"Digital Stoke": a new opportunity for a second-order post-industrial city

Report 1

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Abstract

The "Digital Stoke" project investigates the emergence in recent years of a growing digital sector in Stoke-on-Trent and, more widely, in North Staffordshire. The research aims are to identify and map what it is that makes up the local digital economy, why the digital sector has developed locally, and how it functions. The findings of the investigation will provide an evidence base for the intended outcomes of the project: (i) to identify policies to assist digital firms and employment in Stoke; and (ii) to help raise Stoke's profile as a location for digital firms, and so encourage new investment (including Foreign Direct Investment) as well as the attention of regional and national policy makers.

This document is Report 1 in a sequence of three documents reporting the outcomes of the Digital Stoke project. Report 1 presents the secondary data analysis together with analysis of the characteristics of digital industries and firms that inform our primary research in Report 2. Report 2 will include a mapping and analysis of a web-scraped database of ICT businesses and a survey and interviews of local ICT businesses. Finally, Report 3 will draw upon Reports 1 and 2 together with feedback from local stakeholders to set out policy proposals.

The Advisory Board

We thank the following colleagues for their participation in the Project Advisory Board: Charlie Houston Brown (Silicon Stoke Board, Staffs Chamber); Jonathan Westlake (Wavemaker); Gemma Whalley (Staffs Chamber); Catherine Crockett (LilaConnect); Claire Gaygan (Potteries Educational Board); Raphael Hirschi (Digital Society Institute); Kate Hudson (Haywyre); and Katie Cooper and Trevor Fenton (Office for National Statistics).

Advisory Board members, together with other colleagues, including Sharon Dempsey (Vitalest Ltd, and British Computer Society), Stephen Simcox (Silicon Stoke, Stoke City Council), and Kevin Taylor (United Living [North] Ltd) contributed substantially to this document by sharing their knowledge and/or taking time to review the first version. Thank you all. Shortcomings are the responsibility of the authors.

Advisory Board members also helped to extend consultation with local experts by facilitating presentations of early findings from Report 1 to a Staffordshire Chambers of Commerce Business Breakfast (26-06-2024), the Silicon Stoke Board (13-09-2024) and the Staffordshire Chambers of Commerce Digital Forum (27-09-2024).

Executive Summary

Introduction and Project Overview

The purpose of the "Digital Stoke" project is to understand and support the emergence of a growing Information, Communication and Technology (ICT) sector in Stoke-on-Trent and North Staffordshire. While Stoke-on-Trent has historically been associated with industrial decline, the organic growth of a digital sector presents a new opportunity for economic regeneration. This research aims to (i) identify and map what constitutes the local digital economy, (ii) understand why the digital sector has developed locally, and (iii) analyse how it functions. The findings will inform evidence-based policy recommendations aimed at: (i) supporting digital firms and employment in Stoke; and (ii) raising Stoke's profile as a destination for digital firms, thereby encouraging new investment (including Foreign Direct Investment), as well as attracting the attention of regional and national policymakers.

The present document – Report 1 – reports project findings arising from the analysis of secondary data together with analysis of the characteristics of digital industries and firms. A further document – Report 2 – will report findings supported by our analysis of primary data (comprising a web-scraped database of local ICT firms together with survey responses and extensive interviewing). Finally, policy recommendations – in Report 3 – will reflect the entire evidence base. Accordingly, the policy recommendations concluding this "Summary" are provisional.

The present document comprises four parts. **Part 1** posits that the ICT (or digital) sector, specifically Section J, as defined by Standard Industrial Classification (SIC) codes, serves as a reasonable and practical unit of secondary data analysis. This part then provides national context demonstrating the increasingly significant contribution of the ICT sector to the UK economy. **Part 2** focuses on the three local authority areas comprising North Staffordshire (i.e., Stoke City together with Newcastle-under-Lyme and Staffordshire Moorlands districts) and concludes that Stoke's ICT sector is characterised by substantial size, high productivity, continued growth relative to the local economy, and rates of enterprise entry and exit that compare favourably with national rates. **Part 3** analysis the characteristics of digital industries and firms to better understand the ICT sector, in particular, its creative economy characteristics and its dependence on intangible assets. Finally, based on secondary data analysis (Part 1 and Part 2) and industry and firm characteristics (Part 3), **Part 4** explains how we developed the survey questionnaire and interview schedules, which form the basis of our primary research. These primary research efforts will be reported in Report 2 and will contribute to more comprehensive, evidence-based policy proposals in Report 3.

Key Findings

At the national level, the ICT sector has increasingly contributed to the UK economy, compared to the manufacturing sector

The ICT sector has emerged as a major source of wealth creation in the UK economy, significantly outperforming the manufacturing sector in growth, productivity and employment. From 1990 to 2022, the ICT sector's share of UK total GDP (total Gross Value Added) grew from 0.87% to 7.49%, while manufacturing's share declined from 10.74% to 9.70%. Between 1994 and 2021, the ICT sector's Gross Value Added (GVA) increased by a factor of 11.96, significantly outpacing both manufacturing (1.52) and the overall market sector (1.67). This sector also demonstrated strong growth in the number of businesses, between 2010 and 2021 ranking the third highest (46.6%), compared to all industries (24.7%). In 2021, the ICT sector generated higher turnover per employee, £211,951, compared to the private sector average of £164,955, while the growth of labour productivity (inflation-adjusted GVA per employee) identifies ICT as a strongly emergent sector: over the period 1994-2020, 534% growth in ICT labour productivity, greatly outpacing manufacturing's 149%.

Over the past 50 years, while the manufacturing sector has shown limited job creation due to technical progress and increased capital intensity, the ICT sector has driven both wealth creation and employment growth. These trends highlight the potential benefits for Stoke-on-Trent in fostering its emerging digital sector.

Although economic complexity is highly "history dependent", Stoke has developed a competitive ICT sector
Stoke-on-Trent ranks low in productivity (160th out of the UK's 179 ITL3 regions in 2021) and economic complexity (60th out of 61 British towns and cities in 2019), which is a measure of a region's relative level of accumulated knowledge and capabilities, and which strongly correlates with productivity and economic development. However, the city has developed a competitive ICT sector that exceeds national averages in employment intensity (even without adjusting for the employment of bet365, a major digital company classified under "Gambling and betting," which can be classified as a digital company). "Digital Stoke" is not a one-firm phenomenon, but in 2023 comprised bet365, a major digital firm, 235 smaller enterprises in Stoke, and around 550 across North Staffordshire. This emergence, independent of Stoke's industrial heritage and with minimal policy support, demonstrates the city's potential to develop economic complexity by specialising in new knowledge activities. This transformation offers a model towards enhanced productivity and economic revitalisation for other post-industrial cities.

The ICT sector in Stoke is large and outperforms its local economy
In 2022, in terms of Gross Value Added (GVA) the absolute size of Stoke's ICT Sector (SIC Section J) was around £1 billion: in current price GVA, £775 million (in real - i.e., inflation-adjusted - GVA, £898 million); but, adjusted for bet365, £976 million in current price GVA ($1,077 million in real terms). Two alternative approaches to adjustment for bet365 yield current price GVA of £1,051 million and £1,125 million respectively. Accordingly, the digital sector has already become a major component of Stoke's local economy. In 2022, while the ICT sector accounted for 4.1% of local employment, it contributed 11.3% of GVA, up from 8.2% in 1998. This GVA share of Stoke's ICT sector significantly exceeds that of both the rest of Staffordshire (2.3%) and the UK (6.5%). The sector has also shown strong growth, with a nearly 50% increase in real GVA over the past decade. As a result of this rapid growth, Stoke's ICT sector ranked 40th among the UK's 179 ITL3 regions in 2022, despite being the 118th largest local economy. Notably, when accounting for bet365's contribution, based on three different adjustments, Stoke's ICT sector ranking rises as high as 31st or 32nd nationally. In any case, Stoke's ICT sector ranks by size within the first quartile of the UK's ILT3 regions.

The sector's productivity performance is also impressive, as evidenced by two distinct data sources. According to ITL3 data from the Office for National Statistics (ONS), labour productivity (GVA per employee) in Stoke's ICT sector reached £155,000 in 2022, ranking 7th out of 168 ITL3 regions in Great Britain, significantly outperforming both neighbouring cities (Birmingham: £90,667; Manchester: £101,880) and the UK average (£90,988). The sector's high productivity might come from digital industries SIC 61-63 (Telecommunications;

Computer programming and consultancy; and Information service activities), which dominate Stoke's digital economy in both employment and productivity. As a "sense check", firm-level data from the FAME database indicates that, despite limited samples, Stoke's ICT firms demonstrate productivity levels (Value added per employee) comparable to the national average. This evidence together suggests that the productivity of Stoke's ICT sector is at best substantially better than the UK average and at least "national class".

Stoke has become the engine of the digital economy in the North Staffordshire sub-region
The ICT sector has been increasing its weight in the local economy. From 2015 to 2022, the ICT sector – particularly SIC 62 (Computer programming, consultancy and related activities) – has steadily increased its share of local employment, growing faster than the national average. Based on web-scraped online job adverts and on the assumption that job adverts correspond to jobs filled, there is an indication that digital employment in Stoke not only accounts for a substantial share of employment but also a growing share.

Stoke has established itself as the engine of the digital economy in North Staffordshire, as evidenced by: (i) higher and faster-growing labour productivity compared to Newcastle-under-Lyme and Staffordshire Moorlands between 2015 and 2022; (ii) larger ICT employment (5,000 workers in 2022) compared to Newcastle (1,000) and Staffordshire Moorlands (300); (iii) strong employment growth of 67% (2015-2022), contrasting with declines in Newcastle (-20%) and Staffordshire Moorlands (-14%); (iv) dominance in SIC 62 activities, the largest component of North Staffordshire's digital sector, with both employment and growth rates exceeding those of neighbouring areas; and (v) substantially larger average ICT business size compared to surrounding regions.

Stoke's ICT sector is dynamic, with rates of business entry and exit that compare favourably with national rates: (i) while the number of ICT enterprises and local units peaked nationally in 2019 and locally in 2020, subsequent decline from their respective peaks has been substantially lower in Stoke; (ii) the local fall in the number of ICT enterprises and business units has been accompanied by an increase in average size so that ICT employment has continued to increase; (iii) local ICT employment increase has a strong bias towards full-time jobs; and (iv) in the context of an industry with substantial churn – i.e., exit and entry of businesses – from 2020 the net entry of ICT enterprises in Stoke compares favourably with net entry nationally.

The imperative to innovate is particularly strong in the digital sector, especially for SMEs
Our analysis of the characteristics of digital industries and firms suggests that:

1. non-technological innovation, especially marketing strategy, may prolong short-term premium prices and high profits but cannot maintain them indefinitely; and
2. technological innovation – new processes and new products – is necessary to command premium prices and high profits over time, and therefore to enact a strategy for firm growth.

Policy Implications (provisional, pending Report 3)

Supporting Inclusive Development in an Organically Growing Sector
While Stoke's digital sector has demonstrated organic growth and achieved at least national-level productivity overall, this success should not preclude the need for active policy intervention and support. Particular attention should be paid to businesses lagging the

productivity frontier. Public policies should focus on helping these lagging firms benefit from knowledge transfer initiatives, supported by local institutions such as the Council, Staffordshire Chambers, and local universities and colleges.

Digital skills
Stoke is in competition with other cities to attract and retain digital talent. Institutions contributing to the local digital ecosystem – businesses, Staffordshire Chambers, local universities and colleges, the local authorities, and others – should collaborate on a strategy to increase the supply of digital skills.

Enhancing Local Retention of Digital Talent and Value
The relatively low rate of remote work in Stoke compared to neighbouring regions suggests that the high-earning digital workforce may be living and spending outside the city. This raises the need for policies to attract and retain skilled workers locally. Key initiatives should include improving housing quality and affordability, enhancing transport connectivity both within the city and to neighbouring regions, and developing attractive urban amenities and lifestyle offerings. Additionally, to ensure sustainable development, local fiscal policies should be adjusted for Stoke to capture more of the value it creates, allowing it to reinvest in public services and further growth.

Developing a Well-Functioning Digital Ecosystem
Local authorities should focus on creating a comprehensive and sustainable digital ecosystem through consistent policy interventions. Given that the digital economy extends across wider North Staffordshire, coordinated action among local authorities in Stoke-on-Trent, Newcastle-under-Lyme, and Staffordshire Moorlands is essential. This cooperation should focus on investment in tangible infrastructure (e.g., low-cost housing and workspace, broadband coverage, and transport), intangible assets (e.g., education and skills, knowledge transfer, a business-friendly culture, and an environment in which face-to-face interactions and social capital can flourish) or both (e.g., Science Parks). The ecosystem development should align procurement and business support policies with local universities to promote publicly funded university research into basic intangibles and knowledge transfer initiatives. The success of these initiatives requires policy consistency beyond electoral cycles and strong political consensus among local authorities.

Promoting Innovation
The existential importance of innovation for digital sector firms suggests a two-fold corollary for public authorities, particularly in partnership with colleges, universities and other providers of management education and consultancy advice: (i) to support non-technological innovation to help firms maintain existing markets and enter new markets (including export markets); and (ii) to support activities and infrastructure that enable technological innovation.

Raising Stoke's Profile and Attracting Investment
Despite its strong growth, the ICT sector in Stoke has attracted relatively little foreign direct investment (FDI), partly because of skill shortages — as evidenced by bet365's expansion to Manchester for recruitment. Local authorities need to actively promote Stoke as a digital hub while addressing fundamental challenges. The city should develop a compelling brand narrative focused on digital innovation and establish clear communication channels to make the ecosystem more "readable" to potential investors. By creating a business-friendly culture and streamlining investment procedures, Stoke can position itself as an attractive destination for both private and public sector investment.

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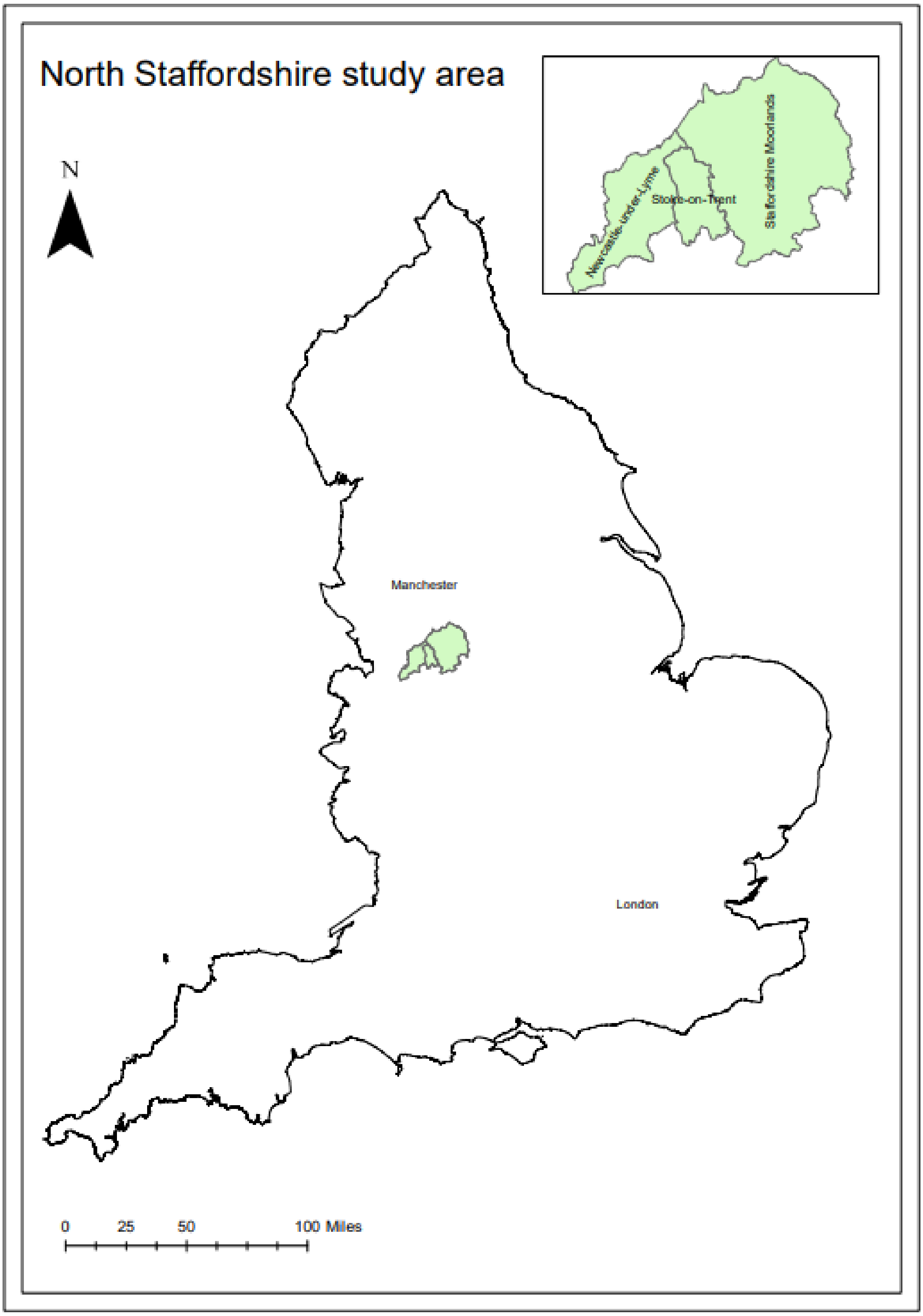
Location of the study area

Within the outline map of England, the City of Stoke-on-Trent is in North Staffordshire (expanded in the box), in immediate proximity to Newcastle-under-Lyme and Staffordshire Moorlands districts, and with London to the South and Manchester to the North.*



"Digital Stoke": a new opportunity for a second-order post-industrial city

1 Introduction

Stoke-on-Trent needs new sources of employment and wealth creation to halt and reverse the legacy of deindustrialisation. For a very long time, bad news about Stoke's economy has dominated. Around 1960, employment in Stoke-on-Trent was dominated by three main industries: the ceramics industry supported 48,184 jobs in 1959 (Lambert, 2009: 5); over 20,000 worked in coal mining[1]; and the Shelton Bar steelworks employed around 10,000[2]. By the mid-2000s, coal mining and steel production no longer featured in Stoke's industrial structure, and current ceramic industry employment in Stoke is commonly estimated at around 5,000[3]. With a population of 265,306 in 1961[4] and an estimated 258,000 in 2025[5] it is clear why, over a long period, economic news from Stoke has been dominated by business closures and job losses. But "Digital Stoke" is a good news story, which needs to be better understood and better known.[6]

This first report documents the presence in Stoke-on-Trent of a new opportunity; namely, an ICT (Information and Communications Technology) or digital sector of substantial size, high productivity, and continued growth relative to the local economy.[7] The purpose of the secondary research and theoretical discussion reported in this document is to motivate and inform additional primary research: (i) to map the IT sector in Stoke; (ii) to analyse its origins, structure, performance, and current and potential role in the local economy; and (iii) thereby to inform evidence-based policies to sustain and develop this emergent sector.

To this end, this document has four parts:

1. the unit of analysis and secondary data on the national context;
2. the ICT sector in Stoke-on-Trent (analysis using secondary data to identify and analyse "what is out there");
3. analysis of ICT industry and firm characteristics to better inform primary research into the emerging ICT sector in Stoke-on-Trent; and
4. a detailed "audit trail" demonstrating how the analysis of secondary data in Parts 1 and 2 and the analysis of ICT industry and firm characteristics in Part 3 together inform our primary research, which will be conducted via a questionnaire survey and extensive

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[1] History of Stoke on Trent Staffordshire | Green4Logistics
[2] Shelton Bar | Martin Tideswell; Shelton Bar - Wikipedia
[3] Stoke the embers - how the ceramics industry is firing up for the future | The Lead
[4] Vision of Britain | 1961 Census: County Report | Table 3
[5] https://totalpopulation.co.uk/authority/stoke-on-trent
[6] HM Government (2022: 40) acknowledges only ceramics and advanced manufacturing as – presumably, the respective – sectoral strengths of Stoke-on-Trent and Staffordshire.
[7] According to the Organisation for Economic Cooperation and Development (OECD) definition (Search Results | OECD iLibrary (oecd-ilibrary.org)): 'Information and communication technology (ICT) refers to both different types of communications networks and the technologies used in them. The ICT sector combines manufacturing and services industries whose products primarily fulfil or enable the function of information processing and communication by electronic means, including transmission and display.'

interviewing into "why" digital firms locate in Stoke-on-Trent and "how" the sector develops.

Each Section is numbered consecutively though the paper. In brief, the contents of each part are as follows.

Part 1. The unit of analysis and the national context

In **Section 2**, we define our unit of analysis: i.e., what we mean by the "digital" sector. We argue that a reasonable and useful proxy is the Information and Communications sector – i.e. Section J, as defined by Standard Industrial Classification (SIC 2007) codes – while demonstrating that any analysis of secondary data must be mindful of digital industries not included in Section J. **Section 3** analyses secondary data at the national level to demonstrate the contribution of the ICT sector to the UK economy, its productivity and employment growth, highlighting each of these by way of comparison with the manufacturing sector.

Part 2. The ICT sector in Stoke-on-Trent

Turning to investigation and analysis of the digital sector in Stoke-on-Trent, in **Section 4** we report descriptive research based on data recently made available at the local authority level. We begin by introducing the concept of economic complexity, which has been developed over the past decade or so to capture the relative levels of accumulated knowledge and capabilities of locations (Section 4.1). Next, we provide an intuitive overview of how economic complexity is defined and calculated (Section 4.2), and then we show that Stoke-on-Trent's economic performance relative to other cities and towns is similarly reflected in both its economic complexity ranking and in its productivity ranking (Section 4.3). Taking our cue from evidence that cities characterised by low complexity and productivity can nonetheless develop new knowledge-based activities, we analyse existing data to investigate Stoke's potential in the digital economy, finding evidence of the emergence in Stoke of an ICT sector with competitive potential (**Section 5**). We then take a deeper look at this potential, which is indicated by high productivity in relation to both other industries located in Stoke and the ICT sector nationally. **Section 6** details the number of ICT businesses in Stoke as well as in Newcastle-under-Lyme and Staffordshire Moorlands, establishing the presence of a sector broadly based on many firms. **Section 7** examines, first, the size of Stoke's ICT sector in relation to other UK cities and, second, the absolute and relative productivity of Stoke's ICT sector. **Section 8** documents the increasing weight of Stokes' digital sector both in the digital sector of the North Staffordshire sub region and in Stoke's own local economy. **Section 9** compares exit and entry into Stoke's ICT sector with exit and entry into the ICT sector nationally. Finally, we draw some conclusions that offer guidelines for further study (**Section 10**).

