefit of the economy and society.

The Research Excellence Framework (REF) puts a spotlight on research impact, rewarding universities through their case studies that outline working with companies or creating other social impact.[5] The Knowledge Excellence Framework (KEF) helps demonstrate the breadth of activity undertaken by universities with a wide range of commercial, non-commercial, and public partners.[6] Activities captured by the KEF include collaborative research and publication, as well as teaching related knowledge exchange, in addition to commercialisation and technology transfer performance. As a result of these frameworks, university technology transfer offices are encouraged to have a double bottom line when measuring success: (1) ensuring university research leads to impact and (2) generating revenue for the university through licences or royalties, ideally sufficient enough to operate as cost neutral enterprises.

Our findings on universities' objectives may differ from others, such as Nurse (2023), that universities largely or only value the potential financial returns of knowledge exchange activities. Through knowledge exchange, universities demonstrate a strong commitment to seeing out the economic, social, cultural, and public benefits their people, knowledge, and assets can create—be that impact local, national, or global. Where universities seek financial returns, they do so in respect of their roles as public institutions, with a responsibility for operating sustainably, with respect for taxpayers, and as important centres of knowledge and innovation requiring fair return on resources invested.

As Dowling (2015), McMillan (2016), the Science and Technology Select Committee (2017), Rees (2019), and Logan (2020) and many others have shown, knowledge exchange is context and technology specific. In general, technology transfer offices need to be experts at creating and fostering relationships—whether it is within the university or finding external partners to which they can licence technologies. They also support knowledge creators from discovery to commercialization to business launch and early scale. The nature of this

support evolves along this pathway, as ideas turn into applications, reach the market, companies become more autonomous, and the involvement of other interests grows—especially those of outside investors.

Regardless of the underlying technology, technology transfer offices' efforts focus first on de-risking an opportunity for the knowledge creator, helping with a diverse range of activities like identifying and managing IP, and business development and management training. They work with spinouts to explore markets and potential applications, recruiting talent and securing early funding, including a growing trend of kick-starting their ventures with in-house or dedicated investment funds.

Academics have limited time and competing priorities: teaching, researching and, sometimes, commercialising their ideas. Mid-career researchers, who face more time constraints than other knowledge creators, are typically the least likely to engage in knowledge exchange. They need time to research, publish, and teach—established markers of success and value to a university, and critical steps to establishing a career. Technology transfer offices report most often working with doctoral students or later-career researchers. Doctoral students have more time and often more interest in careers outside of academia. Later-career researchers are typically well established in their fields, may teach less, and may have a stock of untapped or underdeveloped IP to support new commercial applications.

Previous reports identify in detail the varied activities and approaches taken by universities to support knowledge exchange. Where Dowling (2015) and McMillan (2016) offer overviews of knowledge exchange practices, others provide targeted insights into the commercialisation of digital technologies. In particular, the report of Oxford Insights and Cambridge Econometrics (2022) for the Department of Culture, Media and Sport, on the role of standards in commercialising AI, provides transferable insights on the distinct nature of digital knowledge exchange practices and the needs of those involved in those pathways. Our findings echo their conclusions that the value of a technology is derived from how it is applied, making it difficult to determine its future potential value, especially when technologies may have multiple use cases. We agree that spinouts and their founders, including knowledge creators, need skills and support beyond technical skills specific to the technology being developed. We also share a view that privacy, data and ethics—and trust—is and will be an increasingly important consideration for university approaches to the knowledge exchange of digital technologies.

Technology transfer offices use both supply push and demand pull approaches to commercialise knowledge. Supply push approaches appear to be the most common, involving researchers approaching technology transfer offices with new inventions and then working together to find a market fit for them. The Royal College of Art (RCA) stands out by taking a demand pull approach, adopt-ing a "design-led" pathway to innovation (see Box 1, page 12). Its programs connect graduate students with businesses and other

technology end users to identify real-world problems and needs, and help them develop solutions that address these challenges.

In many, if not most cases, universities will take some form of equity in their spinouts, seeking a return on the effort and resources invested in them. Significant bodies of work, including by Rees (2019), Ulrichsen (2019) and (2022), and Hellman (2023), among others, examine the effect that university equity stakes and IP ownership rights have on developing and successfully spinning-out new ventures. The TenU University Spin-out Investment Terms (USIT) Guide, which was developed with input from investors and global universities, also offers best-practice investment and licensing terms for spinout company formation.[7] Research on university equity stakes is diverse and stakeholder views on the effect of equity stakes on the success of digital spinouts can be polarised, in partic–ular between universities and investors.[8]

As part of its commitment to enhancing the U.K.'s global science ambitions and enhancing the economic impacts of research, the govern-ment has commissioned an independent expert review of university spinouts to "identify best practice in turning university research into commercial success."[9] That review was ongoing and its findings were unavailable at the time of developing this report. While we address questions on the characteristics of universities' equity stakes and digital technolo-gies, this report does not seek to replicate the comprehensive existing and ongoing work on this subject.

Box 1 – The Royal College of Art: not traditional 'technology transfer'

The knowledge exchange focus of the RCA is often on commercialising Master of Arts students' final degree projects, students who often have other degrees or sector experiences before starting an RCA program. These projects take a 'design innovation' approach, which aims to find solutions to real world challenges, instead of inventing a technology and looking for a use-case.

These graduating student founders have a less linear route to market, and often find their inventions can still be applied to many areas. The RCA's commercial support focuses on turning these projects into start-ups, investing funds, and helping them achieve a first sale. It runs a summer business bootcamp after students graduate to select the best. This is then followed by incubation where graduates can further up-skill, refine their ideas and advance commercialisation.

SCOPING DIGITAL TECHNOLOGIES

This report uses a broad definition of digital technologies, taking them to include any systems, software, or hardware to create, process, or use information. This approach helps capture the diversity of potential knowledge exchange activities and commercialization pathways that digital inventions take to market. Digital technologies are often dependent on other capabilities, diverse data resources, and sector-specific skills, and do not always fall neatly into a distinct 'digital' category.

Depending on their application, digital technologies can be viewed either as a distinct sector or vertical—in the same way life sciences or financial services are often viewed—or as horizontal platform capabilities applied within another sector or vertical, such as within life sciences in the form of medical devices or within financial services in the form of fintech. As a result, the commercialization pathways and the support spinouts and other start-ups require can depend greatly on their sector or vertical of application. Their needs may change depending on if they are a pure digital technology play, or if they are a digital technology play within another sector.

Commercialising digital technologies within specific sectors or verticals can raise complex business or regulatory challenges, issues which are highlighted later in this report. The University of Sheffield uses a helpful set of archetypes for approaching different digital technology start-ups (see Box 2, page 14).

Each university's experience commercialising digital technologies is different. Their experiences and level of knowledge exchange activity with digital technologies can depend on their size and character, including their research intensity and how much research they have involving different technologies. Some smaller universities report only a handful of spinouts each year; in some cases, a smaller university may go more than a year without a single digital-specific spinout. Even when taking scale into consideration, this limited experience commercialising digital technologies and spinning out digital companies stands in stark contrast to the level of experience some more research intensive universities have commercialising 'engineered widgets' or pharmaceutical drugs. For technology transfer offices which do have active digital portfolios, these

technologies comprise a larger and growing share of their commercialisation or problem-solving work.

Digital technologies may require new models of knowledge exchange, methods which may be different to established practices, especially in comparison to those used for life science inventions. When digital technologies share similarities with existing products with a defined market they can follow a chartered pathway, as is the case for many software applications. Frontier technologies—those at the cutting edge of science and engineering, such as quantum capabilities—can be much more challenging to commercialise because applications and markets may not be well understood or do not yet exist.

The growth and maturation of digital technologies means that the emergence of new digital capabilities is no longer confined to computer science or engineering departments. They can be created and emerge from anywhere in a university's research ecosystem, from natural sciences to the arts and humanities, as digital technologies become more essential and ever more present both in research and everyday life. The University of Salford has

Box 2 – Sheffield's "archetypes of digital technology start-ups"

The University of Sheffield adapts its methods to help ensure innovators have access to the type of support best suited for their needs, treating digital technologies differently based on three broad archetypes: (1) medical digital technologies; (2) invention-enabled digital technologies; and (3) functionality or customer driven products.