Part 3. Characteristics of digital industries and firms: creative sector; and intangibles

Section 11 begins by demonstrating the substantial overlap of the digital sector and the broad "Creative sector". We then argue that (i) businesses – especially the micro-, small-, and medium-size firms – in these industries share the characteristics of creative sector firms and that (ii) the digital sector occupies a strategic position within the creative sector. **Section 12**

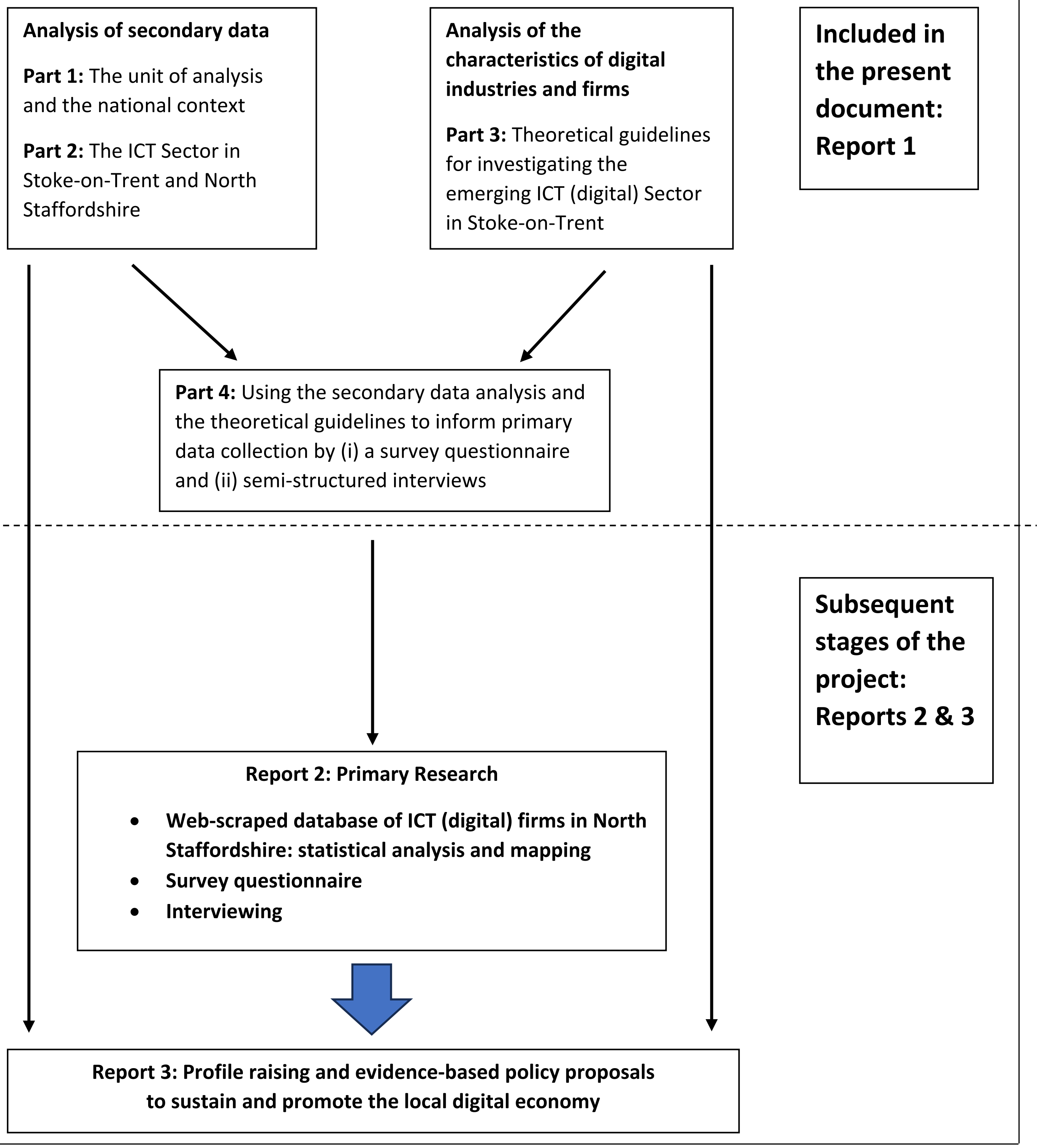
explores the implications of ICT dependence on intangible assets. Both sections suggest lines of enquiry for primary research.

Part 4. Using the secondary data analysis and the characteristics of digital industries and firms to inform data capture instruments

Section 13 explains how the analysis of secondary data at national and local levels in Parts 1 and 2 together with the analysis of ICT industry and firm characteristics in Part 3 inform the primary research to be completed by the "Digital Stoke" project. Appendix F together with Appendix G demonstrate how the research themes, questions, and objectives arising from Parts 1, 2, and 3 inform corresponding survey and interview questions. (The on-line survey questionnaire together with the in-person interview schedule are available elsewhere on the Project website.)

Design of the "Digital Stoke" project

This diagram explains how the four parts of Report 1 fit into the design of the whole "Digital Stoke" project. **In this document,** both secondary data analysis (Parts 1 and 2) and analysis of the characteristics of digital industries and firms (Part 3) inform our data capture instruments (i.e., a survey questionnaire and interview schedules) (Part 4). **The complete project** will be reported in three documents: (Report 1 - secondary data and analysis): (Report 2 – primary data and analysis); and evidence-based policy proposals (Report 3).



Part 1. The unit of analysis and the national context

2 The unit of analysis: what is the digital sector?

First, we describe the digital (i.e., information and communication) sector of the economy. Before getting to grips with the origin, development, and policy needs of Stoke's emergent digital sector, we set out our understanding of what we are dealing with. This is not so easy. The best part of a quarter of a century ago, a study of the ceramics industry in Stoke-on-Trent quoted the 1997 *Panorama of EU Industry* to the effect that it was 'hard to think of another EU industry in which the diversity ... is so great' (Padley and Pugh, 2000: 25). Nonetheless, the scope of the ceramics industry could be succinctly outlined with reference to a few of the then Standard Industrial Classification (SIC) 3- and 4-digit level codes.[8] Today, in contrast, 'it is almost impossible to find an aspect of our lives that has not been touched by digitalization' (Keyhani et al., 2022: 2). Moreover, there is evidence that the impact of digitalisation has accelerated over the past decade or so (for some informal evidence of this, see Appendix A). A correspondingly broad definition has digital entrepreneurs 'creating new economic activities embodied in or enabled by digital technologies' (Keyhani et al., 2022: 5). In this vein, our analysis of the digital sector in Stoke-on-Trent focuses mainly on firms for which activities embodied in digital products – goods and/or services – are their outputs, hence their source of revenue and profit – rather than on the wider range of firms for which digital products are inputs, hence costs.[9] Of course, at points we will be concerned with both "producing" and "consuming" firms, as these are potentially linked in a common ecosystem (for example, via potential competition for the same local labour).

The digital sector is characterised by the continuously developing integration of information and communication technologies (ICTs) and comprises an increasing range of general-purpose or platform technologies, which are (i) versatile, (ii) can be applied across the whole economy, and (iii) transform the way businesses operate, improving efficiency and innovation. Digital general-purpose technologies are pervasive and foundational; for example: the **Internet (**a platform for communication, information exchange, commerce, and global collaboration); **Cloud Computing (**on-demand access to computing resources and data storage, a foundation for various applications, including web services, data analytics, and software development); **Big Data and Analytics (**the collection, storage, and analysis of vast datasets to make data-driven decisions); **Artificial Intelligence (AI) and Machine Learning** (general-purpose tools that enhance automation, data gathering and analysis, content creation,

[8] '... the principal pottery/ceramic products in SIC 262 comprise SIC 2621 – manufacture of ceramic household and ornamental articles, including table ware, kitchen ware, ornamental articles, and toilet articles (excluding large sanitary fixtures); SIC 2622 – manufacture of ceramic sanitary fixtures; SIC 2623 and 2624 – manufacture of technical ceramics; and SIC 2626 – manufacture of refractory ceramic products'.

[9] According to the Wikipedia entry on "Information Technology": 'It is also worth noting that from a business perspective, information technology departments are a "cost centre" the majority of the time ... Modern businesses rely heavily on technology for their day-to-day operations, so the expenses delegated to cover technology that facilitates business in a more efficient manner are usually seen as "just the cost of doing business".' Information technology - Wikipedia

decision-making, and predictive capabilities); **Blockchain (**applications beyond cryptocurrencies include supply chain management and secure document verification, providing trust and transparency); **Internet of Things** (connecting everyday objects and devices to the internet, allowing them to collect and exchange data for data-driven insights and automation); **Mobile Technologies** (a platform for countless applications, from mobile banking and social media to location-based services, transforming how people access information and conduct transactions); **Cybersecurity** (a general-purpose technology protecting systems and data); **E-commerce Platforms** (a foundation for online businesses to sell products and services globally); and **Digital Payment Systems** (making it easier and more efficient to transfer money and make purchases). This industrial structure of platforms each supporting a wide (and widening) range of business activities is consistent with a corresponding range of firm sizes from very large (controlling platforms) to SME, micro and freelancer businesses commercialising activities enabled by platforms. (This point will be developed in Section 12 below.)

The digital sector encompasses a vast array of activities related to the creation, storage, transmission, and utilization of digital information. It encompasses both digital goods (e.g., software, content) and digital services (e.g., cloud computing, data analytics). Moreover, digital technologies are typically combined in different ways by businesses. For example, bet365 – since 2011 Stoke-on-Trent's largest private-sector employer (bet365 Careers | Our History) – is a major online gambling business, which relies on several general-purpose technologies to operate effectively; for example: the Internet (the fundamental technology that enables online gambling); Cloud Computing (to host websites and databases, enabling high levels of traffic during peak betting times); Big Data and Analytics (to track user behaviour, monitor betting patterns, and identify potential issues like fraud or problem gambling); Cybersecurity (to protect user data, financial transactions, and the integrity of their platform); Mobile Technologies (to allow users to place bets and access the platform on their smartphones and tablets); and Digital Payment Systems (to fund accounts and receive winnings). Accordingly, digital businesses and industries cannot be neatly organised under the heading of one or other of these general-purpose digital technologies. To take us closer to a clearly defined unit of analysis and corresponding taxonomy, Table 1 lists 21 interrelated activities within the digital sector and maps these onto the corresponding SIC (2007) codes. This gives an extensive but non-exhaustive overview of the digital landscape.

Table 1. Activities within the digital sector and their corresponding SIC codes.

Activity	Description	2-Digit SIC Code	3-Digit SIC Code	4-Digit SIC Code
1. Information Technology (IT) Services	IT consulting, software development, and hardware manufacturing.	62, 26	620, 261, 262, 263	6201, 6202, 6203, 6209, 2611, 2612, 2620, 2630
2. Telecommunications	Broadband networks, mobile services, and internet connectivity.	61	611, 612, 613, 619	6110, 6120, 6130, 6190 [a]
3. E-Commerce and Retail	Online sales, including retail, mail order, and online stores.	47	479	4791, 4799
4. Digital Content and Media	Digital advertising, streaming, online news, and social media.	58	581	5813, 5911, 6010, 6020, 6312, 7311
5. Publishing of computer games	Overlaps with AR/VR content, hardware, and software solutions.			5821
6. Data Analytics and Big Data	Data processing, hosting, analytics, and IT consultancy.	63	631	6311
7. Financial Technology (Fintech)	Innovative financial services, payment solutions.	64, 66	649, 661	6499,[b] 6611
8. Health Technology (Health Tech)	Healthcare technology, telemedicine, and health data management.	86	869	8690 [c]
9. Educational Technology (EdTech)	Online learning platforms, e-learning solutions, and educational content.	85	855	8559 [d]
10. Internet or Online Gambling	Online betting and gambling services.	92	920	9200 [e]
11. Smart Cities and IoT (Internet of Things)	IoT technology for urban infrastructure and services.	71	711	7111, 7112 [f]
12. Augmented Reality (AR) and Virtual Reality (VR)	AR/VR content, hardware, and software solutions.	58	582	5821, 5829 [g]

Activity	Description	2-Digit SIC Code	3-Digit SIC Code	4-Digit SIC Code
13. Blockchain and Cryptocurrency	Blockchain-based solutions, cryptocurrencies, and decentralised finance (DeFi).	64, 66	641, 661	6419, 6611, 6619
14. Environmental Tech	Green tech solutions for environmental sustainability.	71	711	7111, 7112 [h]
15. Cybersecurity Services	Services focused on protecting digital assets and data security.	62	620	6201, 6203
16. Artificial Intelligence (AI) and Machine Learning	AI development, machine learning algorithms, and AI-based services.	62	620	6201
17. Digital Marketing and Advertising	Digital marketing agencies and online advertising platforms.	73	731	7311, 7312
18. Space Technology	Technologies related to space exploration and satellite communications.	30	303	3030
19. Film, TV, Video, Radio and Photography	Digital production, broadcasting, and media content creation.	59, 60	591, 601, 602	5911, 5912, 5913, 5914, 5920, 6010, 6020
20. Publishing	Digital publishing of books, periodicals, and online content.	58, 59	581, 592	5811, 5812, 5813, 5814, 5819
21. Music, Performing and Visual Arts	Digital music distribution, online performances, and visual arts in the digital space.	59, 90	592, 900	5920, 9001, 9002, 9003, 9004

Notes: [a] Some 4-Digit codes may duplicate the 3-D codes. [b] 6499 is a catch all category: 'Other financial service activities, except insurance and pension funding, (not including security dealing on own account and factoring) nec (not elsewhere categorised).' [c] A catch-all category: 'Other human health activities.' [d] A catch-all category: 'Other education nec.' [e] Nothing specifically digital in this category: 'Gambling and betting activities'. [f, g, and h] Very approximate mappings.

Source: compiled with the aid of ChatGPT, version 3.5.

Table 1 is a list of activities commonly associated with the digital economy. These and other activities – such as e-sports – are appearing and evolving rapidly and so are difficult to map onto the SIC (2007) codes. The mapping in Table 1, which had to be done mainly manually, is therefore indicative, with many activities coded only approximately or captured by residual codes ("not elsewhere categorised").[10]

It is not the intention of this Report to offer its own definition of the digital sector. Nor is there any purpose in so doing. In the available data sources, there is typically a trade-off between level of industrial and geographic aggregation: i.e. disaggregated industry categories are available at national and sometime regional level, but not at local level; conversely, data is obtainable only for aggregated industry categories at the local authority level. Accordingly, to focus on Stoke-on-Trent, the *Digital* sector is taken to be the Information and Communications industries in the Standard Industrial Classification (SIC 2007). This is Section J, covering Divisions 58-63 of SIC 2007, the latest available taxonomy at the time of writing.[11] SIC 2007 Section J, detailed in Table 2, covers the following industries defined at the 2-, 3- and 4-digit levels.

[10] For example, for Internet gambling, 'Gambling and betting activities' is the best fit. And the best we can do for FinTech is: 'Other financial service activities, except insurance and pension funding, (not including security dealing on own account and factoring) nec.'

[11] Responding to concerns regarding the accuracy of the SIC taxonomy, ONS (2023a) compared differences between the SIC of Reporting Units on the Inter-Departmental Business Register (IDBR) (taken from VAT registrations from HMRC) and results of the Business Register and Employment Survey (BRES) in 2021 (which allowed responding businesses to confirm or change the SIC for each of their own Local Units). Section J, of most interest in the present study, was among the most accurate sections, with 96.5 per cent of Reporting Units being correctly assigned (ONS, 2023a: Figure 3), while smaller firms – by either employment or turnover – display higher mismatch rates than do larger firms.

Table 2. SIC 2007 Section J, Information and Communications industries (2-, 3-, and 4-digit levels)

Division	Group	Class	Subclass	Description
58				**Publishing activities**
	58.1			**Publishing of books, periodicals and other publishing activities**
		58.11		Book publishing
		58.12		Publishing of directories and mailing lists
		58.13		Publishing of newspapers
		58.14		Publishing of journals and periodicals
			58.14/1	Publishing of learned journals
			58.14/2	Publishing of consumer, business and professional journals and periodicals
		58.19		Other publishing activities
	58.2			**Software publishing**
		58.21		Publishing of computer games
		58.29		Other software publishing
59				**Motion picture, video and television programme production, sound recording and music publishing activities**
	59.1			**Motion picture, video and television programme activities**
		59.11		Motion picture, video and television programme production activities
			59.11/1	Motion picture production activities
			59.11/2	Video production activities
			59.11/3	Television programme production activities
		59.12		Motion picture, video and television programme post-production activities
		59.13		Motion picture, video and television programme distribution activities
			59.13/1	Motion picture distribution activities
			59.13/2	Video distribution activities
			59.13/3	Television programme distribution activities
		59.14		Motion picture projection activities
	59.2			**Sound recording and music publishing activities**
		59.20		Sound recording and music publishing activities
60				**Programming and broadcasting activities**
	60.1			**Radio broadcasting**
		60.10		Radio broadcasting
	60.2			**Television programming and broadcasting activities**
		60.20		Television programming and broadcasting activities
61				**Telecommunications**
	61.1			**Wired telecommunications activities**
		61.10		Wired telecommunications activities
	61.2			**Wireless telecommunications activities**
		61.20		Wireless telecommunications activities
	61.3			**Satellite telecommunications activities**
		61.30		Satellite telecommunications activities
	61.9			**Other telecommunications activities**
		61.90		Other telecommunications activities
62				**Computer programming, consultancy and related activities**
	62.0			**Computer programming, consultancy and related activities**
		62.01		Computer programming activities
			62.01/1	Ready-made interactive leisure and entertainment software development
			62.01/2	Business and domestic software development
		62.02		Computer consultancy activities
		62.03		Computer facilities management activities
		62.09		Other information technology and computer service activities
63				**Information service activities**
	63.1			**Data processing, hosting and related activities; web portals**
		63.11		Data processing, hosting and related activities
		63.12		Web portals
	63.9			**Other information service activities**
		63.91		News agency activities
		63.99		Other information service activities n.e.c.

Source: ONS, UK SIC 2007 - Office for National Statistics (ons.gov.uk)

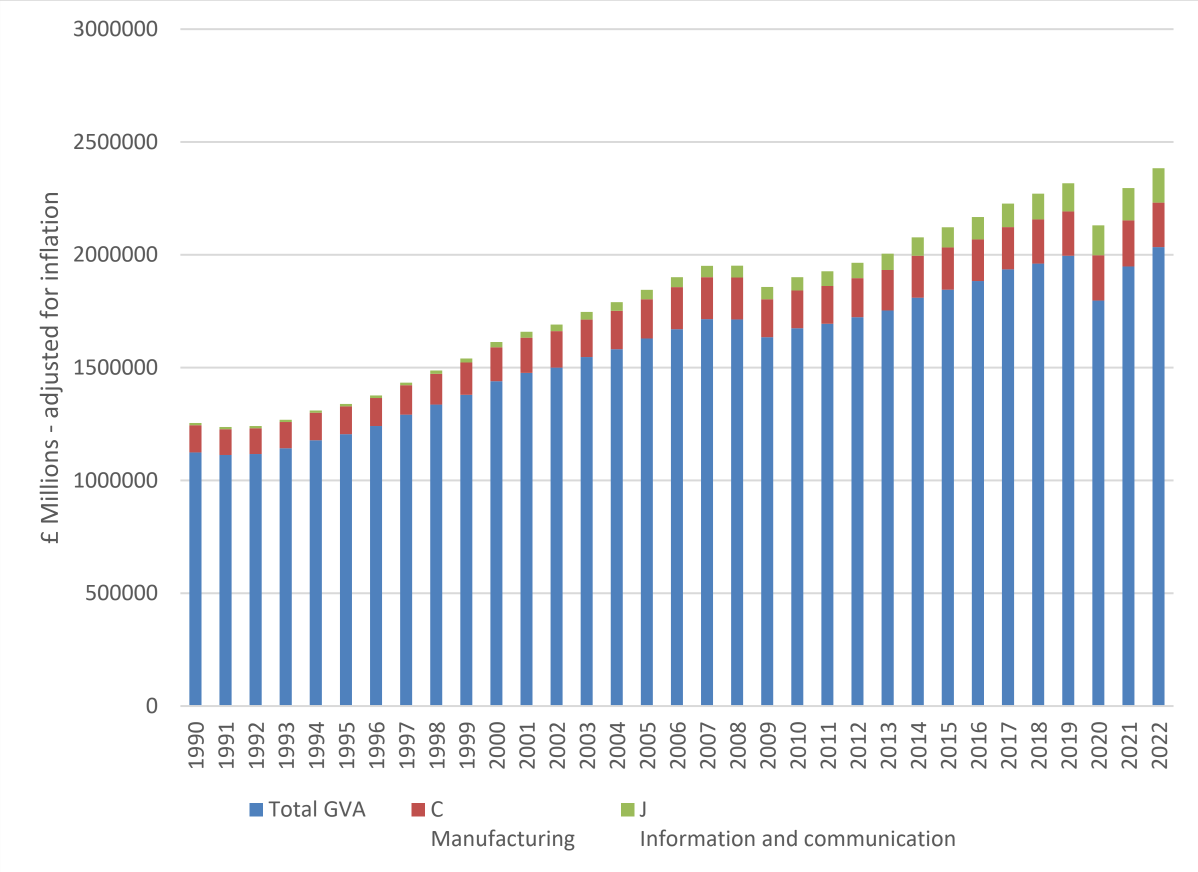
Section J, covering Divisions 58-63 of SIC 2007 – collectively describing the industries in the Information and Communications sector – includes around 55 per cent of the SIC 2-, 3- and 4-Digit level activities included in Table 1. Hence, we have a reasonable proxy for the digital sector. The Office for National Statistics (ONS) publish – or make available upon reasonable request – data on the SIC Information and Communications sector at the local authority level and/or International Territorial Levels Level 3 (ILT3), which will enable investigation of a unit of analysis comparable with and potentially useful for areas beyond Stoke. However, local analysts also need to be mindful of the potential presence of digital industries not included in Section J. In the case of Stoke-on-Trent, the obvious omission is Internet or Online Gambling (SIC 9200; see Table 1). Comparisons of Tables 1 and 2 are likely to reveal other such omissions of importance to other areas. This issue is explored in Section 7.1 below (to anticipate, this turns out to be a second-order problem for the analysis of Stoke's ICT sector).

3 Some national context on Section J: ICT

Over the past 30 years or so, ICT has been a rapidly emergent sector of the UK economy. Whereas in 1990 Manufacturing (SIC 2007 Section C) accounted for 10.74 per cent of UK GDP (total Gross Value Added) and Information and Communication (SIC 2007 Section J) for 0.87 per cent, by 2022 these respective shares had converged to 9.70 and 7.49 per cent. Figure 1 displays real (i.e. adjusted for inflation) total GVA, Manufacturing GVA, and IC GVA as £s million (so that 2,500,000 on the vertical scale is £2.5 trillion).[12] Along with other data presented in this Section, Figure 1 highlights the emergence of the ICT sector as a major source of wealth creation in the UK economy.

[12] Gross Value Added (GVA) is a metric that provides a monetary value for the goods and services that have been produced by a business – or in a country, region or other unit of analysis – minus the cost of all inputs and raw materials that are directly attributable to that production. Typically, GVA is adjusted for inflation to give an estimate of the volume of goods and services – i.e., the real GVA – produced by an industry or in aggregate by a region or the UK.

Figure 1. Gross value added (GVA) in pounds millions, chained volume measures, UK (1990-2022): ICT (Section J); Manufacturing (Section C); and Rest of Total GVA



Source: ONS, 2023b (data extracted from Table 2a)

The growth of ICT in comparison with manufacturing will run through this section of the report, because it is particularly relevant to Stoke, which has a recent history of a large but relatively declining manufacturing base but has more recently benefitted from the emergence of an ICT or digital sector. In each case, the data presented below use the longest available time series, so the periods covered vary.

Of the 16 broad "Sections" of the UK economy identified by the ONS, in the 12 years 2010 – 2021, ICT (ONS Section J) had the third highest growth in the number of businesses (46.6%), well above the "All industries" average (24.7%) (Table 3). This comprised a similar growth of VAT registered (46.6%) and unregistered (46.5%) businesses, in both cases markedly different from the respective "All industries" averages (28.3% and 21.5%).

Table 3. Total number of businesses in the private sector, by industry section, UK, start 2010 - 2021

ONS Sections of the UK economy		Number of businesses, start of:		Percentage growth, 2010-2021 (rounded)
		2010	2021	
L	Real Estate Activities	78300	134100	71.3
N	Administrative and Support Service Activities	307500	465900	51.5
J	Information and Communication	240800	352900	46.6
R	Arts, Entertainment and Recreation	191000	278200	45.7
M	Professional, Scientific and Technical Activities	602200	848800	40.9
S	Other Service Activities	251500	341800	35.9
I	Accommodation and Food Service Activities	151000	200600	32.8
P	Education	224900	298300	32.6
K	Financial and Insurance Activities	75600	98300	30.0
B,D,E	Mining and Quarrying; Electricity, Gas and Air Conditioning Supply; Water Supply; Sewerage, Waste Management and Remediation Activities	22900	29200	27.5
All industries		4484500	5590900	24.7
C	Manufacturing	230000	270000	17.4
Q	Human Health and Social Work Activities	290900	339100	16.6
H	Transportation and Storage	275100	310600	12.9
G	Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	497800	556900	11.9
A	Agriculture, Forestry and Fishing	145900	152600	4.6
F	Construction	899200	913800	1.6

Source: Calculated from Department for Business, Energy & Industrial Strategy (2021: Table 29).

Table 4 shows that companies in the ICT sector have relatively high turnover per employee (£211,951) compared to the “All industries” average (£164,955). It is to be expected that ICT has lower turnover per employee than either industries intensive in tangible assets (utilities and manufacturing) or an industry with relatively little value added (wholesale and retail). For such reasons, turnover per employee is at best indicative as a measure of labour productivity (i.e., value added per employee). However, turnover per employee can indicate relative levels of productivity: the national-level turnover per employee in industrial sectors can be a useful benchmark to compare with similar regional or local data; and relative levels of turnover per employee at different times can be broadly indicative of productivity growth rates, especially when the industry is narrowly and consistently defined (e.g., at the SIC 2-Digit rather than the Section level).

Table 4. Turnover per employee (£s) in the private sector by ONS Section, UK, start 2021

		All companies	By number of employees			
			None [1]	1 - 49	50 - 249	250 +
B,D,E	Mining and Quarrying; Electricity, Gas and Air Conditioning Supply; Water Supply; Sewerage, Waste Management and Remediation Activities	584156	150750	459720	427686	683738
G	Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	311593	103864	335804	572313	277813
C	Manufacturing	245343	53472	130106	186830	386123
J	Information and Communication	211951	76509	162813	251034	310977
F	Construction	172383	84997	178799	244366	324693
All industries[2]		164955	66768	154779	207153	201379
M	Professional, Scientific and Technical Activities	140456	81054	125075	185867	194316
H	Transportation and Storage	140020	51502	154364	214317	149640
R	Arts, Entertainment and Recreation	135266	44722	82963	110216	295950
L	Real Estate Activities	124579	100340	137496	136900	119674
N	Administrative and Support Service Activities	101349	80581	157369	123320	73616
A	Agriculture, Forestry and Fishing	95502	58063	117104	104087	94584
S	Other Service Activities	54049	31733	56549	87140	142234
I	Accommodation and Food Service Activities	48959	51839	42298	53896	54493
Q	Human Health and Social Work Activities	48713	36460	56412	49226	46722
P	Education	45354	29551	65572	59932	55740
K	Financial and Insurance Activities[2]					

[1] "None" comprises sole proprietorships and partnerships with only a self-employed owner-manager(s) and companies with one employee, assumed to be a working proprietor.

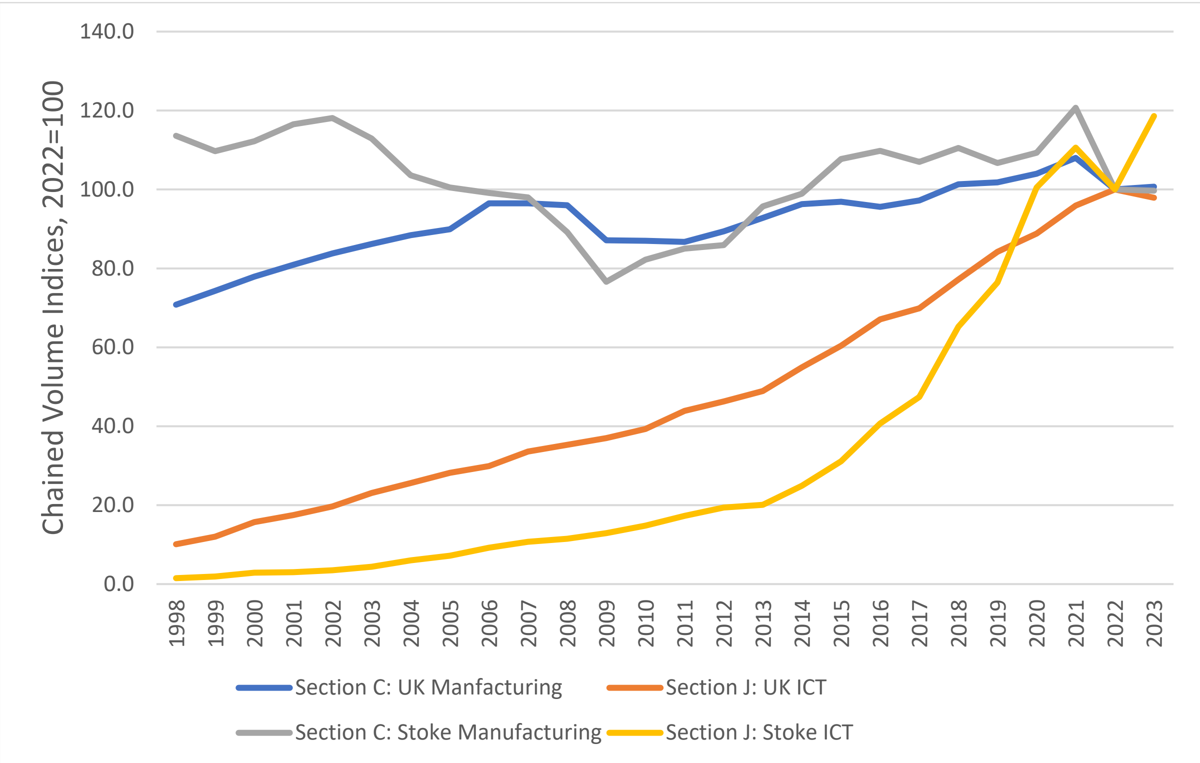
[2] "All Industries" turnover figures exclude SIC 2007 Section K (financial and insurance activities) where turnover is not available on a comparable basis.

Source: Calculated from Department for Business, Energy & Industrial Strategy (2021: Table 4).

Turning to direct UK evidence on (real) Gross Value Added (GVA), over the 28 years 1994-2021 (the entire extent of the available data) the GVA of the ICT sector increased by a factor of 11.96, which may be compared with Manufacturing (Section M) (increase by a factor of 1.52) and the whole Market Sector (increase by a factor of 1.67). The respective percentage increases across the 12 years 2010-2021 are 118 per cent, 15.40 per cent, and 16.45 per cent. (Calculated from ONS, 2022a, Table A1).

In the UK economy, the ICT sector is growing more rapidly than the rest of the economy and thus increasing its share of total GVA. This is also the case for the ICT sector in Stoke. Figure 2 shows indices based on 2022 (=100) that chart the increase in the real value (i.e., adjusted for inflation) of GVA for (i) the ICT sectors (SIC 2007 Section J) in the UK and the Stoke local authority area and, for comparison, (ii) the manufacturing sectors (SIC 2007 Section C) in the UK and the Stoke local authority area. (Note that the relative levels of each index series are not informative; instead, the series are informative about relative changes over time.) From 1998 to 2023, real UK manufacturing GVA increased by 42 per cent while real manufacturing GVA in Stoke declined by 12 per cent. In contrast, while over the whole period the national rise in ICT GVA was strong (869%), the ICT sector was particularly strongly emergent in Stoke (7807% over the period), with particularly strong growth in the most recent years available in the dataset. (See Section 7.1, Footnote 14 for comment on these very large ICT increases; the Stoke increase, in particular, reflects both a low initial index and rapid sector-wide technical progress.) Moreover, the SIC 2007 industries that comprise ICT may not include bet365, which, as we indicate above, can be classified alongside ICT companies as part of the digital sector in Stoke (see Section 7.1 on the issue of adjusting Stoke's ICT data to account for bet365). We demonstrate below (Section 7) that even without adjustment for bet365 Stoke does not lag the national development of the ICT sector.

Figure 2. GVA: Volume (real) Indices (2022=100), UK and Stoke-on-Trent (1998-2023) for SIC 2007 Section C (Manufacturing) and Section J (ICT)

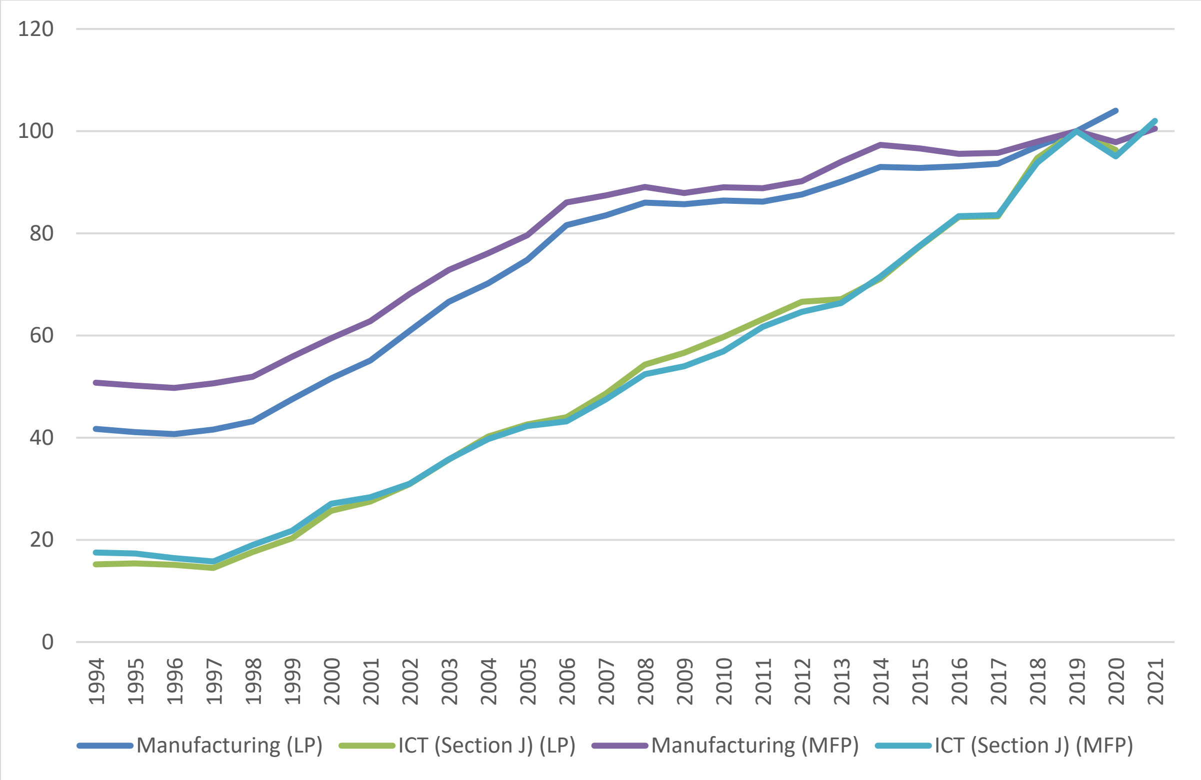


Source: ONS, 2025a: UK indices extracted from Table A1; Stoke indices from Table 3a. The latest year's data are provisional.

The ONS combines data on GVA with employment data to derive labour productivity, i.e. GVA per hour worked. Equivalently, GVA per hour worked is a measure of ability to create wealth. At the aggregate national level, this is tightly correlated with GDP per person and, hence, with the average standard of living. At the sector level, GVA per hour indicates the contribution of different types of economic activity to wealth creation. Regarding Figure 3, we first comment on the striking increase in labour productivity of the ICT sector: by a factor of more than five (534%) over the 27 years 1994-2020, compared to a factor of 1.5 (149%) for manufacturing industry, which is notable for continuously rising labour productivity since the dawn of the industrial revolution. This comparison also identifies ICT as a strongly emergent sector.

Figure 3 also depicts Multi-Factor Productivity (MFP), also known as Total Factor Productivity (TFP), for the UK as a whole. MFP measures the growth in output that is not explained by the growth in inputs of labour and capital into production. Accordingly, MFP might be a good proxy of productive efficiency – i.e., how efficiently multiple inputs are used to produce output by a firm, sector, or national economy – and changes in MFP over time in effect give a measure of technical progress. The disadvantage of MFP is that because it is not directly observable it must be estimated: variations in output are decomposed into corresponding variations in labour input and capital inputs (and possibly other inputs) to isolate a residual component of growth that can be attributed to technical progress. The Office for National Statistics have compiled and indexed real (i.e. inflation-adjusted) data on GVA (output), and labour and capital inputs, to calculate MFP for the total market sector and for each broad industry sector (ONS, 2022a). In Figure 3, we use the ONS estimates to compare MFP (1994-2021) with labour productivity (1994-2020). For ICT, the two measures move more or less in lock step, both demonstrating large productivity increases from the late 1990s. For manufacturing the overall increase is still substantial but less sustained, especially from the mid-2000s, although labour productivity increases somewhat more than MFP.

Figure 3. Labour productivity (LP – i.e., real GVA per hour worked), 1994-2020) and Multi-Factor Productivity (MFP) (1994-2021); indexed, (2019=100): Manufacturing (SIC 2007 Section C); ICT (SIC 2007 Section J)



Note: The measure of output used in these statistics is the chain volume (real) measure of Gross Value Added (GVA) at basic prices.

Source: Labour productivity – ONS, 2022b (extracted from Tables 1 and 5); Multi-factor productivity estimates – ONS, 2022a (extracted from Table 6)

Figure 4 takes us further into the long-run evolution of productivity, covering the period 1970-2021. The left-hand panel shows increase for the Total Market Sector of the UK economy in all three of (i) labour inputs (the black line), (ii) capital inputs (the blue line), and (iii) technical progress (the red line). Together, these sustained the growth in total UK GVA reported in Figure 1. Within the Total Market Sector, Manufacturing (middle panel) and ICT (left-hand panel) display contrasting dynamics. Manufacturing massively reduced its labour input, maintained its capital input at more or less the same level, and achieved sufficient technical progress to modestly increase the real value of output over the period and, thereby, limit the reduction in its contribution to overall GDP (Figure 1 and accompanying text). Greatly reduced labour input while maintaining a similar level of output together with very little increase in capital inputs, which limits "embodied" technical progress, is consistent with the greater growth of labour productivity compared with the growth of MFP noted above. In contrast, since the 1980s, the ICT sector has greatly increased its inputs of both labour and capital as well as – albeit with an initial lag (typical for emerging sectors) – maintaining rapid technical progress. On the evidence of the past 50 years or so, manufacturing remains an important source of wealth creation but is too good at labour-displacing technical progress to be at the centre of job creation strategy. In contrast, ICT as an emerging sector is not only increasing its weight as a source a source of wealth creation but is doing so while increasing employment.

This evidence on the importance of the ICT sector as a source of employment creation is supported by Mandys and Coyle (2024), who indicate as well that the capacity of the UK's digital sector to create employment has been evident in the years since the period covered by Figure 4. These researchers report the following employment levels for 2022 in the UK "computing sector" (from DCMS, 2024):

Table 5. Number of employees in UK computing subsectors, 2022

Computer hardware			
Manufacture of computers and electronics	Wholesale of computers and electronics	Repair of computers	**Total**
96,737	36,710	28,092	161,539
Computing software			
Software publishing	Computer programming	Video games	**Total**
41,039	1,076,718	51,999	1,169,756

Source: Mandys and Coyle (2024) drawing on data from DCMS (2024)

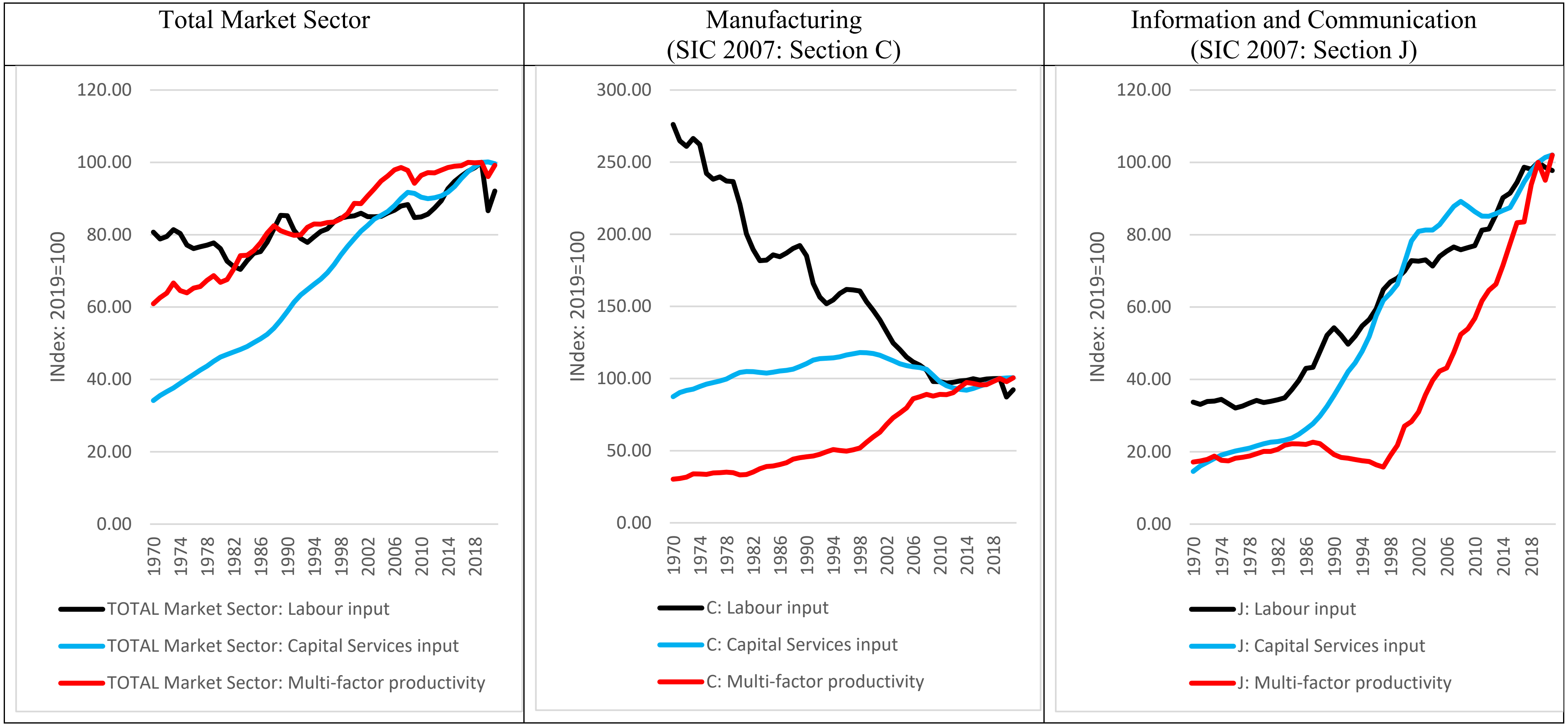
Unfortunately, the authors do not map their definition of the computing sector onto the ICT (or digital) sector of the SIC (2007) taxonomy adopted in the present study. Nonetheless, the coverage is close enough to indicate broad structural features and trends. As well as indicating the dominance of computing sector employment by software – such that hardware and software account for 12% and 88% respectively of total employment of 1,331,295 – Mandys and Coyle (2024: 24-25) also show that software accounts for most of the employment growth: while total hardware employment declined from 201,267 in 2011 to 161,539 in 2022, total software employment more than doubled from 543,232 to 1,169,756. Moreover:

> The rate (of increase) accelerated during and after the Covid-19 pandemic. This could suggest that the lockdowns and working from home arrangements during the pandemic encouraged more people to find employment in work-from-home-friendly environments, such as computer software.

However, although the ICT sector is relatively labour intensive, the type of jobs created are not of all types but are similar to those in the broader "creative sector". (On this point, see Section 11, below).

Direct evidence that ICT is a sector with above average growth coupled with indirect evidence that ICT is a relatively high productivity – i.e., high value added – sector suggests that Stoke would do well to establish itself as an attractive location for ICT and other firms in the digital sector.

Figure 4. Long-run development of labour input, capital input, and multi-factor productivity in (i) the Total Market Sector, (ii) Manufacturing, and (iii) Information and Communication; Index series, 1970-2021 (2019=100)



Source: ONS, 2022a (data extracted from Tables A2, A4, and A6).