- **Medical digital technologies** (i.e., medical interventions) must address healthcare regulations, and usually require long-term, patient capital before they can reach the market. They are often invented in partnership between academics, clinicians and technical staff through sustained publicly or charity funded research and collaboration. They often also require a long-term patent management commitment from the university. Established clinicians and academics may be less likely to want operational leadership roles in a spinout company, making the university more likely to licence technology to an existing business.
- **Invention-enabled digital technology** (e.g., novel AI technologies) have rapid scale up potential and typically attract venture capital (VC) investment. Opportunities may use patents, copyrights or trade secrets to protect their algorithms and inventions. They often require significant seed investment and support from the university but external accelerators will typically play a significant role in developing business plans beyond this point. Often the inventors lead the technical development within the resulting spinout company.
- **Functionality or customer driven opportunities** (e.g., dashboards, analysis tools or consumer facing platforms) are less likely to be based solely on academic science and invention but instead have identified immediately available markets. Opportunities are led by entrepreneurial founders who require streamlined support, modest pre-seed investment, and help deliver their minimum viable product to initial customers to give confidence for establishing their spinout.

found that, regardless of the sector, the most successful commercial projects still have a digital element. Artificial intelligence is a particular capability which now permeates many other fields, sectors, and applications; its use in drug discovery is one growing area of focus for many universities. This diffusion of digital capabilities raises new and unique challenges and opportunities for technology transfer offices. They may now need to work with knowledge creators from disciplines not traditionally associated with commercialisation activities. The University of York's multidisciplinary software accelerator program is a notable attempt to address these emerging needs (see Box 3).

Software can also create new forms of value and IP for the commercialization of hardware technologies. For example, the UCLB-supported spinout Senceive, whose wireless-enabled remote condition monitoring technologies combined both hardware and software related IP, had multiple business lines: the instruments themselves and the digital platform on which the instruments ran. The company had a mixed business model, combining the sale of wireless enabled hardware through to the provision of an information service, allowing customers to visualise in real time key geotechnical data on construction and rail assets.

The organisational design and structure of a technology transfer office appears to have a particular impact on approaches to successfully commercialising digital technologies. Many technology transfer offices acknowledge that universities have a lot of bureaucracy and do not move at the pace of business. These organisations may struggle to agree on licensing terms or other arrangements under time pressure, or fail to provide rapid support when it is most useful to a spinout. A university's lack of speed may especially affect software spinouts, which typically need to launch much faster and get to market much sooner than other types of spinouts, especially in contrast to deep-

Box 3 – York's multidisciplinary software accelerator program: more than just for the computer science department

The University of York has a software accelerator program to support researchers as they navigate commercialisation pathways, helping them deal with IP, develop business models, and learn how to engage with open source software code. In particular, the program is a valuable means to help knowledge creators from outside of computer science or typically software development backgrounds to understand the challenges they may experience commercialising software applications.

More and more digital technology ideas are emerging from across the university's departments, such as biology, physics, arts, humanities. The program had 19 participants, of which only two came from computer science, with 9 from backgrounds unrelated to software. Through the accelerator program, researchers from non-software backgrounds can work and collaborate with experts from the computer science department and York-employed software engineers to develop their projects and commercial use cases.

technology and hardware ventures, such as in semiconductors. Technology transfer offices that operate as a subsidiary to their university typically report having sufficient flexibility to move at the pace of their clients and dealing with less institutional bureaucracy.

Some universities are working to address their digital spinouts' need for speed. The University of Sheffield provides its spinouts access to the skills and services available in local digital companies, who support the university's founders to rapidly build their minimum viable products. Sheffield Digital—a collective of companies within the city ecosystem—provides an excellent access point to skills, services, and mentorship. Its support can result in longer-lasting relationships, such as Exciting Instruments, a joint venture between the university and a Sheffield-based digital company, which applies digital capabilities to make discoveries in biophysics, life sciences, drugs, and medical diagnostics. Mechanisms like Sheffield Digital can help technology transfer offices more effectively address the needs of digital spinouts and their investors.

In cases where an application can easily be duplicated by potential competitors—be it legal or not—first mover advantage and building a network effect of customers is critical to new firms. Moving to market quickly offers competitive advantages in areas where patenting or other IP protections may be unavailable or less effective. Software-based start-ups are encouraged to test the waters and fail faster than other types of ventures, particularly those in life sciences. While some software start-ups require significant computing power, technology transfer offices do not view access to these resources as a barrier, given growing availability of cloud and other distributed computing resources.

KNOWLEDGE EXCHANGE & DIGITAL TECHNOLOGIES

COMMERCIALISATION

Transforming ideas created by research into commercial or social applications, through licensing IP, spinning-out new companies, and patenting.

SECURING INTELLECTUAL PROPERTY

Digital spinouts are more likely to use trade secrets and copyright than patents to protect their underlying technologies.

The commercialisation pathways of digital technologies are affected by how the U.K. patent regime treats the protection of software, as well as the relative ease of which digital products can be copied. When new IP is identified, technology transfer groups may seek formal legal protections, including copyrights, patents, designs and trademarks, which would restrict the use of that novel process or thing to those licensed to do so, protecting product names and brands, inventions, designs or things you write, make or produce.[10]

The Intellectual Property Office issues patents for inventions that are:

- **New**—the invention must not have been made public anywhere in the world, including identified in a publication.
- **Inventive**—the invention must be novel, and cannot simply be a change to something which already exists.
- **Something that can be made and used**, a **technical process**, or a **method of doing something**.

Under this system, patents are not granted for software without a specific technical purpose. For example, in the U.K., "software to control a driverless car could have a patent, while a chess playing app could not".[11] There remains a perception among some participants that U.K. approaches to software patenting are more restrictive than in other jurisdictions, namely as compared with the U.S., despite evidence that the patenting regimes of the

two countries are comparably accessible to software or other digital inventions, including AI-enabled inventions.[12]

While patenting can offer advantages, making a patent application requires sharing detailed information about the invention or process being patented, creating opportunities for competitors to take those ideas and integrate them into their own business. In the case of software, it can be difficult to identify when patents are infringed upon, given how software applications and services are designed and used, reducing the potential effectiveness of patents as a means to commercialisation.

Occasionally, founders will file for design rights, but universities do not view these protections to be as strong. In addition, because software can develop very quickly and be applied in novel ways, the iteration and change inherent to software technologies can often outpace the patenting approval processes. In this environment, while patents are a useful means of protecting hardware and physical devices, software spinouts more readily use copyrights and trade secrets to maintain the integrity of their product or service offerings, particularly in comparison to other areas, such as life sciences or engineering. As a result, many technology transfer offices will begin by seeking other forms of IP protection for digital technologies, especially copyright protections.

Intellectual property protections can also run counter to academic culture, which values impact through publication and sharing new discoveries to expand the world's understanding and knowledge of a subject. Many academics will publish their work in open-source libraries, a practice which appears especially common in AI research (e.g., sharing models on GitHub). When commercialising digital technologies, the effect of this inherent conflict—publish or commercialise—may be felt more acutely than for other technologies. In fields where trade secrets may be the most effective way of protecting an invention or innovation, publishing or speaking about your discoveries puts that new idea at risk of being used by someone else and compromises their ability to seek formal IP protections at a later date.

Technology transfer offices encourage their knowledge creators to engage with them as early as possible to ensure researchers can capitalise on their new ideas. They work hard to develop positive relationships across their institutions and their research communities, as welcoming and supportive places, so that researchers know where to find support as soon as they need it.

Intellectual property ownership policies are generally consistent across the U.K. Universities typically own IP generated by their staff, including copyright, as well as by their doctoral students if they develop new IP while using university resources or relying on background IP owned by the university, usually through working with a university researcher. In limited cases, universities may own the IP of undergraduate and master's students, typically where a student uses university resources or university owned background IP.