Definitions (according to ONS, 2025b: 5 and 12): The **Compositionally Adjusted Labour Input** (CALI) accounts for both the quantity of labour (hours worked) and the quality of labour (composition adjustments for skill level, experience, and education); and **Capital Services** measure the flow of services that different types of assets provide to the production process. These different types of assets are adjusted for additional investment, depreciation and retirement before a further adjustment to take into account changes in their age-efficiency.

Part 2. The ICT sector in Stoke-on-Trent

4 Stoke-on-Trent through the lens of economic complexity

4.1 Why is economic complexity important?

Theory has identified causal pathways from knowledge and capabilities ("know-how") to economically useful innovation – new products, processes, ways of organising and marketing – and, hence, to productivity and living standards. However, empirically verifying – let alone quantifying – these relationships as a guide for policymaking presents difficulties. Whereas the desired outcomes are observable and measurable – e.g., productivity as GDP per worker and living standards as GDP per person – and by definition closely related, and innovation can be proxied by either innovation-related inputs (e.g. R&D and patents) or outputs (e.g. survey responses regarding new products and processes or sale revenues from newly-introduced products), the ultimate drivers of wealth creation and employment – knowledge and capabilities – are difficult to observe and measure. In response to this challenge, recent literature has introduced methods to capture the relative levels of accumulated knowledge and capabilities of countries, regions, and cities – hence their relative levels of economic development – by ranking their levels of "economic complexity" (Rodrigues and Breach, 2021).

Hidalgo and Hausmann (2009: Abstract) 'develop a view of economic growth and development that gives a central role to the complexity of a country's economy', which is motivated as follows.

> For Adam Smith, wealth was related to the division of labor. As people and firms specialize in different activities, economic efficiency increases, suggesting that development is associated with an increase in the number of individual activities and with the complexity that emerges from the interactions between them.

To this might be added Arthur's (2009: 3, 19, 38) theory of technology as a 'self-producing system', whereby new technologies arise from novel combinations of previously existing technologies, which – once in place – give rise to potential new combinations ... and so on, ad infinitum. According to Arthur (2009: 37):

> Modularity [with technologies as modules] ... is to a technological economy what the division of labour is to a manufacturing one.

Consider a world that begins with three technologies: A; B; and C. From these, four new technologies can be developed: A-B; A-C; B-C; and A-B-C, denoted, respectively, as D, E, F, and G. Together, these seven technologies yield 127 potential technologies made up of single technologies or combinations of any number up to all seven (calculated as $2^7 - 1$). Of course, as Arthur (2009: 173-74) notes, not all combinations will make engineering or/and economic sense. Nonetheless, if only one in a million combinations make engineering and economic sense, then 40 initial technologies still yield over one million viable technologies.[13] In turn,

[13] While issues of definition make it difficult to provide simple estimates of how the actual number of technologies has changed through time, the registration of patents gives some indication of the increasing economic complexity underpinning economic development. According to data made public by the United States Patent and Trademark Office (USPTO), in 1790 there were three Utility Patents (e) (inventions) granted,

proliferation of technologies gives rise to a proliferation of inter-related industries producing an associated proliferation of products, including product components and sub-components (e.g., the evolution of the jet engine has increased its number of parts from a few hundred to more than 22,000; Arthur, 2009: 137).[14] As we will see in the next section, complexity measures typically are derived from available data on industries.

Knowledge and capabilities give rise to new technologies, which deepen and reorder the division of labour. Yet new technologies help develop new knowledge. In the words of Arthur (2009: 65; emphasis added):

> ... it is almost impossible to exaggerate the importance of knowledge ... because phenomena used in technology now work at a scale and a range that casual observation and common sense have no access to. Where once common sense could produce new devices for textile weaving, only detailed, systematic, codified, theoretical knowledge can produce new techniques in genetic engineering or microwave transmission ... But that is only half the story ... These technologies help build yet further knowledge and understanding and help uncover yet further phenomena. *Knowledge and technology in this way cumulate together*.

To this may be added that the coevolution of knowledge and technology is likely to be reinforced as experience gained in production gives rise to "learning-by-doing" effects.

So far, we have argued that technological progress and correspondingly advancing division of labour depend on knowledge and capability and are manifested as growing complexity. The corollary is that measurement of economic complexity can be informative about the otherwise unobservable knowledge and capability foundations, and corresponding technological level, of a national, regional, or urban economy.

4.2 How is economic complexity measured?

We focus on how economic complexity has recently been measured for UK urban economies. For two reasons, the method is complicated: (i) because, as economic complexity is not directly observable, it must be derived from related observable variables; and (ii) because these variables are then reduced to a single metric, which can be used to compare and rank urban economies according to their different levels of complexity. In this section, we outline the method only insofar as this will help to interpret the results.

The methodology set out in Mealy and Coyle (2019: 6) uses employment data from the Business Register and Employment Survey (BRES) at the 3-digit Standard Industry Classification (SIC) level for 380 UK local authorities. For each local authority, location quotients (LQs) are calculated for each industry as the ratio of the industry's share of employment in an authority to the industry's share of national employment:

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43 in 1800, 24,656 in 1900 (plus 3,483 Patent Grants to Foreign Residents (a)), 157,494 (plus 78,871 to foreign residents) in 2000, and 352,066 (plus 223,727) in 2020. This increasing complexity is an evolutionary process, akin to biological evolution from single-cell organisms to complex multi-cellular life forms.

[14] According to Coyle (2021: 184) there are 'no economic statistics' on 'the increasing number of products available'. The extent of variety and customisation is simply too vast to quantify at the product level. However, Harford (2017: 7) offers, as an educated guess, the 'approximately 10 billion distinct products and services currently offered in the world's major economic centres', and comments that: 'The global economic system that delivers these products and services is vast and impossibly complex.'

$$Location\ Quotient\ (LQ_{ij}) = \frac{Industry_j share\ of\ employment\ in\ Local\ Authority_i}{Industry_j share\ of\ employment\ in\ national\ employment}$$

where subscript j indexes each particular industry (e.g., j = vehicle manufacturing, professional services ... and so on) and subscript i indexes each particular local authority. If the location quotient is greater than one, then 'the local authority's employment in that industry is greater than the national average', in which case it is assumed that 'the local authority has some degree of competitive strength in that industry'.

Next, the location quotients are used to construct a matrix (M) in which rows represent local authorities and columns represent industries, and each cell content is either 1 if the local authority has a location quotient greater than one (LQ > 1) in the industry – hence, competitive strength – or zero otherwise (signifying competitive weakness in the industry). For two local authorities, 1 and 2, and three industries, 1, 2 and 3, the matrix M might be:

Table 6. Matrix "M" (illustrative)

	Industry 1	Industry 2	Industry 3	**Local Authority Diversity measure**
Local Authority 1	1	1	1	3
Local Authority 2	0	1	0	1
Industry Ubiquity measure	1	2	1	

Source: Authors

This Matrix M informs us that Local Authority 1 has competitive strength in all three Industries, whereas Local Authority 2 has competitive strength only in Industry 2. Matrix M is useful, because it gives direct measures of two concepts from which can be derived an indirect measure of economic complexity (Mealy and Coyle, 2019: 7).

- *Diversity*, which is measured by summing across the rows to give the number of industries in which the local authority has competitive strength.
    - In our illustrative matrix M, Local Authority 1 has a diversity measure of three, which ranks it above Local Authority 2 with a diversity measure of one.
- *Ubiquity*, which is measured by summing down each column to give the number of local authorities in which the industry is located.
    - In our illustrative matrix M, Industry 1 has a ubiquity measure of one (i.e., it is located in Local Authority 1 only); Industry 2 has a ubiquity measure of two (i.e., it is located in both Local Authorities); and Industry 3 has a ubiquity measure of one (i.e., it is located in Local Authority 1 only).

Our illustrative matrix preserves a general feature of such matrices (Hidalgo and Hausmann, 2009: 6): i.e., the average ubiquity of industries located in a particular authority tends to decrease with the level of diversification within the authority. In our case, Local Authority 1's diversity measure is three, while the average ubiquity of Local Authority 1's three industries is 1⅓rd (= [1+2+1]/3); conversely, Local Authority 2's diversity measure is one, while the average ubiquity of Local Authority 2's single industry is two (= 2/1). According to Hidalgo and Hausmann (2009: 6), this relationship reflects *a general relationship between underlying knowledge and capabilities on the one hand and both diversification and ubiquity on the other*. (Hidalgo and Hausmann, 2009: 3, 6, and 7 also provide empirical support for this theoretically derived result.) In our case, local authorities with high levels of knowledge and many capabilities will both be *more diversified* (because they can attract and sustain more industries with competitive strength) and their industries will be *less ubiquitous* (because industries requiring high levels of scarce knowledge and capabilities self-select into local authorities endowed with high levels of knowledge and capabilities, whereas industries with lower knowledge and capability requirements have lower locational constraints and will thus be more ubiquitous across local authorities endowed with commonly available knowledge and capabilities).

Within this framework, local economies are defined by two (negatively) correlated and observable variables, diversity and ubiquity. A local economy is more complex than others if it has both (i) a more diversified range of activities and (ii) these activities are restricted to locations with high knowledge levels and are thus less ubiquitous (Rodrigues and Breach, 2021: Box B). The corresponding *Economic Complexity Index* (ECI) reduces the diversity measure and the inverse of the ubiquity measure to a single measure of complexity (Mealy et al., 2019: 5).[15] The index numbers are purely ordinal, so the ECI can be used to rank local authorities according to the complexity of their resident industries (see: the Harvard Growth Lab: [The Atlas of Economic Complexity (harvard.edu)]). Note that the ECI is *not* a measure of diversity (Mealy et al., 2019; and Mealy and Coyle, 2019). Instead, 'the ECI reflects the type of industries concentrated in places, not the number of different industries' (Mealy and Coyle, 2019: 16). Local authorities 'that are home to a great diversity of productive know-how, particularly complex specialized know-how, are able to produce a great diversity of sophisticated products'.

The practical value of the ECI is two-fold: on the one hand, knowledge and capabilities are plausibly related to both observable components of the ECI, diversity and ubiquity; while, on the other hand, the ECI is strongly related to productivity and living standards. First, we find that for the nine large regional cities highlighted by Rodriguez and Breach (2021: Appendix 1) the ECI index (see Appendix B) is highly correlated with productivity (Gross Value Added per hour worked – see Appendix C). Table 7 gives the respective rankings and adds Stoke-on-Trent for comparison.

[15] The calculation of this index proceeds via the application of matrix algebra, which is set out in Hidalgo and Hausmann (2009) and developed by (amongst others) Mealy et al. (2019) and Mealy and Coyle (2019).

Table 7. ECI is strongly related to productivity

	ECI		**Productivity** (current price GVA per hour worked, £s: 2021)
Glasgow	1.8	Leeds	35.0
Bristol	1.3	Glasgow	34.6
Leeds	1.1	Birmingham	34.2
Liverpool	0.5	Bristol	34.0
Manchester	0.5	Liverpool	33.9
Nottingham	0.0	Manchester [1]	33.5
Newcastle	-0.5	Sheffield	33.0
Sheffield	-0.9	Newcastle [2]	32.7
Birmingham	-1.0	Nottingham	31.5
Stoke	-1.7	Stoke	30.2

[1] Mean value for two parts of Greater Manchester (North East and South West) listed separately.

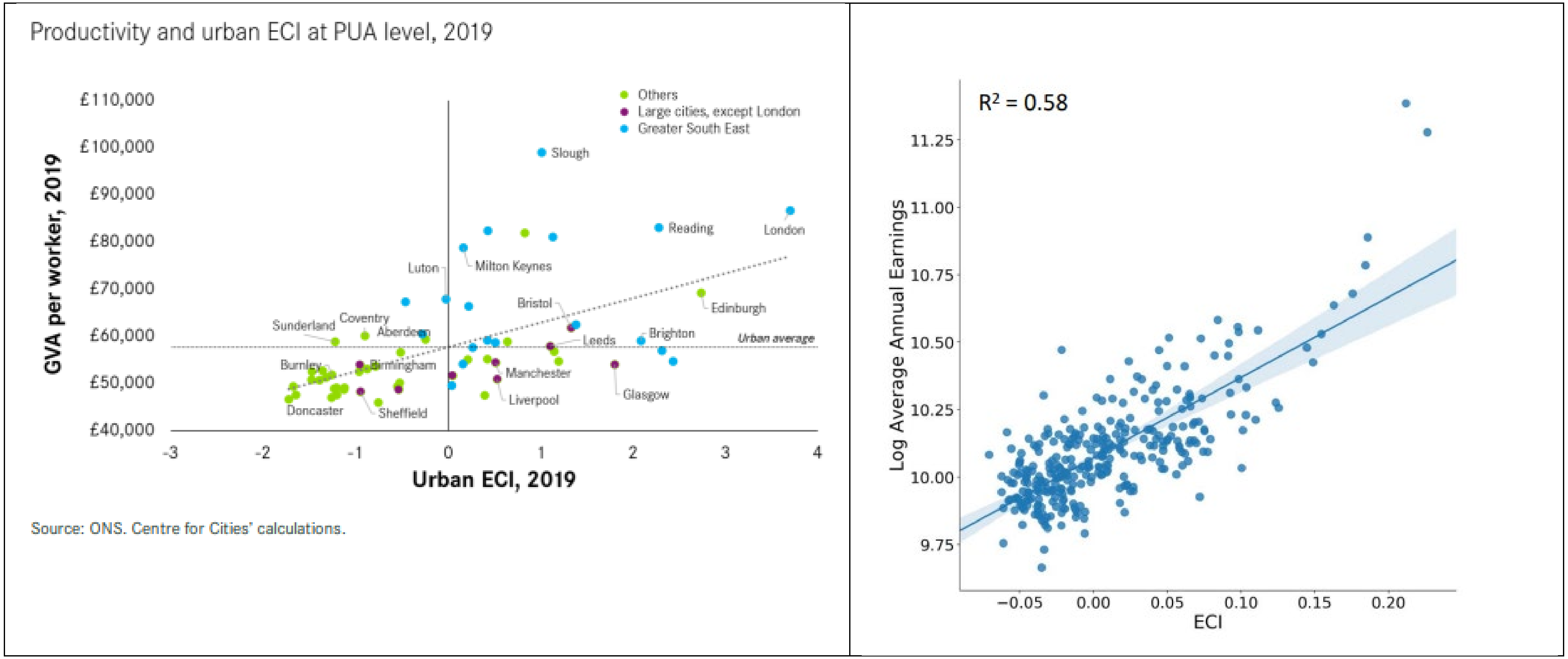
[2] Tyneside

Source: See Appendices A and B and their sources

The Table 7 rankings are indicative only. The areas measured are not precisely the same (see the table notes) and refer to different years. Yet, with or without Stoke, the correlation coefficient is 0.95.

The same relationship is clear in a broader evidence base: Figure 5, Panel A (from Rodriguez and Breach, 2021: Figure 2) depicts the relationship in 2019 between ECIs calculated for the UK's 63 largest towns and cities (Primary Urban Areas) and productivity (Gross Value Added per worker). The link with living standards is clear in Panel B (from Mealy and Coyle, 2019: 16), which depicts the relationship between UK local authorities' ECIs and average per capita earnings.

Figure 5. Panel A: The relationship of UK PUAs' ECIs with labour productivity (2019)
Panel B: The relationship of UK Local Authorities' ECIs with average earnings (2011)



Source. Panel A from Rodriguez and Breach, 2021: Panel B from Mealy and Coyle, 2019: 16

Mealy and Coyle (2019: 16-17) also provide robust econometric evidence that:

> ... local authorities that have higher ECI (and are thus more specialised in knowledge-based industries) are significantly more likely to experience higher future earnings growth.

This is consistent with the Hidalgo and Hausmann (2009: 3, 9) finding that complexity

> exhibits strong path dependency ... because the ability of a country to produce a new product is limited to combinations of the capabilities it initially possesses plus any new capabilities it will accumulate.

We conclude that the ECI 'provides a useful measure of economic development' (The Atlas of Economic Complexity (harvard.edu)). The concept and empirical measures of complexity reflect knowledge and capabilities and are closely related to productivity, living standards and earnings growth. However, economic complexity might also have downside potential: while there is evidence from cross-country comparisons that economic complexity might lower output volatility by diversifying exports and increasing the sophistication of exports (Güneri and Yalta, 2021) this conclusion remains contested (Chu et al., 2023). Moreover, the impact of economic complexity on the volatility of output and employment has yet to be determined at regional or local level.

Next, we take a view of Stoke-on-Trent through the lens of complexity and productivity.

4.3 Stoke-on-Trent through the lens of complexity: the aggregate perspective

Previous studies have concluded that locational economic complexity and productivity are highly 'history dependent' (path dependent) (Hidalgo and Hausmann 2009; see also HM Government 2022: 49). Rodrigues and Breach (2021: Part 3) confirm this conclusion in their study of British cities: 'The majority of cities that were the most complex in 1981 are also the most complex today.' Rodrigues and Breach (2021: Box 2) calculate Economic Complexity Index values for 61 Primary Urban Areas (PUAs) – including Britain's largest towns and cities – using employment data from "exporting activities" only:

> In terms of economic sectors, economic complexity is only based on exporting activities. Because they are not tied to a local market, these exporters could, in theory, locate anywhere but in reality cluster in certain places, and so it is these activities that are of particular interest ... Such exporting economic activities choose their location based on the respective competitive advantages. Given their different needs, high value-added exporting activities and low-cost production activities are likely to be in different locations.

In line with the argument in the previous section, Stoke-on-Trent's economic performance relative to other cities and towns is similarly reflected in both its economic complexity ranking and in its productivity ranking.

- Ranked by economic complexity, in 2019 Stoke occupied 60th place among the 61 largest British towns and cities (PUAs) (54th in 1981). (The complexity rankings calculated by Rodrigues and Breach, 2021, are reproduced in Appendix B.)

- As measured by productivity – Gross Value Added per hour worked in current prices – in 2021 Stoke ranked 160th among the UK's 179 International Territorial Level 3 units (163rd in 2004).[16] (See Appendix C for the productivity data and corresponding rankings.)

These are independent measures both suggesting that Stoke-on-Trent is relatively deficient in knowledge-based, high value-added employment. However, by shifting our focus from aggregate measures of economic complexity and productivity to the range of industries located in Stoke, a more differentiated – and optimistic – picture emerges.

5 Evidence that Stoke-on-Trent is developing complexity: the ICT sector

Although locational economic complexity and productivity are highly "history dependent", Rodriguez and Breach (2021: Box 4) find that 'some of Britain's largest cities were able to become relatively more complex by specialising in new knowledge activities' without strong antecedents, which leads them to the conclusion that:

> At the city level ... having a previous specialism may not be a necessary condition to develop one today.

The good news is that this seems to be particularly true for the digital sector. This suggests the need for an initial investigation of Stoke's potential in the digital economy. We cannot conduct this discussion using the ECI, because this is a relative measure. Instead, we use the location quotient (LQ), which is the basic building block of the ECI and thus ensures consistency in our analysis.

The Office for National Statistics Labour Market Profile for Stoke-on-Trent records jobs at the location of an employee's workplace both for Stoke as a whole and according to major SIC categories. The data in Table 8 below for 2022 (the latest available at the time of writing) gives the percentage of employment for each industry in Stoke together with the industry's share of national employment, from which we calculate the LQ for each industry (as explained above).[17]

Focussing on those sectors most likely to have the greatest potential for constituting a city's export base, Table 8 suggests – as might be expected from Stoke's industrial heritage – competitive strength in manufacturing (LQ=1.53), while its geographical position in the UK probably explains its strength in transport and storage (LQ=1.94). Conversely, LQ scores below one suggest competitive weaknesses in knowledge-based sectors: Financial and Insurance Activities; Professional, Scientific and Technical Activities; and Administrative and Support Service Activities. Stoke's LQ in Information and Communication, which is the basis of our working definition of the digital/ICT sector (see Section 2 above), is higher than these other knowledge-based sectors but still does not suggest an area of competitive strength (LQ=0.91). However, as will be explored further below and in the next Section, this indicator of competitive strength for Stoke's Information and Communication sector may be seriously biased in a downward direction.

[16] For comparison, by productivity, Birmingham ranked 127 from 179 in 2004 and 97 in 2019 (see Appendix C).
[17] The occupational categories in Table 7 map onto the industry categories of SIC 2007. See Appendix D.

This is for four reasons.

1. The data excludes self-employed jobs, which are likely to be important in the digital sector (Schwab, 2017: 48-49, 63 and 71).
2. The relatively large size of the health sector in Stoke-on-Trent (Table 8) reduces the share of other sectors. If health were to be 13.7 per cent of total employment, in line with the GB average, then removing the excess employment in Health would raise the ICT share to 4.44 per cent, so almost the same as the GB share.
3. bet365, headquartered in Stoke and the city's largest private-sector employer since 2011, is misleadingly classified under "Arts, Entertainment and Recreation", because this industry category includes "Gambling and betting activities" (SIC Division 92). This classification is dated (the SIC codes were last revised in 2007). bet365 gains its nearly £3 billion in annual revenue overwhelmingly from 'Internet and Mobile sports betting along with online Casino, Games, Bingo and Poker', and invests hugely in 'IT infrastructure and technology' (bet365 Group Limited, 2022: 7-8). With around 1,000 of its c.3,300 Stoke-based employees (bet365 Careers | Our History) in its Technology Group, bet365 can be included among Stoke's Information and Communication sector. Accordingly, we recalculate the LQ for Stoke's Information and Communication sector by reallocating 1,000 jobs from Arts, Entertainment and Recreation. In this case, the LQ for Stoke's Information and Communication sector rises to 1.10 (and the LQ for Arts, Entertainment and Recreation falls to 1.26). (Of course, reallocating a greater proportion of bet365 employment would yield a higher LQ for Stoke's ICT sector. However, this adjustment for bet365 may be contested, which we discuss at length below; see Section 7.1 below.)
4. ONS data is subject to updates and sometimes major revision. At the time of final editing (May 2025), the number of ICT employees in Stoke-on-Trent had been revised from the 5,000 reported in Table 8 to 6,000 in 2023 (ONS 2024b). This raises the percentage of ICT employment in Stokes total employment from 4.1 to 4.8 per cent. Comparison with the latest percentage of ICT employment in Great Britain's total employment (4.4%) gives a LQ of 1.09.

If we settle on a LQ of 1.1 as a plausible lower limit, then we have evidence for the emergence in Stoke of an ICT sector with competitive potential. The emergent digital sector in Stoke-on-Trent is not obviously related to either its past or other knowledge-based sectors (see Footnotes 1 and 2 above). However, the evidence in this Section indicates the presence of new knowledge activities and thus the potential to develop a more complex local economy.

Table 8. Location quotients by industry, calculated from ONS, *Labour Market Profile* 2022 data for Stoke-On-Trent

	Stoke-On-Trent	**Stoke-On-Trent (%)**	**Great Britain (%)**	**Stoke LQ by industry**
Total Employee Jobs	121000	-	-	
Employee Jobs by Industry				
B : Mining And Quarrying	10	0	0.1	0.00
C : Manufacturing	14000	11.6	7.6	1.53
D : Electricity, Gas, Steam And Air Conditioning Supply	300	0.2	0.4	0.50
E : Water Supply; Sewerage, Waste Management And Remediation Activities	1250	1	0.7	1.43
F : Construction	4500	3.7	4.9	0.76
G : Wholesale And Retail Trade; Repair Of Motor Vehicles And Motorcycles	18000	14.9	14.4	1.03
H : Transportation And Storage	12000	9.9	5.1	1.94
I : Accommodation And Food Service Activities	5000	4.1	7.5	0.55
J : Information And Communication	5000	4.1	4.5	0.91
K : Financial And Insurance Activities	1250	1	3.6	0.28
L : Real Estate Activities	1000	0.8	1.8	0.44
M : Professional, Scientific And Technical Activities	4000	3.3	8.9	0.37
N : Administrative And Support Service Activities	8000	6.6	8.9	0.74
O : Public Administration And Defence; Compulsory Social Security	6000	5	4.6	1.09
P : Education	9000	7.4	8.8	0.84
Q : Human Health And Social Work Activities	25000	20.7	13.7	1.51
R : Arts, Entertainment And Recreation	4500	3.7	2.3	1.61
S : Other Service Activities	1750	1.4	1.9	0.74

Source: Nomis - Official Census and Labour Market Statistics (nomisweb.co.uk). The information comes from the Business Register and Employment Survey (BRES), which is an employer survey conducted in September of each year. The BRES records a job at the location of an employee's workplace (rather than at the location of the business's main office).

Revision for 2023, according to ONS, 2024b.

J : Information And Communication	**6000**	**4.8**	**4.4**	**1.09**

Own calculations.

6 A broad base of ICT businesses in Stoke and across North Staffordshire

In this Section, we advance evidence that the structure of Stoke's digital sector comprises one (very) large firm (bet365) together with a large number of mainly micro-, small-, and medium-size firms.

ONS data from the Inter Departmental Business Register (27th September 2023) – originating from HMRC and Companies House – records the number of businesses registered for VAT and or/PAYE records. From this, we extract the following numbers of ICT – i.e., SIC (2007) Division J, 58-63 – enterprises and local business units located respectively in Stoke-on-

Trent, Newcastle-under-Lyme, and Staffordshire Moorlands. Table 9 sets out this data and adds the total for North Staffordshire together with a note to explain the distinction between business enterprises and units.

Table 9. Number of VAT and/or PAYE based ICT business enterprises and units located in North Staffordshire (2023)

	Stoke-on-Trent	Newcastle-under-Lyme	Staffordshire Moorlands	Total for North Staffordshire
Enterprises	235	190	120	545
Local Units	265	195	125	585

Note. According to the notes attached to the source tables by the ONS: 'A group of legal units under common ownership is called an Enterprise Group. An enterprise is an organisational unit producing goods or services that has a certain degree of autonomy in decision making. An individual site (for example a factory or shop) in an enterprise is called a local unit.'

Source: ONS, 2023c (UK Business, activity, size and location, 2023), Tables 1 and 16.

Because these numbers reflect only businesses registered for VAT or PAYE, some small freelancer businesses will not be accounted for. Nonetheless, this data reveals a substantial digital sector with around 550 businesses located not only in Stoke but also more widely across North Staffordshire. In Section 7 below, we show in addition that this digital sector is undergoing vigorous growth,

To what extent bet365 might be functioning as an "anchor" firm – i.e., a large company that stimulates economic growth and attracts other businesses and investments to the area (or possibly deters other businesses via impact on local factor markets) – is to be investigated. However, it is clear that "digital Stoke" is not a one-firm phenomenon but is broadly based on a wide range of firms in a range of sub-industries. The next section builds upon this insight by taking a more detailed look at the digital sector in Stoke.

7 The size and productivity of "digital Stoke" in national comparison

In this Section, we consider (i) the size and (ii) the productivity of Stoke's ICT sector relative to other locations in the UK.

7.1 The size of Stoke's ICT sector in national comparison

In keeping with many other local authorities, Stoke-on-Trent City Council has recently placed the digital sector at the centre of its economic development strategy. In addition to the findings in the previous Section, anecdotally there does appear to be a strong base to build on. The emergence of a cluster of creative media businesses on the former Spode Pottery site, the success of privately owned, cyber security business Synectics Solutions, and the continuing growth of the e-gaming capabilities at Staffordshire University all suggest that, unlike some areas chasing the digital opportunity, "Digital Stoke" has real potential.

The available data, notwithstanding widely-known limitations at the local area level, is entirely consistent with the anecdotal picture: digital is already a major component of the local economy.

- In 2022, according to our calculations on ONS GVA data (ONS, 2024a: Table 3c), the digital sector (SIC 2007 Section J) accounted for 11.3% of GVA in Stoke-on-Trent, up from its share in 1998 (8.2%) and significantly higher than both its 2.3% contribution to output across the rest of Staffordshire and its 6.5 nominal percentage share of UK GVA (ONS, 2024a: Table 1c).
- The ONS data allows a partial disaggregation of this growing share of local GVA over the 10 years 2013-22 (calculated from ONS, 2024a: Table 3c). Within SIC 2007 Section J, the contribution of the 2-Digit level industries 58-60 (Publishing activities; Motion picture, video and TV programme production; and Programming and broadcasting activities) has declined slightly (from 0.26% to 0.19%), while the contribution of the 2-Digit level industries 61-63 (Telecommunications; Computer programming and consultancy; and Information service activities) has increased substantially (from 7.83% to 11.13%).
- And digital in Stoke-on-Trent is fast-growing: the relatively high share of local economic output reflects a near 50 percent increase in real (i.e. inflation adjusted) GVA terms over the 10 years 2013-22 (calculated from ONS, 2024a: Tables 1d and 3b).[18]

As a result of this rapid growth, in 2022, in current price GVA terms, Stoke-on-Trent had the 40th largest digital sector in the country among the UK's 179 ITL3 regions (calculated from ONS, 2024a: Table 3c), despite being the 118th largest local economy.[19,20] By contrast, Staffordshire County was the 18th local economy in size terms, but only 51st when ranked on the size of its digital sector (calculated from ONS, 2024a: Table 3c).

Striking as these figures are, they don't tell us the full story. As a large, profitable company and a major employer, bet365 exerts an influence on the local labour market and the wider economy. However, although bet365 is a digitally intensive producer, the ONS classifies Bet365 as belonging to the Gambling and Betting sector. (There are other significant employers such as Foodhub and LA Recruitment which may also raise issues of classification

[18] User of ONS, 2024a, should be aware of the values given in Table 3b: ITL3 chained volume measures in 2019 money value, pounds million. The constant price (i.e., in 2019 values) GVA for Stoke-on-Trent Section J (ICT) for 2013 is given as £169 million and for 2022 as £898 million, suggesting an increase over the 10 years by a factor of 5.31. We are sceptical regarding the size of this increase. Hence, we took the current price estimates in Table 3c and deflated these by the UK deflator for ICT from Table 1d, which gives a GVA growth estimate of 47.3%. However, we recognise that our procedure can be contested. We thank Trevor Fenton (Head of Regional Accounts at the Office for National Statistics) for the following counterargument. Our conservative estimate overlooks the fact that the industry deflator for SIC division 61 (telecoms) reflects rapid advances in technology. Hence: "Any place with a large presence in this industry will show heightened volume growth as a result of this. The presentation of volume figures in money terms can be misunderstood, as in such a case it merely reflects that you now get a lot more technology for your money than you used to get just a few years ago. A similar, but lesser effect can be seen in other high-tech industries with rapid product development and enhancement."

[19] International Territorial Level, a recognised classification to allow comparison of places of similar sizes.

[20] While we use real (inflation adjusted) GVA for comparisons over time, we prefer to use the most recent current price GVA for snapshot (cross-sectional) comparisons.

but not on the scale of Bet365.) Using GVA data (ONS, 2024a) from the ONS since 1998, it is clear there was a more or less continuous and substantial rise in the GVA in the gambling sub-sector from the first half of the first decade of this century, which was coincident with the founding of bet365 in 2000 and its subsequent rapid growth: this sector in Stoke-on-Trent accounted for around £100 million of GVA (2019 prices) in 2002 and £239 million by 2022 (down from £393 million in 2021). It is very difficult to explain this growth during a period when the sector was moving online, and high street betting shop numbers were in decline.

Consistent with this extraordinary growth, the latest current price (nominal) GVA data identifies Stoke-on-Trent in 2022 (the most recent data available) as having the 26th largest Arts, Entertainment and Recreation (AER: SIC 2007 Section R (90-93) sector among the UK's 179 ITL3 areas (calculated from ONS, 2024a: Table 3c). The value of the AER sector in Stoke-on-Trent is similar to the value of that of the Staffordshire County Council region (ranked 28th), despite the county's local economy being more than three times that of Stoke-on-Trent. The explanation is not hard to find: in 2022, in terms of current price GVA, "Gambling and betting" accounted for 91.2 per cent of the AER sector in Stoke-on-Trent (calculated from ONS, 2024a: Table 3c), reflecting the presence of the HQ and core operations of bet365, one of the world's leading online betting companies.[21]

As discussed in Section 2 above, bet365 is a digital company. We can use ONS data on employee numbers as a proxy for bet365's GVA share in Stoke's AER Sector (ONS, 2023e: 2022 data from Nomis on 5 June 2024): with an estimated 3,300 employees in Stoke, bet365 accounts for around 75 percent of Stoke's 4,500 AER jobs. Adding 75 percent of Stoke's 2022 AER current price GVA of £268 million (= £201 million) to Stoke's 2022 ICT current price GVA (£775 million) yields a digital sector current price GVA of £976 million, which raises Stoke's ranking among the UK's 179 ITL3 regions from 40th to 32nd place (calculated from ONS, 2024a: Table 3c).[22,23]

To check this adjustment, we use two alternative approaches.

Approach 1: We assume that (i) AER labour productivity (GVA per employee), excluding Gambling & Betting, is the same in Stoke as throughout the West Midlands region, and that (ii) "Gambling and Betting" employment in Stoke is wholly accounted for by bet365. In this case, the percentage share of "Non-bet365 AER employment in Stoke" in "Total West Midlands AER employment net of Gambling & Betting" gives "Stoke's share of West Midlands AER GVA net of Gambling & Betting". Stoke's share of non-gambling AER employment in the West Midlands is 2.86% (see Box 1, Step 2); so Stoke's share of non-

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[21] Over the 25 years 1998-2022 the share of gambling in Stoke's AER Sector rose from 54.2% to be as high as 99.0% in 2020 (reflecting the advantage of a digital firm over live performance activities during the Covid pandemic).

[22] The same story emerges if we make the adjustment to the corresponding real (constant price) data (calculated from ONS, 2024a: Table 3b). Adding 75 per cent of Stoke's 2022 real (constant 2019 price) AER GVA of £239 million (= £179 million) to Stoke's 2022 real (constant 2019 price) ICT GVA of £898 million, the resulting adjusted digital GVA of £1,077 million raises Stoke-on-Trent in 2022 from the 36th to the 31st largest digital ITL3 area in the UK (calculated from ONS, 2024a: Table 3b).

[23] One feature of the data may impart a conservative bias regarding Stoke's ranking. The current price data for Stoke's AER GVA are volatile (for example, in 2021 Stoke's current price AER GVA was £393 million compared to £268 million in 2022). Using the 2021 figure would yield a larger adjustment and thus a higher ranking for Stoke's digital sector.

gambling AER GVA in the West Midlands is likewise 2.86%, which gives a non-gambling (i.e., non-bet365) GVA of £18.5 million (see Box 1, Step 3). Next, we subtract this non-gambling GVA of £18.5 million from Stoke's AER GVA (£294 million) to give an estimate of the gambling or the bet365 contribution, which is £275.5 million (see Box 1, Step 4). Finally, we add bet365's contribution to Stoke's ICT GVA (£775 million) to obtain an adjusted digital sector GVA of £1,050.5m (see Box 1, Step 5). This too raises Stoke's ranking among the UK's 179 ITL3 regions from 40th to 32nd place (calculated from ONS, 2024a: Table 3c). The steps of this adjustment and corresponding calculations are set out in Box 4.

Box 4: Alternative approach to adjusting Stoke's ICT GVA to account for bet365 (2022, in current prices)

			Source / Calculation
Step 1	Stoke AER employment	4,500	ONS, 2023d
	Estimated bet365 (≡ Gambling & Betting)) employment in Stoke	3,300	bet365 Careers | Our History (accessed 22-08-2024)
	• Non-bet365 AER employment in Stoke	1,200	= 4,500 – 3,300
Step 2	Total West Midlands AER employment	51,000	ONS, 2023d
	Total West Midlands Gambling & Betting employment	9,000	ONS, 2023d
	• Total West Midlands AER employment net of Gambling & Betting	42,000	= 51,000 – 9,000
	• Stoke percentage of West Midlands AER employment net of Gambling & Betting	2.86%	= (1,200/42,000) × 100
Step 3	Total West Midlands AER GVA (current price)	£807m	ONS, 2024a: Table 2c
	Total West Midlands Gambling and Betting GVA (current price)	£159	ONS, 2024a: Table 2c
	• Total West Midlands AER GVA net of Gambling & Betting	£648m	= £807m - £159m
	• Stoke's share of West Midlands AER GVA net of Gambling & Betting (2.86%)	£18.5m	= 0.0286 × £648m
Step 4	Stoke AER GVA	£294m	ONS, 2024a: Table 3c
	Of which, Stoke's AER GVA attributable to Gambling & Betting	£275.5m	= £294m - £18.5m
Step 5	Stoke: ICT GVA	£775m	ONS, 2024a: Table 3c
	• **Stoke: ICT GVA adjusted for Gambling & Betting**	**£1,050.5m**	= £775m + £275.5m

Source: own calculations

Approach 2. Here, we use "bottom up" data from the bet365 *March 2023 Group Limited Report and Financial Statements* (bet365, 2023: 36-38). According to Shah et al. (2024), the method of calculating value added from company accounts data is set out in Equation 1.

$$Value\ added = Operating\ profits + Total\ employee\ remuneration \qquad (1)$$

where

$$Total\ employee\ remuneration = Average\ Yearly\ Remuneration\ per\ employee\ (including\ directors) \times The\ number\ of\ employees\ \text{(including directors)}$$

Equation 1 does not provide a measure equivalent to the ONS preferred *Gross* Value Added. GVA is calculated *before* deductions for items such as depreciation (reductions in the value of tangible assets by wear and tear, and/or obsolescence), amortisation (reductions in the value of intangible assets such as software and intellectual property due to expiration and/or obsolescence), holding gains (asset appreciation), and taxes (less subsidies) on production (e.g. National Non-Domestic Rates) (ONS, 2019: 2, 8, 10 and 32). However, for our "bottom up" firm-level approach, we use a *Net* Value Added concept, whereby value added is the sum of the incomes generated by production: (i) Operating Profit, which is calculated *after* (net of) depreciation, amortisation and other deductions; and (ii) total employee remuneration (where employees include directors).[24] These are the incomes directly derived from production of goods and/or services and are reported in (full) company financial statements.[25]

"Bottom up" adjustment via value added is indicative rather than precise. However, because it adds a net magnitude (value added) to a gross magnitude (GVA) the bias is in a conservative direction. Accordingly, "bottom up" adjustment by way of value added (Equation 1) makes some but not a dramatic difference to Stoke's ranking among the UK's 179 ITL3 regions. For the Year ending March 2023, from a turnover of £3,391 million generated by the bet365's Group's Sport and Gaming segment, value added was £761,417,000.[26] Unfortunately, the data do not enable a precise calculation of the value added by bet365's operations in Stoke. A "back of the envelope calculation" is to take bet365's employment located in Stoke (3,300) as a share of the total Group employment (7,177) generating this value added and apply this share to the valued added, giving £350,101,170 (= [3,300/7,177] × £761,417,000). Adding £350 million to Stoke's ICT GVA of £775 million gives a combined digital sector GVA of £1,125 million (rounded), which would raise Stoke's ranking to 31st among the UK's 179 ITL3 regions (ONS, 2024: Table 3c).

The available data do not enable precise calculations. Yet, adjustment for bet365, however accomplished, raises the already high ranking of Stoke-on-Trent's digital sector among UK local authorities.

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[24] It is not the role of this report to make a case for either Gross or Net. However, there are arguments against a complete reliance on GVA. In particular, because GVA is measured before depreciation and amortisation, it does not reflect the wear and tear on capital assets and thus can overstate the actual economic value generated.
[25] Depreciation (etc.) is not an income from but a cost of production.
[26] The sum of an operating loss of minus £24.5 million and total labour costs of £785,890,000 (including directors' remuneration).

A caveat

Before leaving our analysis of the size of the Stoke's ICT sector, we acknowledge that our adjustment of ONS employment and GVA data to account for bet365 may be contested. According to colleagues at the Office for National Statistics, some reallocation of employment at bet365 to ICT in Stoke may already be reflected in the data reported in Table 8. This observation arises from information held on the Inter Departmental Business Register (IDBR), which differs from the information held by Companies House as it has been refined and informed by survey data collection. The corollary is that adjusting Stoke's ICT employment and GVA to take account of the whole or part of bet365 local employment and GVA may cause double counting, hence exaggerating the size of the local ICT sector. Unfortunately, we have had to make our calculations from data publicly available from the ONS and Companies House, whereas the ONS is prohibited from sharing the survey data used to inform the IDBR. The most the ONS is permitted to share with us is that the extent of double counting may be "significant". Beyond this advice, more refined quantification is not possible. Given that the extent of double counting may be "significant" rather than complete, we believe a conservative conclusion to be that the Location Quotient is 1.1, which we calculated based on both (i) partial reallocation from bet365 employment to Stoke's ICT employment and (ii) the revised 2003 employment data (see Section 5 above). (The 2023 GVA data is not yet available at the time of final editing, so we cannot add an analogous conclusion for GVA.) Readers interested in the full debate on this issue should consult Appendix E, which reproduces the ONS critique in full together with our rejoinder.

Finally, the most important point is that notwithstanding our disagreement on adjustment, there is no disagreement on the importance of Stoke's ICT sector documented in this Report. According to the head of Regional Accounts at the ONS:

> I think that the essential point of the study, that there is a significant ICT presence that could represent an important growth industry for the area, perhaps warranting further investment and development, is valid ... The issues that I have with the methodology used do not detract significantly from that basic conclusion ...

In the light of disagreement over the validity of our adjustment procedure, we conclude that the unadjusted position (40^{th}) represents the lowest reasonable ranking, while the highest adjusted position (31^{st}) should be regarded as the highest reasonable ranking. We observe further that both the lowest and the highest reasonable rankings place Stoke in the first quartile of the UK's ILT3 regions. Adjustment is thus not decisive for our substantive point about the largely unrecognised size of Stoke's ICT sector.

A wider issue is that the data disclosure rules that bind the ONS may preclude an accurate assessment of the composition of local economies. An accurate measure of the size of the digital and other sectors in local economies is an essential first step to understanding the drivers of the local growth and the policies likely to continue to support future expansion and profitability. Clearly, local and regional authorities with responsibility for economic strategy and corresponding investments will need to lobby for timely, accurate and accessible data. We will return to this issue in Report 3 on the policy implications of our findings.

7.2 The productivity performance of Stoke's ICT sector in national comparison

In this Section, we show that when judged against national standards it is not only the size of Stoke's ICT sector that is impressive but also its productivity performance.

We analyse two types of available data to assess the productivity of Stoke's digital sector against national benchmarks. Both approaches are limited, albeit in different ways. First, the ONS data from which we estimate the ONS preferred measure of labour productivity – namely, Gross Value Added per Employee – enables us to estimate aggregate averages for Stoke-on-Trent and the UK but not dispersion. Next, we use a measure of labour productivity calculated "bottom up" from companies' accounting data – namely, Value Added per Employee – which allows us to estimate both average and dispersion for both the digital sector in Stoke and the UK benchmark but based on frustratingly small and biased samples. Nonetheless, implementing these two approaches does enable us to "sense check" some noteworthy findings regarding the productivity of Stoke's digital sector.

7.2.1 ONS data: Gross Value Added per Employee

To calculate average labour productivity, we match the available data on employment (ONS, 2023e) to sector GVA data at the local authority level (ONS, 2024a: Table 3c). We find that in 2019 Stoke-on-Trent's ICT GVA of £142,000 per job was considerably above the 2019 local authority average for Great Britain (£102,000 per ICT job) and the 8th highest among the 168 local authorities in Great Britain (i.e., UK excluding Northern Ireland). By 2022, Stoke-on-Trent's ICT GVA had risen to £155,000 per ICT job and its rank to 7th. Table 10 sets out the data for Stoke and three comparators, i.e., the two major neighbouring cities, respectively to the South and North of Stoke-on-Trent, and the surrounding County Council area: namely, Birmingham; Manchester; and Staffordshire County.

Table 10. GVA per employee and ITL3 ranking (out of 168 in Great Britain) (Stoke-on-Trent and selected comparators) (current prices)

	Stoke-on-Trent	**Birmingham**	**Manchester**	**Staffordshire**
2019 ICT GVA (£s million)	641	1,609	1,837	393
2019 ICT Employment	4,500	14,000	19,000	7,000
2019 GVA/ICT job (£s)	142,444	114,929	96,684	56,143
2019 rank among 168 GB ITL3	8th	22nd	31st	121st
2022 ICT GVA (£s million)	775	1,632	2,547	523
2022 ICT Employment	5,000	18,000	25,000	8,000
2022 GVA/ICT job (£s)	155,000	90,667	101,880	65,375
2022 rank among 168 GB ITL3	7th	47th	28th	105th

Sources: GVA – ONS, 2024a: Table 3c; Employment – ONS, 2023e

Even allowing for the fact that by combining some ITL areas the local authority measure may dilute the digital strength of places such as Reading, this ranking is very different to that for productivity (approximated as GVA per job) across the local authority area, in which Stoke-on-Trent is in the bottom quartile nationally (see Section 4.3. and Appendix C).

The outperformance of Stoke's ICT Sector relative to the national average is also apparent in the latest available data. Table 11 compares ICT (SIC 2007 Sector J) labour productivity for Stoke-on-Trent and the UK (i.e., including Northern Ireland) in 2022. Stoke's outperformance is clear in both current and constant price measures of GVA.[27] While there is room for debate concerning the use of GVA per employee as a measure of labour productivity, this measure 'does allow comparison between the countries and regions of the

[27] Data City (The Data City – Understand What Companies Do in Real-Time) provides estimates of current GVA per employee for "All cities" (£95,265) and for Stoke-on-Trent (£145,903). Despite methodological differences between the two approaches, triangulation confirms the outperformance of Stoke's ICT Sector relative to the national average.