While universities almost always own copyright created by their staff, academics are sometimes less well versed in copyright and related ownership policies, and so can wrongly believe that copyrights they produce are their own. This can create challenges to technology transfer groups and how they support the commercialisation pathways for software—which often relies on copyright protections—as they often come across researchers trying to commercialise software independently of the university. This lack of knowledge and awareness can impede the success of these independently launched ventures. A notable exception of significant relevance to the commercialisation of software are the copyright policies of the University of Cambridge (see Box 4).

Spinouts can either licence or be assigned university IP, but approaches to ownership and licensing arrangements for digital technologies can vary. For example, while the University of Surrey takes equity stakes in companies that licence or it assigns its IP to, it understands investors prefer investing in companies that have ownership of their underlying technology and IP. Surrey will licence IP in cases when a spinout may want to limit the university's equity stake, or if there are other good reasons to temporarily withhold IP assignment, such as ensuring the start-up complies with U.K. law, such as the National Security and Investment Act. However, IP assignment always remains an option to the firm as it scales and the value of the underlying technology at the point of assignment is better understood. Some universities caution against assigning IP directly to spinouts because, if they fail, the IP cannot be recovered by the university and "recycled" for other purposes. Similarly, the RCA sees itself as a "custodian" of IP, which is often generated by its master's students. Typically, it assigns IP to students upon graduating, unless RCA staff helped with the commercialization process, at which point the university may become a joint owner, with graduates owning a majority share.

The research and development (R&D) of digital technologies is often collaborative, interdisciplinary, and dependent on the inputs of multiple researchers, funders, and ideas. As a result, determining the origins and ownership of IP that arises from R&D can be a difficult process; determining the origin and

Box 4 – The Cambridge copyright exemption

Unlike other institutions, the University of Cambridge does not take ownership of IP that exists without need for formal application, namely copyright, unless subject to third-party funding rights or certain other restrictions, such as works created for university administrative and managerial purposes. As copyright is a common form of IP protection for software, academics who own their copyrights will sometimes seek to commercialise that knowledge without support of the university's technology transfer subsidiary, Cambridge Enterprise. As a result, Cambridge Enterprise sees a need to provide a strong set of support services to demonstrate why knowledge creators benefit from working with its organisation, even when founders are not obligated to do so.

ownership of new software assets can be especially challenging. Universities must establish a clear and auditable chain of creators and contributors to demonstrate the ownership of software. Projects may combine code from many creators supported by multiple funders, creating complex due diligence processes. In some cases, third-party code can be used as part of a software's development without recognition of its terms of use, whether open source or subject to a restrictive licence.

These challenges can emerge well before a new asset or business idea arrives on the doorstep of a technology transfer office. Universities have limited means to establish professional version and IP controls during the early research stage of a technology's development. As a result, technology transfer offices must look back and sort through who wrote or contributed to code, what data sources were used, and who funded the underlying research. The result can be projects for which confidently establishing IP ownership—and, more importantly, whether or not a university has commercial rights to use that IP—is almost impossible, reducing the value of the asset. To help address these challenges, the University of York, as part of standard due diligence processes, uses a unique software disclosure form to understand the history of the software and IP issues that may need to be addressed before commercialising an idea.

SUPPORTING STUDENTS

Students may be an underutilised source of value to commercialization at large from universities, and in particular when commercialising digital technologies.

As a result of typical university IP policies, which generally allocate ownership of new assets created by faculty researchers and doctoral students to the university, it is no surprise that the type of knowledge creator or spinout founder greatly affects what support universities will provide to new ventures and other commercialisation activities. In general, technology transfer offices support university employees, namely faculty, as well as doctoral students. Both groups will often receive funding and other forms of support from the university, including the use of university equipment or facilities for their research.

Students, both at the undergraduate and master's level, invariably own their IP. Trained by and working in a university's ecosystem, students are free to commercialise their ideas without licence or restriction, so long as they do not seek to commercialise what has been learned from working on a university employee's research project or by using university facilities. As Logan (2020) shows, student start-up activity forms an important part of university ecosystems and can generate significant returns for local economies.

Student engagement in entrepreneurial activities is acknowledged and well understood, but is not often considered by universities in the context of

commercialisation and problem-solving activities. Several technology transfer offices note that while funding from the Office for Students and Research England through the "Student engagement in knowledge exchange" project funding has enabled new approaches in how universities support undergraduate students' enterprises, this support often operates outside of the structure of their work.[13] Students and teaching elements of knowledge exchange are also eligible for support through the HEIF, which supports knowledge exchange between higher education providers and businesses or other organisations, including contributions by the Department for Education.[14] Larger universities, such as Cambridge, offer fulsome commercialisation support to both university employees and students, whether it is through the technology transfer office or a separate group. However, in many cases, this support for students is less robust—more often described as mentoring or small accelerator services—and not something the more resourced and well-connected technology transfer offices involve themselves with.

Some universities, such as the University of Exeter and the RCA, actively consider student enterprise in their technology transfer offices' mandates. For example, Exeter's student enterprise supports are within its Impact, Innovation and Business group, though may not treat student IP or efforts through the same mechanism provided to other knowledge creators. This support is augmented by the University of Exeter Business School Centre for Entrepreneurship, which offers startup support (e.g., workshops, peer-to-peer network building, one-on-one advice, and access to early-stage funding), as well as a degree pathway where graduates can get "with Proficiency in Entrepreneurship" added to their degree title. The RCA operates programs helping its master's students to launch projects and new ventures, directly as part of students' academic requirements.

Other technology transfer offices find that student enterprise activities and successful student ventures are not well captured by university metrics, even though the companies themselves can often find significant commercial success. The success of Castore (see Box 5) is a prime example of this disconnect, and raises an interesting question: if the U.K. wants to drive a business culture that is favourable to business-university links and business investment in R&D, what should be the role of universities in supporting student start-ups? There seems to be potential in helping launch, incubate, and

Box 5 – Castore: a Newcastle students' success story

Founded by Newcastle University graduates, Castore had support from the START UP Foundership program, part of a pre-accelerator initiative for new and recent graduates with an early-stage business offered by Newcastle University's Careers Service group.[15] The University did not play a traditional technology transfer role, outside of creating an entrepreneurial environment in which a successful student venture could launch. Castore is now worth £750 million, a clear Northern success story.[16]

grow new ventures from a range of founders, which may then be more likely to pursue further future relationships with university partners, if they are given the right resources.

Many student enterprises work with or bring to market new digital technologies or applications that typically have lower barriers of entry and do not require capital intensive inputs like machinery or inventory, despite other resource needs such as computing power. Students' experiences working with and learning about new digital technologies and ways of applying them, inspiring them to create the next big thing in the first place. This is an important area of commercial potential, including for how universities can play a greater role in driving the commercialisation and adoption of digital technologies. Some technology transfer offices are expanding their work with student start-ups or considering focusing more on student enterprise, in some cases taking equity stakes in exchange for their services, as they would with any other university researcher. Taking an ecosystem approach which acknowledges and supports the ideas of all knowledge creators and founders may help universities create greater impact, but may also require a redistribution or additional resources.

LICENSING & TAKING EQUITY

Universities accommodate diverse interests when licensing and taking equity in digital spinouts, balancing return on investment, obtaining value for taxpayers, and supporting spinout growth.

Determining the terms of an IP licence or the amount of equity a university takes in a spinout must work for many stakeholders, including researchers, universities, and investors. Universities rarely support researchers who create new technology in a vacuum, but rather support them over the course of long careers, providing departments with research infrastructure, and enabling the ecosystem of people and ideas that help create new knowledge. This support is complemented by research grants and other forms of public funding.

As a result, universities' licensing and equity terms reflect these long-term multifaceted investments—rather than just their contribution to a single idea—and technology transfer offices view taking equity and generating return on these investments as an important part of creating value for taxpayers and supporting the broader public interest. Universities also use 'dual-licensing regimes', which allow products like software to be released under different terms, depending on the use case (e.g., free for academic research purposes, but fee paying for commercial use) in order to provide larger societal benefit.