UK' and 'the relative importance of different industries to regional economies' (ONS, 2019: 4).

Table 11. ICT (SIC 2007 Sector J) labour productivity for Stoke-on-Trent and UK in 2022 (£s): nominal (current price GVA per employee) and real (constant price GVA per employee)

	Current price estimates	Constant price (chained volume, 2019 prices)
Stoke-on-Trent	£155,000	£179,600
UK	£90,988	£94,623

Sources.

- UK – ICT Employment data, June 2022 from [Labour Market Profile - Nomis - Official Census and Labour Market Statistics (nomisweb.co.uk)](); Current price GVA from ONS, 2024a (Table 1c); Constant price GVA from ONS, 2024a (Table 1b):
- Stoke-on-Trent – ICT Employment data, see note to Table 8; Current price GVA from ONS, 2024a (Table 3c); Constant price GVA from ONS, 2024a (Table 3b)

In the following Section, we probe these estimates derived from ONS data to address concerns that Stoke-on-Trent may be host to a concentration of low-productivity firms. However, first we conjecture that the industry composition of Stoke's ICT sector might give rise to relatively high aggregate productivity.

We have noted above in Section 7.1 that Stoke's digital economy is dominated by the SIC 2-Digit level industries 61-63 (Telecommunications; Computer programming and consultancy; and Information service activities). Digital industries 61-63 dominate digital industries 58-60 (Publishing; Film and TV production; and Broadcasting) with respect to both total employment (in 2022, 5,275 compared to 205) and GVA per employee (£144,455 per employee compared to £63,415).[28] This provides a clue as to where Stoke's relatively high productivity might come from. Telecommunications, digital industry SIC 61, accounts for a substantial part of employment in digital industries 61-63 (1,910 employees from 5,275). Moreover, Telecommunications is dominated by Vodafone, which in 2004 located in Stoke by a £405 million purchase from the then Caudwell Group, and in 2006 rebranded its Stoke-on-Trent site as a "centre of excellence" that currently employs around 900 to deal with the care of higher value customers, technical support and credit control.[29] Accordingly, the sectoral composition of Stoke's ICT sector may reflect the location of some very large firms in Stoke – either registered in Stoke or via subsidiary business units – which in turn contribute to the above average aggregate productivity performance of Stoke's digital sector.

[28] Elsewhere we use 5,000 for total ICT employment in Stoke-on-Trent. This discrepancy arises from rounding practice: in its NOMIS employment data, the Office for National Statistics reports Stoke's current ICT (Section J) employment as 5,000 (rounded down); yet at the disaggregate level – as we are reporting here – the employment numbers sum to a larger figure, which is rounded down when reported at the aggregate level. (The GVA data for this paragraph continue to be sourced from ONS, 2024a: Table 3c).
[29] See: Vodafone UK - Wikipedia; and Vodafone to create 300 new sales jobs in Stoke-on-Trent - BBC News.

7.2.2 FAME data - Value Added per Employee: ICT productivity averages and dispersion, comparing the UK and Stoke

In this Section, we use firm-level data from the FAME database to assess the aggregate level and distribution of productivity levels among the businesses in Stoke's ICT sector.[30] Theoretical reasons to expect productivity dispersion among ICT businesses are advanced in Section 12.9 below. We begin by advancing data on the distribution of companies' productivity in the UK's ICT sector as a benchmark. Second, we compare average labour productivity and its dispersion (i) across the UK and (ii) in Stoke to "sense check" the productivity of Stoke's ICT sector derived from ONS data (see Table 11). Following Shah et al. (2024), for firms in the FAME database we calculated labour productivity as follows:

$$Labour\ productivity = \frac{Value\ added\ by\ the\ firm}{Number\ of\ employees\ of\ the\ firm} \qquad (2)$$

where (restating Equation 1)

$$Value\ added = Operating\ profits + Total\ employee\ remuneration$$

and

$$Total\ labour\ costs = Average\ Yearly\ Remuneration\ per\ employee \times The\ number\ of\ employees$$

This approach does not provide a measure that is easily comparable with the ONS Gross Value Added measure, according to which consumption of fixed assets is counted as adding to rather than as a reduction of value added. Because productivity dispersion may occur in narrowly defined sectors, and to focus on firms with as much in common as possible, we investigate one of the six digital industries within the broader ICT sector (embracing the SIC two-digit level industries 58-63): i.e., firms whose primary activities are within the "Computer Programming, Consultancy and Related Activities" Industry (SIC 2007 62). This is both the dominant digital industry by employment throughout North Staffordshire (see Figure 9 below) and the most disaggregate level at which the following investigation could be conducted.

The reduction in the number of firms from 4644 in the whole ICT sector (SIC 58-63) available in the FAME database to 604 in "Computer Programming, Consultancy and Related Activities" (SIC 62) reflects (i) the selection of recent accounts data (2023) and, above all, (ii) the financial data required for calculating labour productivity for each business, which is available for relatively few businesses.[31] Using this sample, Figure 6 displays the labour productivity distribution among active UK firms in the "Computer Programming, Consultancy and Related Activities" industry (SIC 2007).

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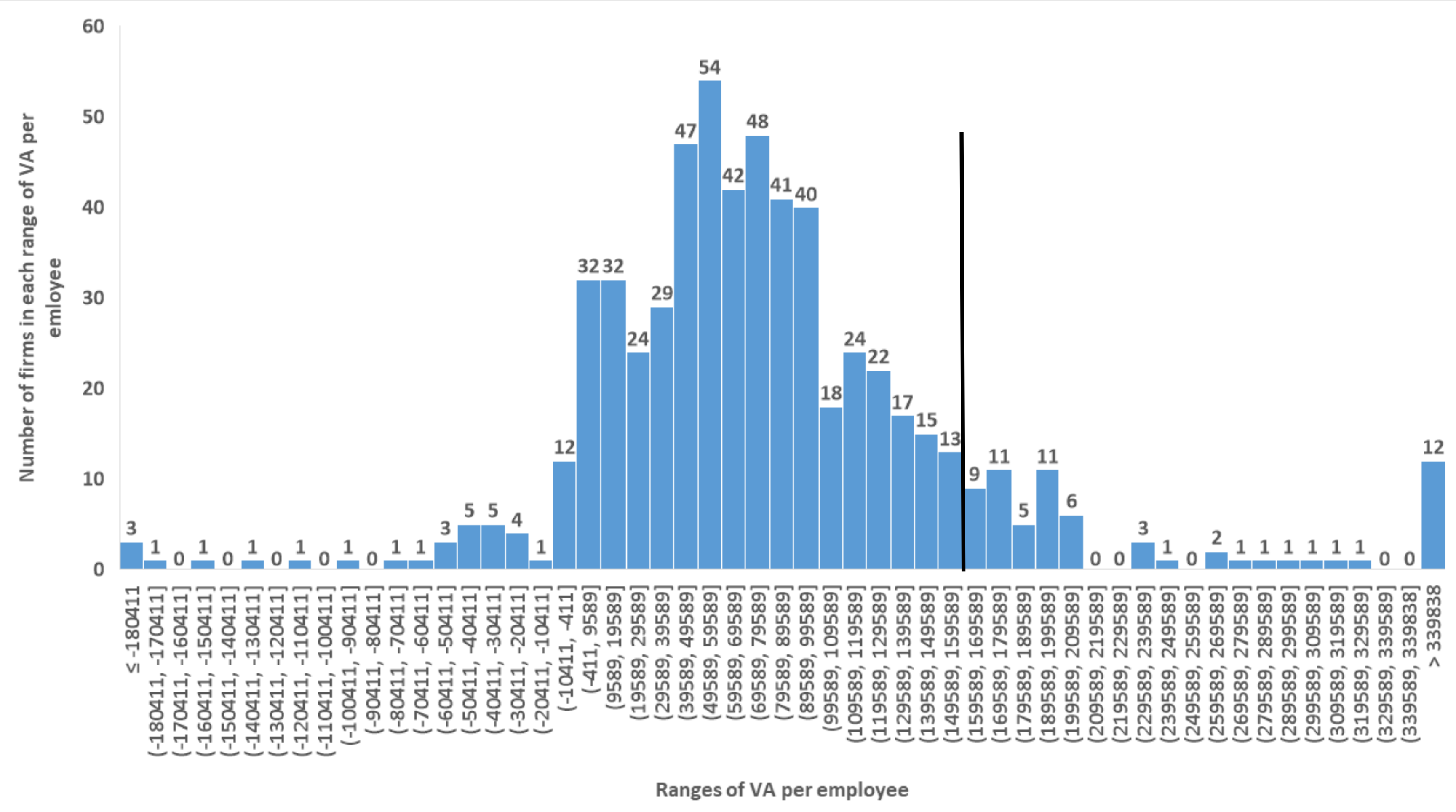
[30] The FAME (Financial Analysis Made Easy) database provides Annual Report data for public and private companies across the UK and Ireland that match the criteria of annual turnover of more than £1.5 million or profits of more than £150,000.

[31] This lack of financial data is not a specific shortcoming of our dataset, but an endemic problem for much small business research. Financial data are not available in principle for businesses that are not limited companies, because no filing of financial results is required. Moreover, limited companies that fall below the Companies Act 1985 and/or the Companies Act 2006 thresholds for the small company exemption are permitted to file only abbreviated accounts. Small company abbreviated accounts provide only balance-sheet information and hence do not provide data on turnover or profitability.

Figure 6. Labour productivity (value added per employee in £s) distribution among UK (active) companies in the "Computer Programming, Consultancy and Related Activities" Industry (SIC 2007 62) (2022-23: Sample Size = 604)



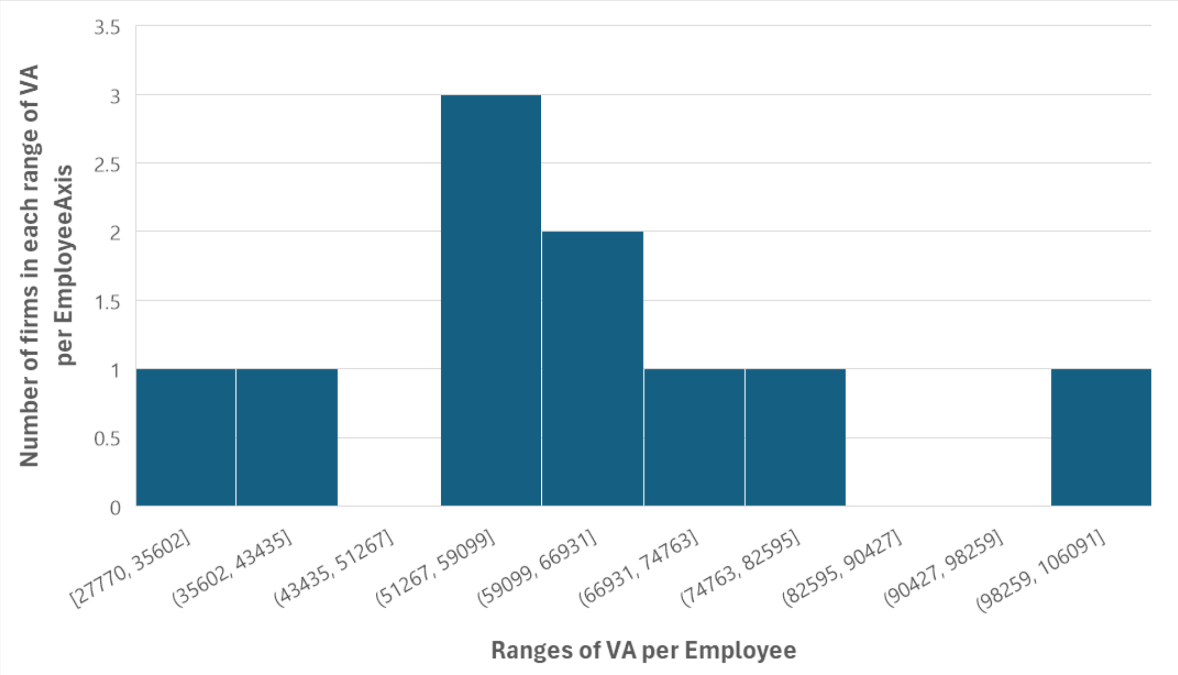
Source: Own calculations from the Bureau van Dijk FAME database; latest accounts date, 2023.
The vertical black line demarcates the top 10.93% of firms by labour productivity (indicative of those at the productivity frontier).

In line with ICT sector characteristics (see Section 12.9), labour productivity among the sample firms in SIC 62 is widely dispersed. Figure 6 reveals 66 from 604 firms (10.93%) with a labour productivity greater than £159,589 per employee p.a. (marked by the vertical black line). These may reasonably be regarded as frontier firms. However, most firms operate to a greater or lesser extent behind the frontier. The modal group of firms has average productivity of between c.£50,000 and c.£60,000, and the mean aggregate Value Added per Employee is £82,708.

As a "sense check" on the relative productivity of Stoke's digital sector we use the FAME database to calculate labour productivity – Value Added per Employee (including directors) – for all digital businesses (i) located in Stoke either as an independent enterprise or active in Stoke through a subordinate unit (see the notes to Table 9 for an explanation of this distinction), and (ii) reporting either primary or secondary SIC ICT codes (SIC 2007 Section J: 2-digit industries 58-63). There are 21 such enterprises or units that report the data needed to calculate average Value Added per Employee (including directors). After excluding four flagged by Companies House as "Accounts overdue", two with accounts still "being processed" (as of 02-10-2024), one erroneously reported as having operations in Stoke (using local knowledge), one double counted (Hillside Technology with its parent bet365),[32] and three cinema chains, we are left with 10. Of course, this sample is biased towards larger firms (mean employment 1,817 compared to 94 in the UK sample), and we assume that business units located in Stoke operate with the same productivity as the national operations of the enterprises to which they belong. Moreover, of the 10, only five have their primary activities categorised by SIC 62 (Computer Programming, Consultancy and Related Activities). Accordingly, we compare the UK SIC 62 sample of 604 firms with the Stoke sample of 10 ICT firms with either primary and/or secondary activities categorised by SIC Section J (2-digit industries 58-63). With these caveats, it is striking that the modal group is much the same in the national and the Stroke sample – i.e., between c.£50,000 and c.£60,000 – and the mean is similar, £80,673. However, whereas the UK sample has many firms in the extreme tails (79 firms with labour productivity of less than £10,000 in 2023 – including many with negative value added – and 163 firms greater than £110,000), Figure 7 shows the distribution for Stoke with both extremes notable by their absence.

[32] Hillside (Technology) Limited is a subsidiary of bet365 created 'as a response to the rapid proliferation of promising emerging technologies' (Bet365's Hillside Technology Drives Industry Advances with New Division (gamblingnews.com)).

Figure 7. Labour productivity (value added per employee) distribution of ICT sector companies active in Stoke-on-Trent (SIC Section J, 2-digit industries 58-63) (2022-23: Sample Size = 10)



Source: Own calculations from the Bureau van Djik FAME database (adapted in the light of local knowledge); latest accounts date, 2023.

Unfortunately, the Office for National Statistics (ONS) was not able to provide descriptive statistics – including measures of dispersion – calculated from firm-level data on the digital sector for North Staffordshire in general or for Stoke-on-Trent in particular. The next best alternative proved to be ONS datasets that allowed us to 'calculate aggregate average' GVA per Employee but are uninformative 'regarding the distribution'.[33] Therefore, using this data, Section 7.2.1 above (see Table 11 in particular) suggests that Stoke-on-Trent is host to a digital sector with an average productivity substantially above the national average and thus highly ranked in relation to the UK's other local authority areas. In this Section, we have advanced "bottom up" evidence that Stoke's ICT firms operate at a level of productivity more in line with the national average, although we readily acknowledge the limitations of our national and – especially – our local sample. In sum, the evidence on the productivity of Stoke's digital sector suggests performance *at best* substantially better than the UK average and *at least* "national class". Conversely, the evidence is ***not*** consistent with the concern that Stoke may be host to a large but low productivity digital sector. To draw firmer conclusions regarding productivity will require more firms to share financial data (regarding operating profit, total employee remuneration – including directors' remuneration – and number of employees).

[33] We are grateful to ONS officials for their efforts on behalf of our project. Unfortunately, they were unable to provide the data we requested – necessary to analyse the productivity dispersion of ICT firms in North Staffordshire – 'due to significant disclosure concerns' (email: July 8th 2024).

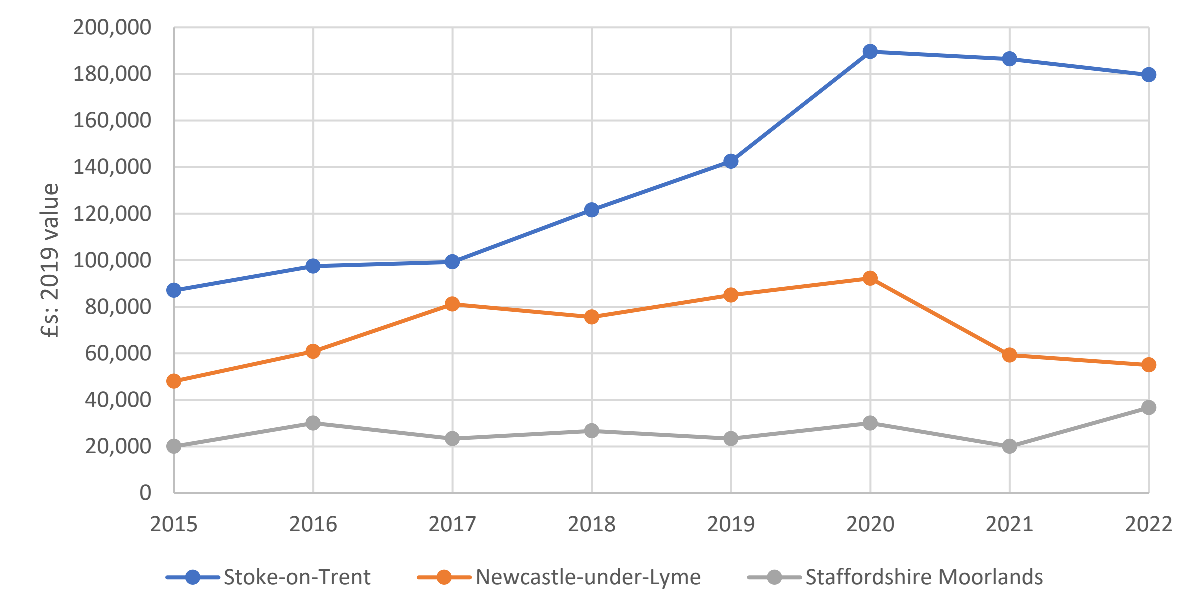
In any case, Stoke's ICT sector greatly outperforms Stoke's economy as a whole. In 2022, Stoke's ICT sector accounted for 4.0 percent of employment in the local authority area (calculated from ONS, 2023e) but 11.3 per cent of GVA (in current prices; calculated from ONS, 2024a: Table 3c).[34] Stoke's ICT Sector is thus not only productive by national standards but is unusually productive by local standards. Yet, the evidence of productivity dispersion at both national and local levels – supported by theoretical reasoning advanced in Section 11.9 – suggests that behind the aggregate average productivity of Stoke' digital sector may be businesses at or close to the productivity frontier together with businesses lagging the frontier. A policy corollary is that at least some firms require help to benefit from knowledge transfer initiatives supported by local institutions such as the Council, Staffordshire Chambers, and the universities and colleges.

7.3 Digital sector productivity in Stoke-on-Trent and in North Staffordshire

Next, we delve further into the productivity of North Staffordshire's digital economy businesses. To show how labour productivity – i.e. GVA per employee – has developed over the years 2015-22 in Stoke City, Newcastle-under-Lyme, and Staffordshire Moorlands districts respectively, we combine time-series data on real (i.e., inflation adjusted) GVA (ONS, 2024a: Table 3b - ITL3 chained volume measures in 2019 money value, pounds) with employment count data (ONS, 2023e). The resulting time-series of labour productivity are presented in Figure 8.

[34] The comparison is even more striking if we calculate the 2022 share of ICT GVA in Stoke's total GVA using ITL3 chained volume measures in 2019 money values (ONS, 2024a: Table 3b): in constant prices, the 2022 ICT share in Stoke's total GVA was 14.25 percent.

Figure 8. Labour productivity (constant price GVA per employee) of digital economy businesses (SIC 2007 Section J – ICT) in North Staffordshire, 2015-22



Source: Real (i.e., inflation adjusted) GVA, ONS, 2024a: Table 3b; Employment count data, ONS, 2023e

Figure 8 shows that, in recent years (2015-22), ICT businesses located in Stoke-on-Trent have generated both a higher level and higher growth of labour productivity than have ICT businesses located in either Newcastle-under-Lyme or Staffordshire Moorlands. On the measures not only of the number and size of digital businesses but also of their productivity it is apparent that Stoke is the engine of the digital economy in the North Staffordshire sub-region.

7.4 Policy Implications

Stoke's position as the engine of the digital economy in North Staffordshire is due to organic growth with very little policy support. Work is ongoing to build out a city-wide fibre network and there have been attempts to secure 5G pilot status, but neither has contributed to the growth to date. Aside from Staffordshire University's launch of its digital strategy, there have, until recently, been no major initiatives to develop digital skills locally.

The differences between the digital sector and other high value-added services in Stoke-on-Trent are striking (compare the location quotients in Table 8 above). In the last 30 years, the number of people working in accounting and law has fallen in the city. In the same period the numbers employed nationally in these industries has doubled. It is possible the local digital sector is an exporter of services allowing it to flourish, whereas service businesses serving the local market have faced falling demand as the decline of manufacturing and the centralisation of operations has reduced the potential market in Stoke-on-Trent.

There are areas for improvement. Despite its strong growth, the digital sector has attracted relatively little foreign direct investment (FDI). Stoke-on-Trent's overall FDI performance, based on an analysis of Ernst & Young's *European Investment Monitor* (Ernst & Young, 2022), is in line with similar places across the East and West Midlands, consisting primarily of investment in manufacturing and logistics. However, digital FDI lags elsewhere in the city's region. For example, Warwick attracted eight e-gaming FDI projects in 2021, but Stoke-on-Trent achieved none, even though Staffordshire University is recognised as a UK leader in the field. The skills challenges reported by bet365 – the company has set up a Manchester operation as it is unable to fill all its vacancies locally – may be at least part of the explanation. If a well-regarded local company can't hire the people it needs, foreign investors may be reluctant to locate in the area.