When licensing IP to their own spinouts, technology transfer offices will typically seek to secure equity stakes. Some universities take a set equity stake in all companies, where others are more flexible and accommodate founders who want more equity themselves, by asking for upfront fees, stage-gated milestone payments, or royalties on sales. In approaching negotiations with a spinout, technology transfer offices vary their position

based on many factors. They look at the value of public investment made to develop the IP, the value of the underlying technology, the known potential market size, the contributions made by university and technology transfer offices, how many founders are involved, and the founders' objectives, such as if the founder wishes to launch the spinout as a social enterprise.

The University of Cambridge follows a flexible approach, taking equity on a case by case basis, considering the specific merits of each case in question. It also views how much equity it takes in a spinout as a signal to investors—a low equity could indicate to investors the IP is not of great value. Both UCLB and the RCA emphasise a founder-friendly philosophy when it comes to digital technologies: a small stake in a successful spinout is worth more than a large stake in a worthless one.

Personal dynamics may be at play in how technology transfer offices address equity arrangements between universities and founders. In general, equity stakes can be lower for digital spinouts because of the value of founders as the driving force behind successful digital companies and the often lower inherent value of digital IP. Some types of technologies, a patented pharmaceutical drug, for example, can be developed by anyone; the underlying IP can be acquired by a firm and brought to market without the original inventors.

Market applications for digital technologies, including software, are not always straightforward or clear and there is often no one right route to market. These technologies and businesses typically "develop because of the passion and motivation of founders." Universities recognise their role in supporting founders and seek to position them for success. In other cases, universities agree to more flexible terms and lower equity stakes because they want to avoid creating barriers to further investment and firm growth through follow-on investment rounds. Some have also gone on to amend their terms for some of the digital spinouts to help future proof founders' shares through follow-on rounds of funding.

When technology transfer offices licence IP to external organisations, such as an existing business, the type of organisation they are working with affects the terms they seek. When working with a large multinational digital or pharmaceutical company, universities want a greater remuneration than they might expect from a smaller company or a social enterprise. These are not straightforward considerations; no university wants to pass up an opportunity to gain fair and reasonable rewards for their inputs, or "miss out on millions" in cases where a technology is developed as a successful commercial product.

When licensing IP, technology transfer offices see companies in established sectors—such as pharmaceutical companies—as generally more advanced and able to engage and negotiate with them on licensing terms and agreements. Digital technology companies, not including global multinationals (e.g.,

Google or Microsoft), are generally less prepared to negotiate on terms and agreements, are less interested in these arrangements, and may have limited experience working with and building relationships with universities.

The sector or industry in which a partner organisation operates can also affect how those businesses engage with universities and their deal term expectations. For example, pharmaceutical companies already understand what a relationship with a university will look like and what licence and royalty arrangements they can expect. Experts in an industry like pharmaceuticals may expect and at least tolerate royalties due to the large potential margins achievable when a new product such as a drug is introduced to the market. Other industries may not be as willing to accept royalties, and so other arrangements must be negotiated.

Digital assets—particularly software and digital platforms—can also be licensed outside of standard university-business collaborations. For example, the University of York has the ability to licence IP directly to customers and end users. It runs a platform to share assets, including digital assets, which it can use to sell software or make it freely available to download, subject to its licensing terms. Such models allow universities to differentiate access and licence terms between different types of end uses, charging fees to for-profit users while granting cost-free access to public bodies or social enterprise.

ATTRACTING INVESTMENT

Investors in digital technology want faster returns, have less experience working with universities, and are heavily influenced by technology trends.

Following spinout creation, universities often help new ventures take their ideas to market, scale-up, and maximise their impact. This process requires more investment, which can come from a number of different channels—private sector investments, government, and in some limited cases, dedicated and pooled university investment funds. University investment is often the first form of funding spinouts receive, allowing new ventures to focus on developing product and service offers, working with accelerators or mentors to gain business or other skills, or seeking follow-on funding from larger investors. For example, Cambridge Enterprise has a well established venture arm with a team dedicated to software and digital start-ups. It often invests alongside other VC funds, who have their own sectoral specialties. In making their own investments, universities typically take an equity stake and, in some cases, will secure positions on the spinouts' boards of directors to advise founders along their business growth journey and manage the university's interests in the firm.

University investment also helps address gaps in available business financing. Many founders utilise near sources of funding to kick-start their business, such as personal finances or

family loans.[17] The Royal College of Art, whose knowledge exchange activities focus on commercialising students' ideas and projects, points out that its founders have a lot of degrees and private sector experience—but also debt. This debt limits the ability of knowledge creators to launch new ventures. By acting as a first investor, the RCA can help bridge this financing gap and de-risk projects, kickstart its students' entrepreneurial journeys, and help launch new companies. The RCA is currently raising funds to launch its own fund, the Seed Enterprise Investment Scheme, which would enable it to invest more in its spinouts and give them enough time to develop more market-ready products.

All early stage spinouts can struggle to find follow-on investments from sources beyond their universities. Investors often want to invest in companies that are more advanced and have sales in a proven market. This can pose a challenge to a spinout's underlying technology that requires time and investment to develop new products or services, and get to market. Universities reflect that digital technology spinouts may fare slightly better than others, because digital products and services can often be easier to get to market. Universities also acknowledge that there is generally a more robust angel investing ecosystem for digital ventures, especially as compared to life sciences ventures, which may have greater startup costs. They also reflect that there are a greater number of digital-specific accelerators.

Technology transfer offices perceive variations in the availability of investment within the scope of digital technologies, including between software and hardware. Investors in software often expect faster returns than other sectors, whether through a public offering or acquisition and exit. Creating software-based spinouts typically has lower costs and barriers to starting and scaling-up. In contrast, deep technology spinouts—today including fields such as quantum technologies—require both more patient investors and larger capital pools. Deep technology spinouts bear similarity to life sciences ventures, which likewise require more time and often require a large institutional backer to make a large bet on their success.

The availability of investment for digital technologies spinouts can fluctuate with technology trends, ebbing and flowing based on fads of the day. In recent years, technology transfer offices saw investors "throw ridiculous amounts of money with ridiculous valuations" at fintech companies. Today, fintech interest has levelled off, with money moving on to new areas, such as AI-enabled technologies, in particular large language models (i.e., ChatGPT-like applications).

Some technology transfer offices believe that U.S. spinouts and universities have an easier time finding co-investors. In and around major U.S. universities, such as in Silicon Valley, Boston, or New York, spinouts have near access to potentially thousands of VC investors. Technology transfer offices in the U.K. must work harder to gain access to this level of financing, especially when they are outside the London–Oxford–Cambridge

'Golden Triangle'. London-based universities have a different experience, and are even able to attract these large U.S. investors to co-invest alongside them, often in Series A rounds for software companies.

Some universities—namely those located outside of London—note that geography plays a much greater role in financing opportunities than the sector, vertical, or market of a digital technology's application. Smaller universities and those outside the Golden Triangle find it particularly difficult to attract investors in technologies or sectors where they do not have established clusters. However, technology transfer offices in these regions have seen access improve in recent years, particularly in the North and the Midlands. In contrast, offices like UCLB, which has a more developed set of funding networks through initiatives such as the UCL Technology Fund and an internal seed fund, do not generally see these funding challenges. Spinouts from larger offices and universities—especially those with AI-enabled product or service offerings—are consistently oversubscribed by potential investors.

Universities themselves are often working to address the geographic availability and limitations of capital. For example, the University of Surrey finds that putting its own money on the table to attract and incentivize investors to join a very early-stage investment round is helpful and builds investor confidence. Surrey believes these "first cheque" investments help it receive better deal terms and help its spinouts attract more funding. The universities of Leeds, Manchester and Sheffield launched Northern Gritstone to draw capital to their region attracted by their combined spinout pipelines.[18] The SETsquared partnership is seen as another effective means of showcasing spinouts from outside London to potential investors (see Box 6).[19]

Outside of London, universities also face challenges to accelerating the growth of digital technology spinouts. In many cases, technology transfer offices have insufficient deal flow to run permanent programs to support the startup or scale up of digital firms. They are interested in gaining access to a shared service or program that could support digital companies and "take the pressure off of individual universities" in helping digital spinouts navigate their startup journeys.

Box 6 – SETsquared: building networks of investors and skills

The SETsquared Partnership is a collaborative enterprise partnership and a dynamic collaboration between the six leading research-led U.K. universities of Bath, Bristol, Cardiff, Exeter, Southampton, and Surrey. As a business incubator, it provides many different startup supports, but the main benefit is that its critical mass means it can attract more outside investors for their spinouts than they could individually. In particular, SETsquared's annual investor showcase in London brings together a large number of investors for promising spinouts, and student- and graduate-led businesses to pitch themselves in front of. It also runs sector-specific events, which again the individual universities would not have enough deal flow to organise themselves.

Universities note that programs such as the UKRI ICURe Programme can help, but that digital spinouts may benefit from focused programs or streams of support. For example, a national pre-accelerator such as a dedicated stream of ICURe or a district new initiative inspired by the program could provide a shared on-ramp for digital founders.

The University of Salford has found that investors—both public and private—can be more focused on bigger hi-tech issues, than smaller more mundane problems where the most impact can be. Echoing the ebbs and flows of technology trends, a focus on flashy, popular ideas about how technologies can be applied may leave potentially high-impact ideas on the shelf. Technology transfer offices believe small grants for more basic projects like these—encouraging universities to help small- and medium-enterprises identify technology use cases—could open new pathways to bring universities' digital knowledge and assets to market. In some cases, universities may delay spinouts fully launching until they have created a proof of concept and are ready to go to market. The Northern Accelerator's Pre-incorporation Funds are an example of the kind of support that enables this preparation.[20]

Overall, universities note there are not enough small flexible pools of funding for undertaking proof-of-concept work to test and try out ideas to see what business may work and be successful. At the same time, while public funds are an important source of spinout financing, universities reflect that public funders must be mindful to not support 'zombie' firms indefinitely. Some technology transfer offices share how spinouts can limp along for years on public funding without being able to attract private investment or generate returns. This is a warning sign of a business without a workable strategy; it is likely the businesses would have failed much earlier without public funding.

PROBLEM-SOLVING

Working with partners through consulting, contracted research, joint research, and the creation of physical facilities.

WORKING WITH PARTNERS

For some universities, problem-solving activities, such as contract research, direct hiring, joint research, and the creation of physical facilities—rather than licensing or spinning out companies—are more important pathways for turning digital knowledge and assets into real world applications.

While some universities treat problem-solving activities separately from commercialisation, namely spinout and licensing support, contract research and direct hiring are common pathways for the exploitation of digital technology knowledge and assets. Digital problem-solving can often take different forms when compared with other technologies. Many digital companies, outside of the large global multinationals, do not typically have sufficient in-house capacity to develop consistent relationships with universities and regularly engage in certain problem-solving activities, such as consultancy work on collaborative projects. In life sciences, companies seem better prepared to engage in problem-solving activities and have a stronger understanding of the process. Pharmaceutical companies, for example, typically operate dedicated R&D groups and employ knowledge exchange liaisons to build long-standing relationships with technology transfer offices. Instead, digital firms, and digital start-ups in particular, appear to often benefit from directly recruiting knowledge creators and other talent through hiring or acquiring a company for the expertise of its founders, or "acquihiring" (see Box 7).

Providing infrastructure to local businesses is another mechanism for attracting partners who may then engage more with universities to solve their problems. In the digital space,

Box 7 – "Acquihiring": buying talent and ideas

Academic researchers are highly demanded assets who can be recruited with large salaries to work at global multinational companies like Google or Meta. University College London's technology transfer office, UCLB, aims to build high-growth businesses focused in the U.K., but the acquisition of its portfolio of new ventures is often a common result of collaborations with big business. Large companies will acquire spinouts, bringing spinout founders and other key employees into the acquiring business—what UCLB terms "acquihiring"—gaining access to their ideas and skills in addition to their existing IP. For example, UCL's Department of Computer Science has seen a number of acquihires in recent years, such as spinout Chirp, a company that specialised in data-over-sound technology and direct to consumer software kits. Chirp was acquired by U.S.-based audio firm Sonos, with key people and IP moving to the U.S.

this sometimes means providing companies with access to computing capability and capacity, where traditionally this was access to speciality lab equipment. In opening up their facilities, universities are embracing an important convenor role in their local ecosystems. One technology transfer office suggests helping outside start-ups to access university facilities in a safe and responsible way could be done in exchange for equity in the companies, in turn providing firms with access to the offices' services and university-backed capital.

As the capabilities of digital capabilities have grown, so has the share of problem-solving activities that involve some form of 'digital'. For example, today roughly half of the University of Salford's knowledge exchange activities involve artificial intelligence and data science. Many of their knowledge exchange partnerships with business have evolved from developing new widgets to focusing on how digital technologies and data can be applied to traditional sectors. They work with companies in insurance, legal, and transport industries, who are exploring how existing data assets can be used or monetized, with the university seeing a recent significant growth in the volume of these projects. As another example of a university driving digital adoption and data use, Newcastle University hosts the National Innovation Centre for Data to build capacity for innovation with data in both private and public sector organisations (see Box 8).

Box 8 – National Innovation Centre for Data: "this is not technology transfer the way we understood it 15-20 years ago"

Newcastle University hosts the National Innovation Centre for Data, which was created in 2017 with £30 million of funding from the government and the university to transfer data skills to the U.K. workforce.[21] It has developed a new model of knowledge exchange focused on training other organisations to unlock their data on a contractual basis. The Centre's dedicated team of doctoral and masters educated data scientists work alongside teams in both private and public sector organisations to complete data projects that bring immediate return on investment and build ongoing capacity within the organisations.

Among larger institutions, technology transfer offices can appear discouraged from working with smaller businesses, a trend which may have an outweighed impact on digital start-ups. Consultancy contracts can take the same amount of work for the technology transfer office regardless of the contract's value, whether it is £10,000 or £100,000. As a result, some larger offices prioritise higher value contracts, inadvertently favouring work with larger companies over many smaller businesses, to improve efficiency and overall return on investment. Working with smaller companies also presents different challenges and opportunities compared to engaging with large multinationals, companies which may be more likely to undertake contracted research at the frontiers of technology development.

At De Montfort University, working with small businesses, digital or otherwise, is undertaken using a "small plates" approach. The technology transfer office will work on many small projects, with many organisations, reflecting the composition of Leicester's business ecosystem. The importance of universities' engagement with their local ecosystem and business community is further discussed later in this report.

ENABLERS & BARRIERS

ENGAGING LOCAL ECOSYSTEMS

Universities are anchors of their communities, as both sources and receptors of people and ideas. A university's local ecosystem shapes the knowledge exchange pathways of digital technologies.

Previous studies, like McMillan (2016), the Science and Technology Select Committee (2017), and Logan (2020), show how a university's local ecosystem can affect its knowledge exchange outcomes. For example, universities in the Golden Triangle often have direct access and can build long-standing relationships with some of the world's largest digital technology companies. Those companies in turn provide opportunities to researchers and other knowledge creators through mentoring, research funding, consultancy contracts, licensing opportunities, and investments in spinouts. At the University of Cambridge, the likes of Google, Microsoft, and Amazon, among other technology superpowers, have offices directly on the university's campus, facilitating close contact and relationships with the university's researchers. In London, the RCA is able to build networks that include top digital companies, allowing them to call on leading firms, such as Arm, to present and provide mentorship to their spinouts.

A strong local innovation ecosystem and access to a diverse community of digital companies can also pose challenges. Larger companies have the resources to employ top negotiators, meaning IP licensing arrangements can be tough, a process which some universities call "cut-throat." In other cases, the presence of large companies and deep-pocketed investors can create stiff competition for technology transfer offices. These types of players, who want access to knowledge creators and their ideas, may not always act in the best interests of universities, researchers, or founders. They may want access for reasons that may not be beneficial to a university's mission, health of the local ecosystem, or the public interest. In this context, technology transfer offices, in particular at small institutions, are seeking best practice guidance for negotiating with larger companies and investors.