Typically, the digital sector is associated with high levels of flexible and remote working. This does not appear to be the case in Stoke-on-Trent. In the 2021 Census, only 15.2 per cent of people in employment in Stoke-on-Trent reported working from home and the position across Staffordshire was very similar. However, in Cheshire East, a neighbouring local authority to Stoke-on-Trent, 35.2 per cent of people reported working at home, and 46.1 per cent in the Holmes Chapel sub-area. It is possible that a significant share of the relatively high-earning digital workforce in Stoke-on-Trent lives outside the city. This view is consistent with the relatively low level of consumer spending in the city, especially in hospitality. If this is the case, in addition to the implications for policy in areas such as housing and transport, it raises strategic questions about local government finances and structure: Stoke-on-Trent may be creating value it is unable to capture through business and personal taxes and spending.

8 Increasing weight of the digital sector in the local economy

Sections 5, 6 and 7 above presented evidence that the emerging digital sector in Stoke-on-Trent is both substantial and that it has competitive potential. In this section, we review evidence suggesting that the digital sector has been increasing its weight in local employment relative to other sectors in the tradables sector of the local economy. To this end, we advance two types of evidence: (i) digital sector employment over time in the three North Staffordshire local authority areas; and (ii) web-scraped online job adverts.

Figure 9 graphs employment count data (by location of an employee's workplace) (i) for each year 2015 to 2022, (ii) for each industry in the broad ICT category (SIC 2007 Division J), and (iii) for each of Stoke-on-Trent, Newcastle-under-Lyme and Staffordshire Moorlands. Although we have advanced evidence that "digital Stoke" extends more broadly to North Staffordshire (Table 9), comparison between the three panels again suggests that Stoke is the engine of the digital economy in the sub-region:

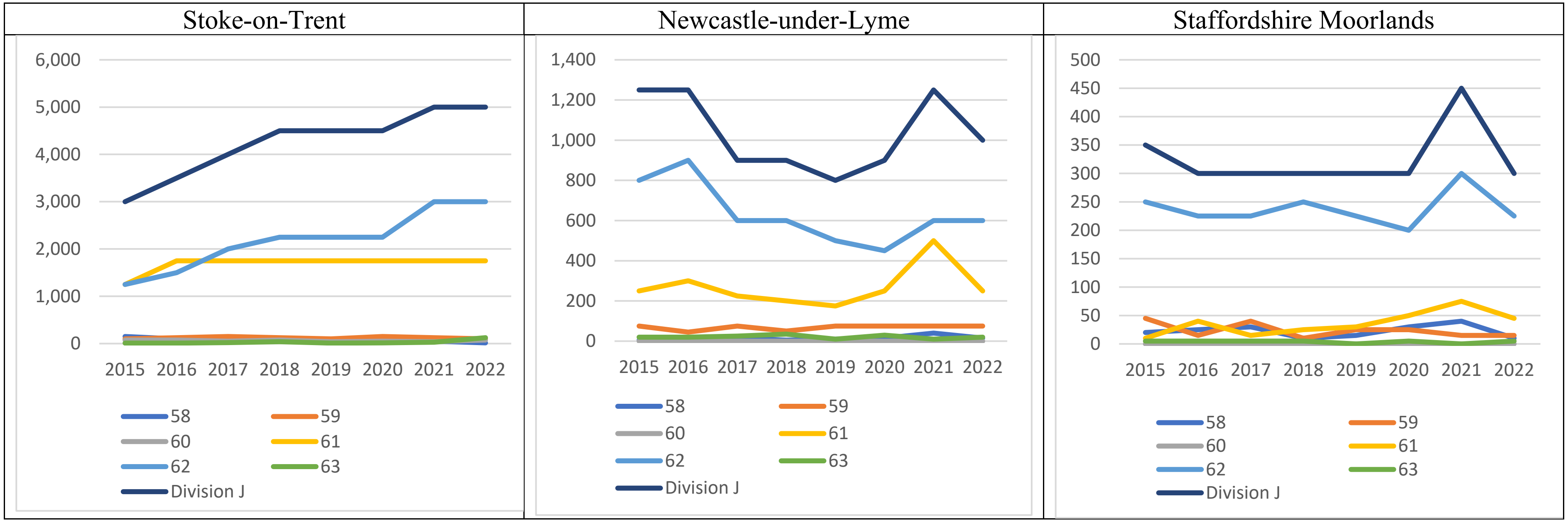
1. total ICT employment is much larger in Stoke (5,000 in 2022) compared to either Newcastle (1,000) or Staffordshire Moorlands (300); and
2. compared to slightly declining employment over the eight-year period 2015-2022 in both Newcastle (-20%) and Staffordshire Moorlands (-14%), Stoke has substantially increased its ICT employment (by 67%).

The same picture emerges for the largest component of the digital sector, SIC (2007) 62 – Computer programming, consultancy and related activities:

1. employment is much larger in Stoke (3,000 in 2022) compared to either Newcastle (600) or Staffordshire Moorlands (225); and
2. compared to slightly declining employment over the eight-year period 2015-2022 in both Newcastle (-10%) and Staffordshire Moorlands (-14%), Stoke has substantially increased its employment in Computer programming, consultancy and related activities (by 140%).

It is also clear from Figure 9 that the overall growth in digital employment in Stoke is driven by computer programming, consultancy and related activities, while the other ICT industries make relatively minor contributions to growth in digital employment. (Telecommunications is a major contributor to the level of digital employment but not, in recent years, to its growth.)

Figure 9. ICT employment count data for each year 2015 to 2022 for Stoke-on-Trent, Newcastle-under-Lyme and Staffordshire Moorlands



Note. Employment includes employees plus the number of working owners. BRES therefore includes self-employed workers as long as they are registered for VAT or Pay-As-You-Earn (PAYE) schemes. Self-employed people not registered for these, along with HM Forces and Government Supported trainees are excluded. Working owners are typically sole traders, sole proprietors or partners who receive drawings or a share of the profits.

SIC (2007) codes: 58: Publishing activities; 59: Motion picture, video and television programme production, sound recording and music publishing activities; 60: Programming and broadcasting activities; 61: Telecommunications; 62: Computer programming, consultancy and related activities; 63: Information service activities. Division J: Information and communication (aggregate of 58-63)

Source: ONS, 2023d (Business Register and Employment Survey: open access)

In Table 12 we combine data on the number of businesses from Table 9 with employment data underlying Figure 9 to gain a rough idea of comparable average size of ICT businesses across North Staffordshire in 2022. Gauged by average (mean) employment, it appears that the average size of ICT business is substantially larger in Stoke than in Newcastle or in Staffordshire Moorlands.

Table 12. Average employment per business enterprise and unit located in North Staffordshire for ICT, SIC (2007) Division J

	Stoke-on-Trent	Newcastle-under-Lyme	Staffordshire Moorlands
Enterprises	21.3	5.3	2.5
Local Units	18.9	5.1	2.4

Source: own calculations from ONS data (i) presented in Table 9 and (ii) underlying Figure 9. Although these data sources were both released in 2023 within a month of each other (respectively in September and October) their timing of data capture may not line up precisely. In any case, these calculations are to be regarded as indicative.

According to Mandys and Coyle (2024: 26), drawing on data from DCMS (2024), the average UK computing firm had 8.8 employees in 2022. Although, as we have noted, their sector of analysis (the Computing sector) is not the same as ours (the ICT or digital sector), it is close enough to indicate that the typical ICT business is larger than the national average in Stoke while smaller in the Newcastle or Moorlands areas.

Finally, Table 13 shows that, in relation to total employment,

1. the employment shares of Stoke's digital industries – both in general (i.e., SIC [2007] Division J, 58-63) and of SIC (2007) 62 in particular (Computer programming, consultancy and related activities) – have both steadily increased over the eight years 2015-2022, while the respective shares elsewhere in North Staffordshire have declined;
2. both Stoke shares are greater than both the North Staffordshire sub-regional and the West Midlands regional shares; and
3. while slightly less than the respective employment shares for Great Britain the respective Stoke shares have grown more rapidly.

Table 13. Shares of ICT employment in total employment, 2015-2022: North Staffordshire (Stoke, Newcastle and Moorlands); West Midlands; and Great Britain

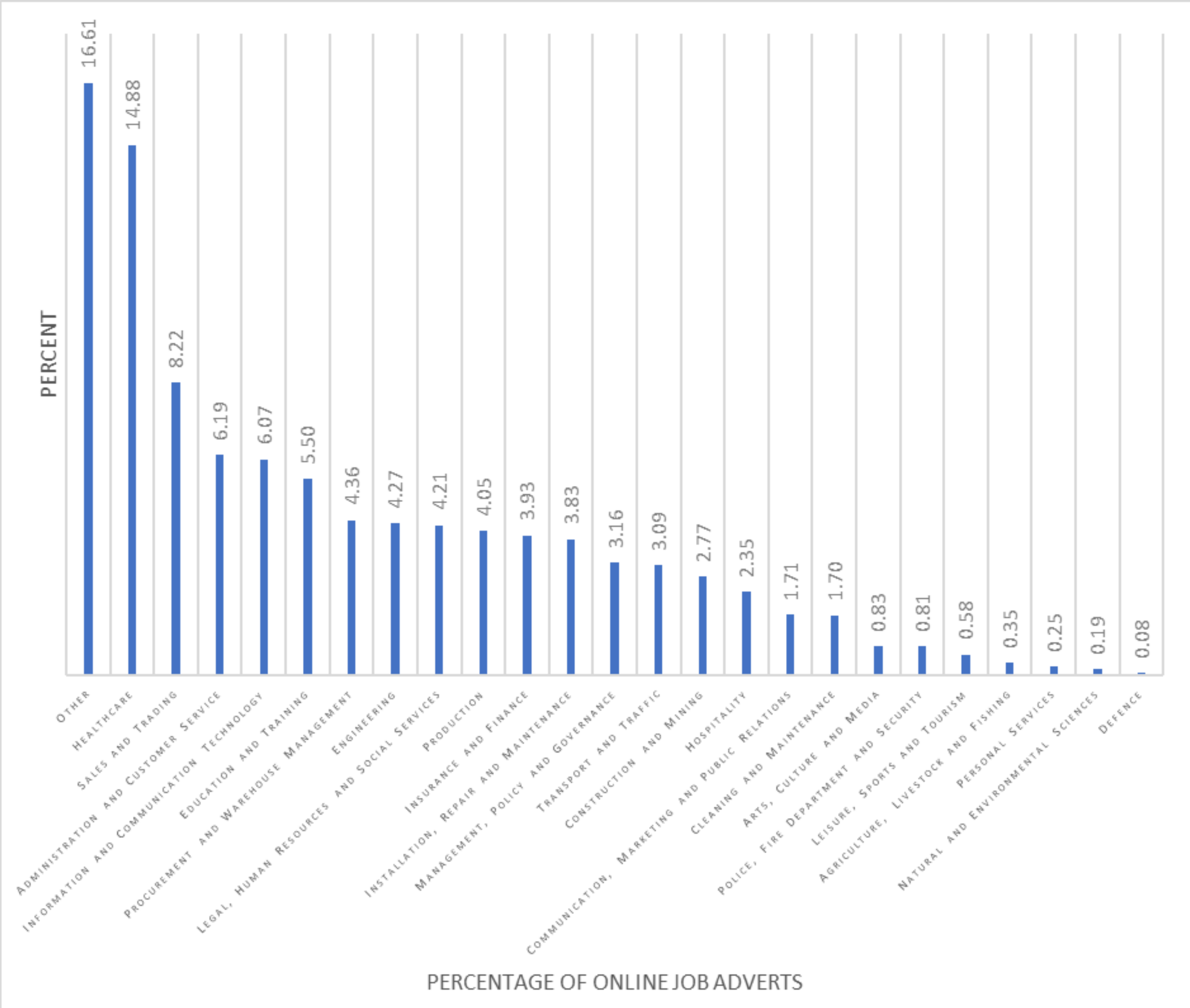
	Stoke-on-Trent		Newcastle-under-Lyme		Staffordshire Moorlands		West Midlands		Great Britain	
	SIC (2007) 62	SIC (2007) Division J	SIC (2007) 62	SIC (2007) Division J	SIC (2007) 62	SIC (2007) Division J	SIC (2007) 62	SIC (2007) Division J	SIC (2007) 62	SIC (2007) Division J
2015	1.1	2.6	1.7	2.6	0.8	1.1	1.7	2.5	2.1	4.0
2016	1.3	3.0	1.9	2.7	0.7	0.9	1.7	2.6	2.3	4.1
2017	1.7	3.3	1.2	1.9	0.7	0.9	1.7	2.6	2.4	4.2
2018	1.8	3.7	1.3	1.9	0.8	0.9	1.8	2.7	2.4	4.1
2019	1.8	3.7	1.1	1.7	0.7	0.9	1.7	2.5	2.4	4.2
2020	1.9	3.8	1.0	2.0	0.6	0.9	1.7	2.8	2.5	4.3
2021	2.4	4.1	1.3	2.7	0.9	1.3	2.3	3.5	2.3	4.3
2022	2.4	4.0	1.3	2.1	0.7	0.9	1.9	2.8	2.5	4.4

Note. Employment includes employees plus the number of working owners. BRES therefore includes self-employed workers as long as they are registered for VAT or Pay-As-You-Earn (PAYE) schemes. Self-employed people not registered for these, along with HM Forces and Government Supported trainees are excluded. Working owners are typically sole traders, sole proprietors or partners who receive drawings or a share of the profits.
Source: ONS, 2023d (Business Register and Employment Survey: open access)

Recently, the ONS has released data on web-scraped unique online job adverts as a proxy measure of changing labour demand volumes by profession and local authority over the six years 2017-2022. This is experimental data, hence 'will potentially have a wider degree of uncertainty' than other ONS data, so the conclusions presented in this section should correspondingly be regarded as indicative rather than definitive.[35] From this data, we calculated the total number of live adverts for jobs located in Stoke, 2017-22: i.e., the sum of the monthly averages for each of the 25 "summary profession categories" for which data is reported by local authority after removing duplicate adverts. Figure 10 presents the percentage of this total accounted for by each profession.

[35] The data is web-scraped job advert information from approximately 90,000 job boards and recruitment pages, which includes job titles, descriptions, posting dates and expiration dates. Subsequent data cleaning removes duplicate job adverts. On the nature of experimental data, see: [Guide to experimental statistics - Office for National Statistics (ons.gov.uk)]

Figure 10. Percentage of online adverts for jobs located in Stoke-on-Trent by professional category between January 2017 and December 2022



Source: Own calculation from Labour demand volumes by profession and local authority, UK: January 2017 to December 2022 - Office for National Statistics (ons.gov.uk): Table 12: Snapshots of online job adverts in the UK, split by Local Authority District and detailed profession category between January 2017 and December 2022; snapshot volumes of non-duplicate online job adverts.

Our profession of interest is "Information and Communication Technology", which includes the following 13 sub-categories: Consultants and Specialists; Database Specialists; Information and Communication Technology (other); IT Coordinators; IT Managers; IT R&D Professionals; IT Testers; Network Specialists; Programmers; Support Staff; System and Application Administrators; System Developers and Analysts; and Web Professionals. Together, these account for 6.07 percent of the total job adverts. Of course, there are other occupations that may be classed as "digital" employment: for example, if we reallocate the 1,475 "CNC Operators and Programmers" from the "Production" category to "Information and Communication Technology" then our category of interest accounts for 6.48 percent of the total job adverts.

Although the 25 professional categories used in this dataset do represent all types of jobs, they do not align completely with the Standard Occupational Classification (SOC) used for

Table 8.[36] Nonetheless, even though the categories in Table 2 and in Figure 10 are at best a rough match, comparison is revealing. The "Information and Communication" category in Table 2 accounts for 4.1 percent of jobs in Stoke, or 5.0 percent if we include in this category 1,000 technical employees of bet365. Hence, on either measure, the share of job adverts for the digital occupations (6.07%) is larger than their combined share of current employment. On the assumption that job adverts correspond to jobs filled, then we have some indication that digital employment in Stoke not only accounts for a substantial share of employment in Stoke but also a growing share. Moreover, the digital sector share of adverts for jobs in Stoke is larger than the shares of other professions linked to the tradables sector: the next largest shares clearly linked with the tradables sector are accounted for by "Engineering" (4.27%) and "Production" (4.05%).

Finally, we consider two caveats.

1. The data do not reveal the extent to which relative shares of job adverts reflect more or less rapid labour turnover. However, even if more rapid turnover were to be part of the explanation for rising labour demand in Stoke's digital sector this is still consistent with sector dynamism and the need for policies to promote the sector (e.g., by increasing the supply of digital skills).
2. While in Stoke labour demand from the "Information and Communication" sector is relatively high compared to other sectors, this is not remarkable by national standards. For the UK as a whole, in December 2022 "Information and Communication" accounted for 9.7 per cent of online job adverts, second only to Healthcare (12.7%).[37] In part, this is a London effect. Nonetheless, Stoke is in competition with other cities to attract and retain digital talent.[38] This may also point to the need for enhanced policy interventions to increase the supply of digital skills.

Together, the evidence advanced in this Section suggests that the broad digital sector in Stoke-on-Trent is a sizeable and increasingly important contributor to the local economy. This is an opportunity for Stoke.

9 Entry and exit of ICT businesses nationally and in Stoke-on-Trent

In this Section, we show that: (i) while the number of ICT enterprises and local units peaked nationally in 2019 and locally in 2020, subsequent decline from their respective peaks has been substantially lower in Stoke; (ii) the local fall in the number of ICT enterprises and business units has been accompanied by an increase in their average size so that ICT employment has continued to increase; (iii) local ICT employment increase has a bias

[36] According to the ONS, the taxonomy of professions 'has a bespoke classification similar, but distinct to, other occupational classifications'. Moreover: 'In the coming months, we aim to produce an experimental online job advert series by Standard Occupational Classification (SOC) codes at a sub-national level, to inform on local occupation demand.' Labour demand volumes by profession and local authority, UK - Office for National Statistics (ons.gov.uk)

[37] The ONS provides an online calculator to compare: 'Local authority share of total online job adverts (left) and summary profession category breakdown of online job adverts by local authority and for the UK (right), local authorities of the UK, December 2022.' Labour demand volumes by profession and local authority, UK - Office for National Statistics (ons.gov.uk)

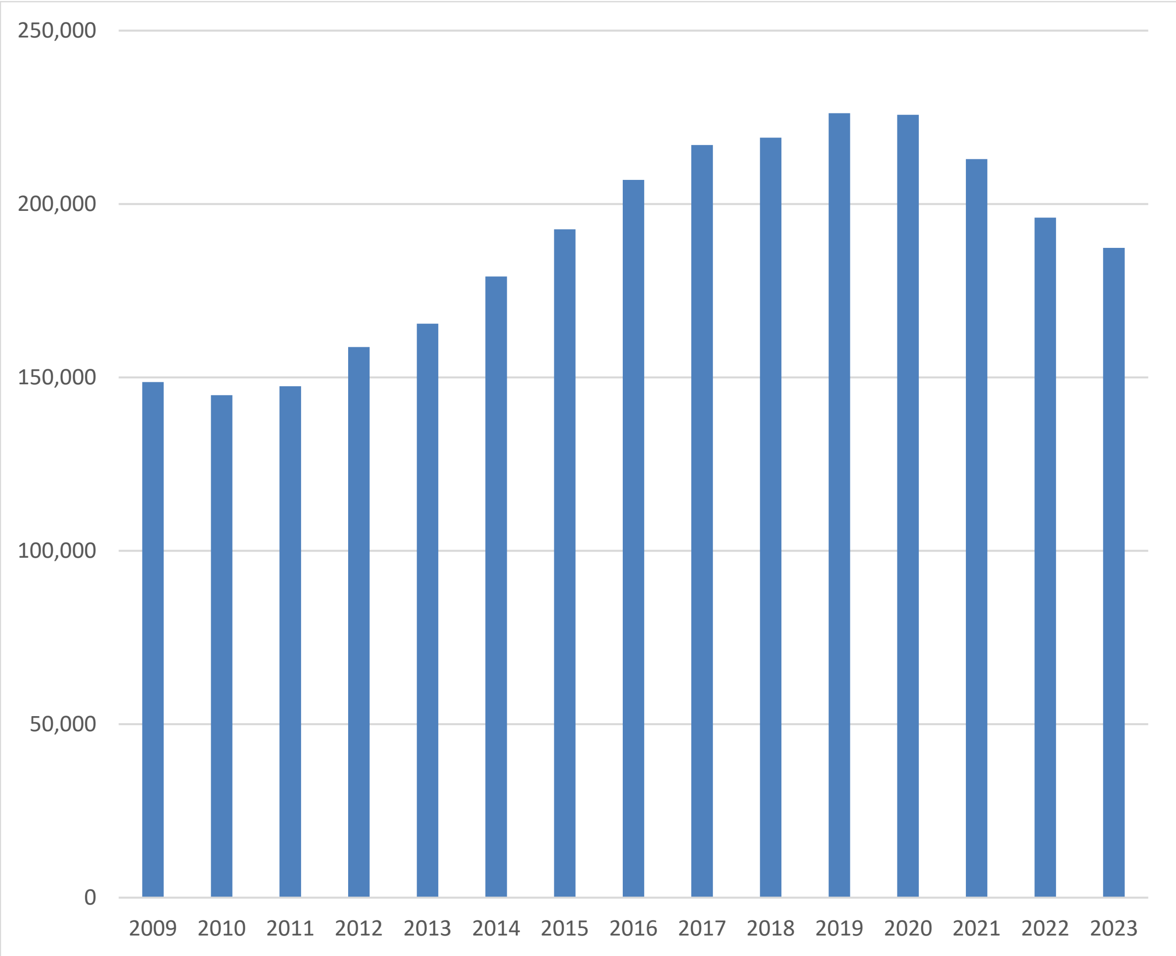
[38] '8.1% of local authorities showed information and communication technology as the summary profession category with the highest number of job adverts.' Labour demand volumes by profession and local authority, UK - Office for National Statistics (ons.gov.uk)

towards full-time jobs; and (iv) in the context of an industry with substantial churn – i.e., exit and entry of businesses – from 2020 the net entry of ICT enterprises in Stoke compares favourably with net entry nationally.

9.1 Changing number of ICT businesses

ONS data from the Inter Departmental Business Register (27th September 2023) – originating from HMRC and Companies House – records the number of businesses registered for VAT and or/PAYE records. From this, we extract the following numbers of ICT – i.e., SIC (2007) Division J, 58-63 – enterprises and local business units located in the UK, 2009-23. Figure 11 shows a slight dip in 2010 and 2011, following the Global Financial Crisis, a steady rise until 2019, followed by a year-on-year fall.