A university's geography can shape its impact and technology exchange objectives. Universities in the Golden Triangle emphasise the extent of their global ambitions, believing the impact of their research not only

benefiting their region or the nation—but having the potential to change the world. Similarly, large research-intensive universities expect to create the next generation of unicorns and leading global companies, while some smaller and less research-intensive institutions explicitly indicate that they do not expect to "create the next Google". In the North, Midlands, and South West, universities share a stronger focus on driving local and regional impact, creating jobs in their local economy, and positioning the university at the centre of a strong ecosystem. Universities outside of the Golden Triangle—especially less research-intensive institutions—appear generally more focused on supporting local small- and medium-enterprises through applicable problem-solving activities.

Public sector institutions, such the National Health Service (NHS) can play an important role in supporting knowledge exchange pathways, whether as first customers for spinout services, acquiring technology licences, and using university consultancy services. Despite these potential benefits, relationships with large organisations can be difficult to navigate. Many technology transfer offices describe the NHS as a major client, but "a nightmare to deal with," reflecting that it can struggle to adopt new digital technologies that it has not used previously and to work with new companies. Some offices find it easier to licence software in the health space to companies that already sell to the NHS in order to expedite their way through its complex procurement processes.

Government agencies can also play an important anchor role in a university's ecosystem. For example, the University of Exeter signals that the presence of the Met Office has contributed to attracting leading environmental scientists and meteorologists to the region, creating a dense cluster of expertise in a space dominated by digital technology applications. Access to this cluster of skills and knowledge can lead to valuable knowledge exchange activities, including for digital technologies using climate data for environmental modelling and impact analysis.

PROVIDING INCENTIVES

Spinouts are an important way of commercialising digital technologies and universities should incentivise and enable academic entrepreneurs, including by recognising entrepreneurship as a legitimate career pathway.

Universities often work to incentivise and enable knowledge creators to engage in commercialisation activities. For example, De Montfort University has career development pathways based on teaching, research, and knowledge exchange, legitimising the entrepreneurial efforts of their faculty. With research very often undertaken collaboratively and in teams, new commercialisable ideas, including patentable inventions, can include inputs from multiple people. As a result, participating universities typically reward individual contributions to knowledge

exchange on a case-by-case basis. For example, the University of Sheffield breaks down its incentives for commercialization based on how it disperses licensing revenues: (1) inventors, who are named on patents and receive licensing revenue, and can receive other funding and advice from the university; (2) contributors, who made research contributions but may not be named on a patent but may still receive a share of licensing revenue and milestone fees; and (3) founders, who come in to start a company, but may not always be the inventor, may get equity in a spinout, and other commercialisation support.

While technology transfer offices look to see how they can better incentivise commercial activity, at the same time, some university hiring and promotion boards do not acknowledge commercialisation efforts at all, and, when they do, they do not always treat it in the same regard as other academic pursuits. Changing this outlook requires a longer-term culture shift, a shift which some universities are working to push forward. Participants note that they least frequently work with mid-career researchers, given those academics' many competing priorities. Some institutions maintain rigid approaches in how they recognize or not the diverse experiences of academics' career pathways, which may further discourage mid-career researchers in particular from pursuing commercial ideas (see Box 9).

Reducing or eliminating negative effects on academics' careers if they choose to pursue knowledge exchange opportunities is often seen by technology transfer offices as equally important to giving them financing and rewards. Research England's allocation of quality-related research funding is based on REF outcomes and HEIF formula funding uses data from the Higher Education Business and Community Interaction (HE-BCI) survey to calculate allocations, creating an inherent financial incentive for universities to pursue impact and related activity, including to promote knowledge exchange activity by

Box 9 – Innovation on the back foot: an academic-entrepreneur own goal

The experiences of academics pursuing commercialisation can be very mixed; some universities openly encourage their researchers to take on entrepreneurial challenges, where others may set in place inadvertent roadblocks. In one case shared, a researcher was rejected by a university's internal promotion board for a professorship appointment. The researcher had a patent, a multimillion research grant and was a fellow of their discipline's national academy—someone with a record of achievement and impact. The promotion board signalled that its rejection of the appointment reflected the researcher's insufficient support of their colleagues on internal, academic activities, including teaching. The university's technology transfer office reflected that "there's only so much time in the day and if you spend it on commercialization that should be reflected by the hiring committee. It is not important if there is a start-up or commercial success. We should want to raise these people up because of their efforts to transfer their knowledge into society, and if this does not happen, innovation is always on a back foot to teaching and research."

their faculty. In addition, Innovate UK's ICURe Programme provides incentives and opportunities for academics to pursue commercial ideas. A number of participants note the importance of ICURe, but also identify that additional support from public funders, including Research England, could help to better integrate experience with knowledge exchange in promotion criteria, and provide more funding to allow researchers to take a step back from teaching. Targeted public funding for pursuing knowledge exchange projects could help to legitimise academics spending time on impact projects as well as provide resources to universities to offset costs associated with academics taking leave from teaching or other responsibilities. While there is support to expose academics to commercial activity, unless universities allow academics the time to do less teaching or research, these competing priorities will continue to present a systemic challenge for knowledge exchange activity.

The culture of knowledge exchange within individual academic departments can also affect how predisposed researchers are to pursuing knowledge exchange, commercialisation in particular, as there is variation in how knowledge exchange activities are acknowledged, including at the faculty level. Some disciplines, which have a history of knowledge exchange, such as life sciences, are noted for being better than others at rewarding or offering peer to peer support to academics who pursue commercial efforts. Some universities' academic departments have in place formal or informal commercialisation support mechanisms in ways that complement technology transfer office's work, including entrepreneurial mentoring or review of colleagues' commercial ideas.

Technology transfer offices note that, given the rigours of pursuing entrepreneurship, there is a high attrition rate for all researchers who pursue commercialisation endeavours. While these findings are not necessarily specific to the knowledge exchange of digital technologies, they present a common theme of these discussions: how do universities best incentive or enable academics to engage in knowledge exchange activities? It is important that universities and funders value these experiences, whether it produces successful outcomes or not, but as a means to grow the pool of potential academic entrepreneurs.

BUILDING SKILLS CAPACITY

Having the right skills is a critical enabler for any successful spinout. With digital skills in high demand, spinouts and technology transfer offices cannot always access the skills they need to succeed.

Digital technology spinouts often require new and different skillsets than other types of university spinouts focused on other types of technologies. In particular, user experience and design skills are important for turning an idea into a usable product or service. Being able to adapt and iterate on a minimum viable product after talking to users is especially important for digital companies, where

markets and technologies can move quickly. Having the right skills enables digital spinouts to build customer networks and maintain a competitive advantage.

Digital spinouts also increasingly require a knowledge of how issues including ethics, equity and diversity, and bias relate to their work, as well as a basic understanding of domestic and international privacy regulations (e.g., the European Union General Data Protection Regulations). Spinouts and technology transfer offices do not necessarily need to have deep knowledge of these issues, but need access to those people who do. While technology transfer offices often bring in experts as needed, with digital and related skills in high demand, access to these services can be limited and their cost prohibitive.

The skills, time, and interests of knowledge creators are also important considerations in the knowledge exchange pathways of digital technologies. Sometimes knowledge creators will launch or join a spinout to manage it or to further develop its underlying technology as an extension of their research program. In other cases, knowledge creators have no interest in or are unable to launch or be involved in a commercial venture. In these cases, a technology transfer office may bring in outside talent to launch a new venture, or licence the underlying technology's IP to a new or existing enterprise.

The success of founders and spinouts often depends on non-technical skills. Technology transfer offices often help up-skill founders or attract people to help address problems that require specific skills. For example, the RCA runs an incubation program where founders can work and learn for two or more years if they are making progress on their ideas, noting that "this support is really vital, otherwise you have people with great ideas but not a clue on how to bring them to market." Several technology transfer offices point to the success of ICURe in helping researchers access training with industry experts and discover the potential of their commercial ideas in the real world.

One role of technology transfer offices is helping founders understand their strengths and weaknesses, and then finding the right people to augment their core team. While this need is not specific to digital technology, a university's ability to respond and address skills needs is particularly challenging when launching and growing digital spinouts. As with investment, demand and supply for different types of digital skills ebbs and flows with technology trends. For example, the University of York worked with a blockchain spinout which faced challenges attracting needed talent, as skills relating to these underlying technologies followed cryptocurrency market cycles. Due to the high wages paid for some digital skills, digital spinouts must often pay "eye watering sums of money to recruit talent", especially if they are working with in-demand technologies. Universities share that even ventures which raise significant amounts of money can struggle to find and secure access to the right talent. Recruitment challenges are not confined to digital-first firms; today, spinouts across various sectors can have a digital play,

and need to find software experts to develop their code up to expected commercial quality standards, increasing demand for digital skills overall. Some universities note that the shift towards remote work during and after the COVID-19 pandemic is improving access to some digital skills. However, there are still clusters of talent, and for universities outside those clusters, it remains difficult to attract talent.

Regardless of the sector or vertical where digital technologies are being applied, technology transfer offices speak of the importance of bringing in sales and marketing support into digital spinouts at an early stage. Sales attract follow-on investment, and knowledge creators—in particular academic researchers—rarely have these to begin with. However, finding skilled sales people to join spinouts can be difficult because private sector salaries in large businesses are typically much higher than what spinouts or technology transfers offices are able to pay.

In addition to the skills within spinouts, technology transfer offices also need new skillsets within their own teams to support digital technologies. Generally, these offices are staffed with a variety of sector-specific experts, including former founders, ex-academics with doctorates, IP experts, and lawyers. They recruit staff for their offices to inspire founders and help them with problem-solving. Technology transfer offices would like to be able to support their companies with more subject-matter knowledge in the digital space. However, even the largest technology transfer offices—including those that are university subsidiaries with more flexible pay scales and hiring practices—find it difficult to attract people who have digital experience due to salary competition.

Despite these challenges, larger technology transfer offices often have dedicated teams working on digital technologies. Smaller offices typically have a few specialists focusing on certain sectors (e.g., physical sciences, life sciences, and the arts and humanities) where projects may have a digital component, but digital technologies are not their sole focus or area of expertise. Like start-ups outside of large technology clusters, universities in certain regions can find it challenging to attract even general talent. Initiatives like the SETsquared Partnership offer an effective way to share knowledge and collaborate when technology transfers offices face specific project needs or challenges.

Small offices note especially that their own skills capacity is a potential barrier to the successful knowledge exchange of digital technologies. The smallest offices—sometimes with just one or two employees—rely on general technology transfer specialists, who typically have more entrepreneurial-focused skills and experience than a technology-specific background. In response, some groups report different approaches to up-skill themselves or plugging knowledge and capacity gaps, including sending staff on training courses on software commercialisation. In some circumstances, small offices have service level agreements with offices at larger universities, allowing them to use those offices' teams and resources on an ad hoc

basis, such as Salford, which partners with the University of Manchester. Other small offices contract in certain business or legal expertise.

Some universities have a very small volume of spinouts or licensed technologies—in some cases less than one spinout a year—that a technology transfer office will not generate enough return to justify a large budget or team. This can result in IP sitting on a shelf unused because an office may not have the time to determine how best to commercialise it. Having access to shared pools of digital technology and related expertise and skills would improve cost efficiency of knowledge exchange activities by allowing universities to access support as and when they need it.

Smaller technology transfer offices find it would also be helpful to have access to programs or other resources that can build capacity to undertake digital technology knowledge exchange activities. This could include guidance specific to small institutions which have small deal flow, tailored to their experiences and needs.

Universities are aware of the TenU guidance —an international collaboration which provides guidance and advice on effective practices for research commercialisation, with a particular focus on life sciences—which is noted as an exemplar of this type of advice.[22] However, because TenU represents the interests of larger research-intensive universities—those with larger budgets and access to dedicated investment funds—smaller institutions find TenU's resources less applicable.

While digital technologies have different costs and needs, they are also changing how technology transfer offices work to support knowledge exchange, by improving efficiency (see Box 10). PraxisAuril notes that technology transfer offices are often themselves using new or more capable digital technologies, such as to identify possible knowledge exchange partners or search patent databases. This could change the type of skills needed in these technology transfer offices. More guidance on how to use these technologies could increase how broadly they are

Box 10 – e-lucid: express licensing

UCLB's e-lucid is a licensing platform that helps manage contracts for low-cost, higher-volume IP assets, such as software and data sets, which can result in small, often frustrating tasks that can occupy much of the time of tech transfer professionals.[23] The platform changes the business case for many IP assets at the university, which may have previously been unprofitable due to the high administrative burden required to market and licence them. The platform also provides information to the academic teams on downloads, whether free or paid for, that could be useful for tracking impact. Having an automated system makes it easier to work with organisations in different time zones, and by allowing licence deals to be agreed upon through the click of a button, e-lucid reduces transaction times from weeks to days. The success of e-lucid has led to it being adopted by over 20 universities and research institutes in the U.K., Europe, and the U.S., and led to the creation by UCLB in early 2023 of a spinout company to further develop the platform.

adopted by technology transfer offices, and help smaller offices with less capacity to make a greater impact.

ADHERING TO REGULATIONS

Founders and technology transfer offices often face layers of regulation and must contend with emerging issues as privacy and national security concerns catch up to the pace of technological development.

Regulation can help protect research subjects and consumers, including to guard against violations of privacy and to prevent harm. The dependence of many digital technologies on data ensures that technology transfer offices must consider the regulation of data and related issues, such as privacy, when working to commercialise data-enabled research and knowledge. In particular, they must determine the source of data used to develop and sustain an underlying technology. Some researchers may use datasets to design and create new platforms which can only be used for research purposes or that come with restrictions on their use for commercial activities, such as data from the Ordnance Survey or certain sources of energy data.

Such limitations can create barriers to founders and technology transfer offices when seeking investment. Investors can be deterred from financing spinouts if or when there are significant complexities and risks regarding the spinout's use of data; this is especially the case when working for health and healthcare related spinouts and their applications. Digital health applications may rely on patient healthcare data covered by the Data Protection Act 2018, which sets out specific legal protections and requirements for companies working with such data.

Both the Data Protection Act and the Networks and Information Systems Directive are examples of regulatory frameworks which technology transfer office note set out important cybersecurity principles which spinouts must consider and respect. As grey areas often exist when using data, technology transfer offices tend to take cautious approaches. They will not commercialise digital technologies where data-related risks are too great, including cases in which data origin and terms of use are unclear.

Digital spinouts sometimes operate in regulated sectors or industries, such as for financial services or medical devices. In these cases, founders and technology transfer offices may need to address stacked or layered regulatory requirements—dealing with both data governance and privacy, as well as complying with other regulatory issues unique to these sectors—before bringing a product to market. Technology transfer offices are generally comfortable with longer standing regulatory regimes, particularly for pharmaceutical drugs or medical devices. Due to the technical nature of these regulations, technology transfer offices typically provide basic information or training to founders, but may bring in outside consultants or professionals to help founders address and comply with more complex regulatory requirements.

In addition to established regulatory regimes, the National Security and Investment Act 2021 imposes restrictions on foreign investment in sensitive areas of the economy, implicating advanced digital technologies, including robotics, AI, computing hardware, data infrastructure, and quantum technologies.[24] Universities reflect that these restrictions can affect digital technologies, both in general and when they are applied in other spaces—such as AI for healthcare—in ways that researchers and founders do not always expect. They do not view these restrictions as barriers overall, but as a key consideration when attracting investment or licensing IP.

CONCLUSION

The knowledge exchange pathways of digital technologies are shaped by place, people, and purpose. There is no one-size-fits-all approach to commercialising digital technologies or to applying them to solving real-world problems. As technology changes, universities and their technology transfer offices require new ways of securing or licensing intellectual property, negotiating equity, and seeking outside investment. Local ecosystems and students must be engaged in the processes, and universities must be involved in how regulatory frameworks for emerging technology and the use of data are developed and deployed. In turn, both spinouts and technology transfer offices need new skills and experienced talent, seeking guidance and shared resources, as well as unique programming to help digital technology spinouts and innovations succeed.

Universities and digital technology knowledge exchange have a role to play in shaping local and national productivity and competitiveness, aiding the government's goal of securing the U.K.'s role as a science and technology superpower. Universities are excited about the economic, social, and environmental benefits these new technologies can bring, but are looking for support to unlock their potential. How the country responds to the challenges and opportunities universities face will help decide the success of those efforts.

This report has sought to explore the pathways digital technologies take from universities to market, but there are questions this report has identified that can be further investigated. The following represent key issues for future exploration, which we believe would help Research England and others to further identify how universities and public funders can work together to grow their impact for the benefit of the economy and society:

- pathways for digital hardware (e.g., semiconductors or quantum technologies), which may have less well understood knowledge exchange pathways than software;
- university support for student-led start-ups in the context of knowledge exchange activity;
- the effects of regulatory frameworks for data and emerging technologies like artificial intelligence on university knowledge exchange;

- the skills composition of technology transfer offices and how shared pools of skills and experiences could augment them;
- the U.K. patent regime, assessing if it meets the needs of digital technology creators when international competitors can secure protections for certain software assets;
- the growth and impact outcomes of digital technology spinouts who receive funding from university investment funds; and
- the technologies universities could use to better support technology transfer offices.

ENDNOTES

1. As presented by the Lambert Review, 2003.
2. Technology transfer offices or organisations of the following universities participated in this study: De Montfort University, Newcastle University, the Royal College of Art, University College London, the University of Cambridge, the University of Exeter, the University of Salford, the University of Sheffield, the University of Surrey, and the University of York. Participating universities were identified both by Research England and through the course of interviews.
3. From McMillan, 2016.
4. UKRI (online), August 15, 2023.
5. UKRI (online), 2021.
6. Ibid, 2022.
7. USIT TenU Guide media release (online), April 24, 2023. Note that TenU is supported with funding from UKRI via Research England.
8. Referencing work like Smith in Sifted (online), April 3, 2023, and Mundell in Science|Business (online), March 14, 2023.
9. HM Treasury announced this work on March 9, 2023, as this study was initiated.
10. U.K. Intellectual Property Office (online), 2012.
11. Ibid, 2014.
12. AppleYard Lees (online), 2021.
13. Office for Students (online).

14. UKRI (online), 2023.

15. Newcastle University media release (online), November 29, 2017.

16. Kleinman in SkyNews (online), February 11, 2023.

17. As presented in the UK Innovation Strategy (2021), from the U.K. Department of Business, Energy, and Industrial Strategy (online).

18. Northern Gritstone (online), 2023.

19. SETsquared Partnership (online), 2023.

20. Northern Accelerator (online), 2020.

21. National Innovation Centre for Data (online), 2021.

22. USIT TenU Guide reference materials (online), 2022.

23. UCLB and e-lucid (online). The e-lucid platform was noted as an example in interviews and in additional information collected from participants.

24. Referencing NortonRoseFulbright information brief (online), June 2022.

REFERENCES

Department of Business, Energy, and Industrial Strategy. (2021). UK Innovation Strategy. U.K. Government.

Dowling, A. (2015). Dowling review of business-university research collaborations. Department for Business, Innovation & Skills.

e-lucid. (2023). About us. e-lucid. https://e-lucid.com/about-us/

Hellman, T. F., Mulla, J., & Qian, M. (2023). How does equity allocation in university spinouts affect fundraising success? Evidence from the UK. University of Oxford. Saïd Business School.

HM Treasury. (2023). University and investor experts to head up review of UK spin-out landscape. U.K. Government. https://www.gov.uk/government/news/university-and-investor-experts-to-head-up-review-of-uk-spin-out-landscape

Intellectual Property Office. (2012). Intellectual property and your work. U.K. Government. https://www.gov.uk/intellectual-property-an-overview

Intellectual Property Office. (2014). Apply for a patent. U.K. Government. https://www.gov.uk/patent-your-invention/What-you-can-patent

Kleinman, M. (2023, February 11). Sportswear brand Castore gets into shape for $200m fundraising. Sky News. https://news.sky.com/story/sportswear-brand-castore-gets-into-shape-for-200m-fundraising-12808113

Lally, P., Gregory, T., & Appleyard Lees. (2021, July 22). Is it really easier to get your software patents granted in the U.S.? Lexology. https://www.lexology.com/library/detail.aspx?g=c218725a-9819-448e-8bb4-2d54c76324c5

Lambert, R. (2003). Lambert Review of Business-University Collaboration. HM Treasury.

Logan, M. (2020). Scottish technology ecosystem review. Scottish Government.

McMillan Group. (2016). University knowledge exchange (KE) framework: good practice in technology transfer. Higher Education Funding Council for England.

Mundell, I. (2023, March 14). The Ecosystem: UK puts university spin-offs under the microscope. Science|Business. https://sciencebusiness.net/news/Technology-transfer/ecosystem-uk-puts-university-spin-offs-under-microscope

National Innovation Centre for Data. (2021). About us. https://www.nicd.org.uk/about-us

Newcastle University. (2017, November 29). Success for Newcastle University start-up casting a wide net. https://www.ncl.ac.uk/press/articles/archive/2017/11/castore/

Newcastle University. (2023). What KEF results will mean for universities and businesses. https://from.ncl.ac.uk/what-kef-results-mean-for-universities-and-businesses

Northern Accelerator. (2020, December 4). Pre-incorporation Funds. https://northernaccelerator.org/pre-incorporation-funds/

Northern Gritstone. (2023). Home. Northern Gritstone. https://northern-gritstone.com/

NortonRoseFulbright. (2022, June). The UK's new NSI regime: What do you need to know? https://www.nortonrosefulbright.com/en/knowledge/publications/c8b20a65/the-uks-new-nsi-regime-what-do-you-need-to-know

Nurse, P. (2023). Independent review of the UK's research, development and innovation organisational landscape. Department for Science, Innovation and Technology and Department for Business, Energy & Industrial Strategy.

Office for Students. (2023). Knowledge exchange funding. https://www.officeforstudents.org.uk/advice-and-guidance/funding-for-providers/knowledge-exchange-funding-competition/

Oxford Insights, & Cambridge Econometrics. (2022). Understanding UK Artificial Intelligence R&D commercialisation and the role of standards. Department for Digital, Culture, Media & Sport and Office for Artificial Intelligence.

Rees, M. (2019). Advice on university-investor links. Research England.

SETsquared Partnership. (n.d.). About SETsquared Partnership - A Unique Collaboration. SETsquared. https://www.setsquared.co.uk/about-us/

Science and Technology Select Committee. (2017). Managing intellectual property and technology transfer. (HC 2016–17 755). Parliament. House of Commons (U.K.)

Smith, T. (2023, April 3). How bad are Oxford University's spinout policies? Sifted. https://sifted.eu/articles/oxford-university-spinout-policies

TenU. (2022). About. https://ten-u.org/about

TenU. (2023). The USIT Guide: Leading Universities and Investors Launch Set of Recommendations for the Innovation Sector. https://ten-u.org/news/the-usit-guide

UK Research and Innovation. (2021). What is the REF? Research Excellence Framework. https://www.ref.ac.uk/about-the-ref/what-is-the-ref/

UK Research and Innovation. (2022). Research England: About the Knowledge Exchange Framework. Kef.ac.uk. https://kef.ac.uk/about

UK Research and Innovation. (2023). Higher Education Innovation Funding. https://www.ukri.org/what-we-do/our-main-funds-and-areas-of-support/browse-our-areas-of-investment-and-support/higher-education-innovation-fund/

Ulrichsen, T. C. (2019). Developing University Spinouts in the UK: Key Trends in Spinout Activity, Investments and Investor Involvement. University of Cambridge.

Ulrichsen, T. C., Roupakia, Z., & Kelleher, L. (2022). Busting myths and moving forward: The reality of UK university approaches to taking equity in spinouts. University of Cambridge. University Commercialisation and Innovation Policy Evidence Unit.

Ulrichsen, T. C., Kelleher, L., & Roupakia, Z. (2023). Knowledge exchange funding review: Insights from a review of the literature. University of Cambridge. University Commercialisation and Innovation Policy Evidence Unit.