Figure 11. Number of VAT and/or PAYE based ICT enterprises, UK, 2009-2023



Source. ONS, 2023c (UK Business, activity, size and location, 2023), Table 28.

Table 14 first shows a similar evolution for both business enterprises and business units in the UK's ICT sector; a decline from the 2019 peak by around 17 per cent. This table also shows that the number of ICT business enterprises and business units in Stoke-on-Trent peaked a year later and by 2023 had declined by somewhat less, by around 11 per cent.

Table 14. Number of VAT and/or PAYE based ICT enterprises in the UK and Stoke-on-Trent, 2017-2023 (and percentage change - %Δ - from peak)

	UK				**Stoke-on-Trent**			
	Enterprises	%Δ from peak	Local Units	%Δ from peak	Enterprises	%Δ from peak	Local Units	%Δ from peak
2017	217,025		225,645		250		280	
2018	219,150		228,085		235		270	
2019	226,215		234,930	Peak	250		285	
2020	225,745		234,325		265		295	Peak
2021	212,960		221,240		260		290	
2022	196,090		204,475		250		285	
2023	187,360	-17.2	195,495	-16.8	235	-11.3	265	-10.2

Source: ONS, 2023c – Table 1 and 16; plus the equivalent publications, following the same table numbering and format, for 2017, 2018, 2019, 2020, 2021 and 2022.

The declining number of enterprises and units does not indicate a declining sector. For Stoke-on-Trent, comparison of Table 14 with Table 15 reveals that declining numbers from 2020 of enterprises and business units in both the broad ICT Sector (SIC Section J) and the narrower SIC 2-digit industry 62 (Computer programming, consultancy and related activities) have been accompanied by rising employment, and consequently, by increasing average size. For example, in 2020, Stoke-on-Trent's 265 ICT enterprises employed 4,500, giving average employment of a little under 17, whereas in 2023 235 enterprises employed 5,000, giving average employment of a little over 21.

In addition, it is revealing to compare the percentages of local full- and part-time employees accounted for by Stoke's ICT Sector reported in Table 15 with the overall percentages of local employment accounted for by Stoke's ICT Sector reported in Table 13. For example, in 2022 the whole ICT Sector (SIC Section J) accounted for 4.0 per cent of employment in Stoke-on-Trent but 5.4 per cent of full-time employment and 1.5% of part-time employment. Accordingly, Stoke-on-Trent's ICT Sector has not only generated many jobs but has a strong bias towards full-time employment. This may be useful information for employment creation strategy in Stoke-on-Trent.

Table 15. Stoke-on-Trent ICT employment together with full-time and part-time employees, 2015-2022
(SIC 62 - Computer programming, consultancy and related activities; and SIC Section J - Information and communication)

	Employment			**Full-time employees**			**Part-time employees**		
	62: Computer programming, consultancy and related activities	J: Information and communication	J: Information and communication (% total Stoke employment)	62: Computer programming consultancy and related activities	J: Information and communication	J: Information and communication (% total Stoke full-time employment)	62: Computer programming, consultancy and related activities	J: Information and communication	J: Information and communication (% total Stoke part-time employment)
2015	1,250	3,000	2.6	1,250	2,500	3.2	100	300	0.9
2016	1,500	3,500	3.0	1,250	3,000	3.9	75	300	0.8
2017	2,000	4,000	3.3	2,000	3,500	4.4	200	450	1.1
2018	2,250	4,500	3.7	2,000	4,000	4.8	175	450	1.2
2019	2,250	4,500	3.7	2,250	4,000	4.9	175	400	1.0
2020	2,250	4,500	3.8	2,250	4,000	5.1	150	450	1.2
2021	3,000	5,000	4.1	3,000	4,500	5.6	225	500	1.3
2022	3,000	5,000	4.0	3,000	4,500	5.4	200	600	1.5

Definitions: from Nomis - Official Census and Labour Market Statistics - Nomis - Official Census and Labour Market Statistics (nomisweb.co.uk)

Employees: An employee is anyone aged 16 years or over that an organisation directly pays from its payroll(s), in return for carrying out a full-time or part-time job or being on a training scheme. It excludes voluntary workers, self-employed, working owners who are not paid via PAYE.

Full-time employees: those working more than 30 hours per week.

Part-time employees: those working 30 hours or less per week.

Employment includes employees plus the number of working owners. BRES therefore includes self-employed workers as long as they are registered for VAT or Pay-As-You-Earn (PAYE) schemes. Self employed people not registered for these, along with HM Forces and Government Supported trainees are excluded. Working owners are typically sole traders, sole proprietors or partners who receive drawings or a share of the profits.

Source: ONS, 2023d (Business Register and Employment Survey: open access)

Behind the number of enterprises, in a dynamic business sector there is enterprise "churn" as failing enterprises exit (or possibly merge or are taken over) and new enterprises enter the sector. This is addressed in the following section.

9.2 ICT Sector churn (enterprise entry and exit)

Table 16 presents data on churn in the UK ICT Sector (SIC 2007 Section J). Consistent with the declining number of enterprises in the UK ICT Sector (see Table 14 above) after 2019, Table 16 below (Columns 4 and 8) shows declining net entry from 2020.

Table 16. UK ICT Sector (SIC 2007 Section J) – enterprise births (entry), deaths (exits) and net entry (count data and as a percentage of total active enterprises) (2017 – 2022)

	Births Of New Enterprises	Deaths Of Enterprises	Net Entry	Count Of Active Enterprises	Entry as a percentage of total active enterprises	Exit as a percentage of total active enterprises	Net entry as a percentage of total active enterprises
2017	30,000	25,365	4,635	245,875	12.20	10.32	1.89
2018	30,900	24,105	6,795	249,815	12.37	9.65	2.72
2019	30,080	25,850	4,230	254,775	11.81	10.15	1.66
2020	22,455	32,330	-9,875	249,700	8.99	12.95	-3.95
2021	22,350	36,800	-14,450	237,000	9.43	15.53	-6.10
2022	22,455	30,080	-7,625	221,075	10.16	13.61	-3.45

Source. ONS, 2023f: calculated from Tables 1.2 (Count of Births of New Enterprises for 2017 To 2022 Standard Industrial Classification (SIC2007) Group), 2.2 (Count of Deaths of Enterprises for 2017 To 2022 Standard Industrial Classification (SIC2007) Group), and 3.2 (Count of Active Enterprises for 2017 To 2022 Standard Industrial Classification (SIC2007) Group).

A birth is identified as a business that was present in year t, but did not exist in year t-1 or t-2. Births are identified by making comparison of annual active population files and identifying those present in the latest file, but not the two previous ones.

A death is defined as a business that was on the active file in year t, but was no longer present in the active file in t+1 and t+2. In order to provide an early estimate of deaths, an adjustment has been made to the latest two years deaths to allow for reactivations. These figures are provisional and subject to revision.

Differences may exist in totals across tables due to disclosure methods used.

Table 17 provides the same data for Stoke-on-Trent (although for one additional year). In the three years 2017-2019, net entry as a percentage of total active ICT enterprises was higher nationally than locally, but in the three subsequent years 2020-2022 the comparison is in Stoke's favour.

Table 17. Stoke ICT Sector (SIC 2007 Section J) – enterprise births (entry), deaths (exits) and net entry (count data and as a percentage of total active enterprises) (2017 – 2023)

	Births Of New Enterprises	Deaths Of Enterprises	Net Entry	Count Of Active Enterprises	Entry as a percentage of total active enterprises	Exit as a percentage of total active enterprises	Net entry as a percentage of total active enterprises
2017	35	35	0	280	12.50	12.50	0.00
2018	35	30	5	285	12.28	10.53	1.75
2019	40	30	10	295	13.56	10.17	3.39
2020	35	35	0	300	11.67	11.67	0.00
2021	35	40	-5	290	12.07	13.79	-1.72
2022	30	40	-10	275	10.91	14.55	-3.64
2023	20	35	-15	265	7.55	13.21	-5.66

Source: Provided by special request to the ONS (December 19th 2024: Das Number AH1613). Disaggregated from the same sources as the previous table.

10 Digital Stoke: conclusions and provisional research agenda

Our main finding is evidence of the emergence in Stoke of a digital sector with competitive potential. However, the emergence of this sector is unexpected and still not well understood. As yet, Stoke's digital sector is too small to have transformed Stoke's low aggregate economic performance ranking among UK urban areas/local authorities (see Appendices B and C). Accordingly, we propose to research the potential for "digital Stoke" to grow, especially by attracting inward foreign direct investment in digital industries, and – given the enabling or platform nature of digital technologies – to raise productivity in existing industries and stimulate investment in other knowledge-intensive activities.

10.1 Provisional research agenda

The high level of performance by a sector that until recently has received little if any policy attention raises the following questions that we would like to explore. (There are certainly others.)

1. What have been the drivers of the sector's growth? Does this vary by sub-sector (creative, cyber, e-gaming, etc)?
2. How do we explain the success of digital compared to professional services in the city?
3. What role have the local universities and FE providers played in the growth?
4. Why is FDI performance so relatively poor in digital? How could we change this?

5. What initiatives (skills, support, infrastructure etc) are required to support resilience and future growth, being mindful that IT clusters not only rise but may also decline within short periods (Lazzeretti et al. 2024: 2 and 4 give such an example from Japan in the 1970s and 80s).
6. What are the implications for the structure and financing of local government?
7. Is the experience transferable? To other areas or to other sectors locally/nationally?

Our initial thinking is to start with a mapping of the sector to provide the basis for structured questionnaires and semi-structured interviews with businesses in the city to explore the issues raised above.

In addition, we will seek to engage with potential foreign investors in key sub-sectors and digital businesses located out of the city to develop a broader perspective.

Part 3. Characteristics of digital industries and firms: creative sector; and intangibles

In this part we report more general analysis of ICT industry and firm characteristics to inform primary investigation into Stoke's emerging digital sector. In particular, we consider: (i) ICT as part of the broader creative sector; and (ii) intangible assets as a leading characteristic of ICT businesses.

11 ICT as part of the creative sector

The SIC (2007) Section J Information and Communications (ICT) industries extensively overlap with the standard Department for Culture, Media and Sport (DCMS) definition of "Creative Industries". Table 18 distinguishes between the 16 SIC (2007) Section J 4-digit industries that belong to the "Creative" sector and the 10 that do not (although Bakhshi et al. [2013: 37] notes that Wireless telecommunications activities [6120] is 'a plausible candidate for inclusion'). Given the extensive overlap of the digital sector and the creative sector, in this Section we consider the economic characteristics of the digital sector from the perspective of its creative sector characteristics.

Table 18. Information and Communications industries (SIC 2007, Division J) classed and not classed by the DCMS as belonging to the "Creative" sector: 4-digit level (SIC 2007)

Creative Sector digital industries (16)	**Digital industries not belonging to the Creative Sector (10)**
Film, TV, Video, Radio & Photography	**Wired telecommunications activities**
59.11 Motion picture, video and television programme production activities	61.10 Wired telecommunications activities
59.12 Motion picture, video and television programme postproduction	**Wireless telecommunications activities**
59.13 Motion picture, video and television programme distribution	61.20 Wireless telecommunications activities
59.14 Motion picture projection activities	**Satellite telecommunications activities**
60.10 Radio broadcasting	61.30 Satellite telecommunications activities
60.20 Television programming and broadcasting activities	**Other telecommunications activities**
IT, Software and Computer Services	61.90 Other telecommunications activities
58.21 Publishing of computer games	
58.29 Other software publishing	
62.01 Computer programming activities	**Computer programming, consultancy and related activities**
62.02 Computer consultancy activities	62.03 Computer facilities management activities
Publishing	62.09 Other information technology and computer service activities
58.11 Book publishing	**Data processing, hosting and related activities; web portals**
58.12 Publishing of directories and mailing lists	63.11 Data processing, hosting and related activities
58.13 Publishing of newspapers	63.12 Web portals
58.14 Publishing of journals and periodicals	**Other information service activities**
58.19 Other publishing activities	63.91 News agency activities
Music, Performing and Visual Arts	63.99 Other information service activities n.e.c.
59.20 Sound recording and music publishing activities	

Source: VAT and/or PAYE based Enterprises in Stoke-on-Trent involved in Creative Industries, Analysis of enterprises in Stoke-on-Trent involved in creative industries 2022 - Office for National Statistics (ons.gov.uk)

Definitions of the creative industries are not uniformly agreed on (UNCTAD, 2010). Since the focus of this report is within the context of the United Kingdom, we follow the Department of Digital, Culture, Media and Sport (DCMS) definition of the creative industries. The DCMS in its *Creative Industries Mapping Document* defines creative industries as

> those industries which have their origin in individual creativity, skill and talent and which have a potential for wealth and job creation through the generation and exploitation of intellectual property (DCMS, 2001: 5).

The definition and scope of the *creative industries* used by the DCMS is widely used both nationally and internationally (Müller et al., 2008) and is arrived at via three steps (DCMS, 2015): (i) identification of creative occupations; (ii) calculating for each industry the proportion of jobs belonging to creative occupations; and (iii) identification of industries as creative that have a proportion of creative jobs above a specified threshold (30 per cent: DCMS, 2016, p. 7). DCMS publications do not specify the conceptual grounds for identifying particular occupations as creative, instead referring readers to Bakhshi et al. (2013) for a 'replicable method of determining whether an occupation is creative' (DCMS, 2016: 5 and 7; also DCMS, 2015: 4).

According to Bakhshi et al. (2013: 24) creative occupations combine cognitive skills (problem solving) and collaborative relationships 'to bring about differentiation to yield either novel, or significantly enhanced products whose final form is not fully specified in advance'. There is no single criterion for whether an occupation is creative. However, occupations displaying all or most of the following five characteristics 'are very likely to function as an economic resource that the creative industries require' (Bakhshi et al., 2013: 24).

1. *Novel process*: Achieving a goal, even one that has been established by others, in novel ways. Requirements are typically 'expressed semantically rather than in terms of process … the creative worker has a concept of what "kind" of effect is required but is not told how to produce that effect in the same way that … even a skilled technician is instructed' (Bakhshi et al., 2013: 22).
2. *Mechanisation resistant*: Specialised creative labour is not subject to automation.
3. *Non-repetitive or non-uniform function*: The cognitive task or problem to be solved is likely to vary each time it is applied, because each product is novel (at least to some extent).
4. *Creative contribution regardless of the context*: People in creative occupations can be found in industries not defined as creative.

5. *Interpretation rather than transformation*: Creative occupations do more than “shift” the product form or place or time.[39]

Occupations with four or five of these characteristics are deemed creative.[40] This approach is reflected in the DCMS list of nine creative occupational categories (DCMS, 2015): (i) Advertising and marketing; (ii) Architecture; (iii) Crafts; (iv) Design (product, graphic and fashion design); (v) Film, TV, video, radio and photography; (vi) IT, software and computer services; (vii) Publishing; (viii) Museums, galleries and libraries; and (ix) Music, performing and visual arts. There are other occupations that may be creative. However, whereas these nine creative occupations are concentrated into a narrow range of industries, other occupations with creative characteristics are dispersed across a broad range of industries (Bakhshi et al., 2013: 12-14). Table 19 lists the creative industries (with their SIC 2007 codes) together with the corresponding DCMS creative occupations.

[39] Bakhshi et al. (2013: 24) states that ‘for instance, a draftsperson/CAD technician takes an architect’s series of 2D drawings and renders them into a 3D model of the building. While great skill and a degree of creative judgement are involved, arguably the bulk of the novel output is generated by the architect and not by the draftsperson.’

[40] Bakhshi et al. (2013: 26) explain their use of the 2000 Standard Occupational Classifications from the Labour Force Survey: ‘All occupations were examined and the value ‘1’ assigned where the occupation complies with the criterion, and ‘0’ where it does not. The values were then totalled to provide an overall grid score. We set a threshold of four to qualify an occupation as creative.’ The creative occupation scores then determine whether the corresponding industries belong to the creative sector.

Table 19. Creative industries SIC (2007) codes and definitions alongside the DCMS list of nine creative occupational categories.

SIC07 Code	**SIC07 Description (Creative industries sector)**	**DCMS creative occupational categories**
3212	Manufacture of jewellery and related articles	Crafts
5811	Book publishing	Publishing
5812	Publishing of directories and mailing lists	Publishing
5813	Publishing of newspapers	Publishing
5814	Publishing of journals and periodicals	Publishing
5819	Other publishing activities	Publishing
5821	Publishing of computer games	IT, software and computer services
5829	Other software publishing	IT, software and computer services
5911	Motion picture, video and television programme production activities	Film, TV, video, radio and photography
5912	Motion picture, video and television programme post-production activities	Film, TV, video, radio and photography
5913	Motion picture, video and television programme distribution activities	Film, TV, video, radio and photography
5914	Motion picture projection activities	Film, TV, video, radio and photography
5920	Sound recording and music publishing activities	Music, performing and visual arts
6010	Radio broadcasting	Film, TV, video, radio and photography
6020	Television programming and broadcasting activities	Film, TV, video, radio and photography
6201	Computer programming activities	IT, software and computer services
6202	Computer consultancy activities	IT, software and computer services

7021	Public relations and communication activities	Advertising and marketing
7111	Architectural activities	Architecture
7311	Advertising agencies	Advertising and marketing
7312	Media representation	Advertising and marketing
7410	Specialised design activities	Design and designer fashion
7420	Photographic activities	Film, TV, video, radio and photography
7430	Translation and interpretation activities	Publishing
8552	Cultural education	Music, performing and visual arts
9001	Performing arts	Music, performing and visual arts
9002	Support activities to performing arts	Music, performing and visual arts
9003	Artistic creation	Music, performing and visual arts
9004	Operation of arts facilities	Music, performing and visual arts
9101	Library and archive activities	Museums, galleries and libraries

Source: DCMS (2022: Table 1b)

Turning to the intensity with which people in these nine creative occupational categories are employed across different industries, Bakhshi et al. (2013: 32) show that the distribution of creative occupational intensities by industry identifies creative industries as a coherent grouping: according to their corrected assignment of creative occupations to SIC 2007 codes, the mean creative employment intensity in the creative industries is 57 per cent (Standard Deviation 15%) and in the non-creative industries a mean of four per cent (Standard Deviation 9%).

ICT is not only one of the creative industries, but it has a unique role throughout the creative sector. On the one hand, ICT firms are themselves intensive employers from the creative occupations. According to Bakhshi et al. (2013: 9 and 34-36) in 2010 (the latest calculation available), the creative occupation intensities in “Other software publishing” (SIC07 5829), “Computer programming activities” (SIC07 6201) and “Computer consultancy activities” (SIC07 6202) were 60, 58, and 55 per cent respectively. (The other creative industry included in "IT, Software and Computer Services" – see Table 18 above – is "Publishing of computer games", for which calculations were volatile and based on too small a sample to be reliable.) On the other hand, Bakhshi et al. (2013: 17-19) demonstrate that ICT labour plays a special role within the creative industries 'when it is deployed in combination with other types of creative labour', 'because of the structural changes to the creative industries brought about by digitization, and more generally the impact of ICT'. In general, 'creative talent has great economic impact when working in tandem with ICT'.

Given the extensive overlap of the digital sector and the "Creative Sector", sharing similar creative occupation intensities, it is reasonable to consider the economic characteristics of firms in the digital sector – especially SMEs, micros, and freelancers – from the perspective of their creative sector characteristics (see Section 9, especially 9.8, below).

The creative industries are not only statistically distinct, but also constitute a coherent unit of analysis on economic grounds, because structural changes in the economy have given rise to new opportunities to which creative industries have responded in similar ways.

1) Broader economic developments have favoured the creative industries.
    a) *On the supply side*, information and communications technologies (ICT) have a strategic, cross-industry importance among the heterogeneous creative industries, which typically engage in the joint application of ICT and other creative skills. In particular, digitization 'provides the capacity to transcend the traditional barriers of service production … distance … time… quantity' (Bakhshi et al., 2013: 21). This is particularly evident in the growth in the creation and delivery of creative "content" for both consumers and firms. In addition, ICT has promoted "open innovation" (i.e., the use of external knowledge sources to inform, and collaborative contracts to enact, product development), which according to Bakhshi et al. (2013: 23) is characteristic of the production processes of creative industries.
    b) *On the demand side*, there are (i) the increasing importance of discretionary spending by consumers and (ii) the changing emphasis of business investment: consumers spend an increasing proportion of their income on products in which 'taste and subjective perception of experience predominate over pure quantity';[41] while 'businesses are investing more on creative services, such as design, advertising and software, than on more "tangible" expenditures' (Bakhshi et al., 2013, p. 21).
2) Because the economic functioning of these industries is grounded in the characteristics of their workforce (as detailed above), the responses of the creative industries have been conditioned by their intensive employment of people in creative occupations. Specialised labour applying cognitive skills to address customer needs in new ways gives creative industry firms the capacity to produce highly differentiated products 'adapted to customer needs' (Bakhshi et al., 2013: 22). In turn, this favours a business model in which 'the key requirement is no longer the production of large volumes at low prices, but a continuous

[41] According to Bakhshi et al., 2013: 21): 'In 1994, for the first time, UK families spent more on leisure products and services than on food. By 2004 they were spending twice as much.'

succession of small runs of products each varying from its predecessors … sufficiently highly prized … to attract the loyalty of a discriminating clientele' (Bakhshi et al., 2013: 22). In this model, creating and maintaining competitive advantage requires not only the legal defence of intellectual property (IP) (through copyright, trademarks and patents), but also non-IP methods such as 'first-mover advantage … in which the seller … creates and maintains a client base on the basis of brand, distinctiveness and "novelty"' (Bakhshi, 2013: 22).

Building on the above insights from Bakhshi et al. (2013), we can explain in addition why the creative sector is characterised by an imperative to innovate, which is a theme explored in Section 12 below.

12 ICT and intensity in intangible assets

12.1 Introduction: the intangibles economy and ICT

Competitiveness – hence, sustainability and growth – increasingly depends not only on tangible or physical assets (e.g., buildings and equipment) and finance but also on intangible (i.e., insubstantial) assets that give firms unique – or at least hard to copy – knowledge, know-how, and capabilities to innovate. In turn, innovation enables businesses both (i) to differentiate their products, gain market power and charge a premium price and/or (ii) to lower their costs of production.

Following the taxonomy and examples of Hazan et al. (2021: 5), radical or even incremental innovation of new products, new processes, new organisational forms, and new ways to market products requires four types of intangible assets:

1. **innovation capital**, arising from 'investments that build a company's intellectual property (IP)' (e.g., in R&D and design of either digital or physical products, or in creating artistic originals including books and films etc.);
2. **digital and analytics capital**, arising from investment in software (e.g., to manage databases and customer relationships, or to develop digital platforms and analytic models and algorithms);
3. **human and relational capital –** i.e. organisational capital – including developing
    a. human capital (e.g., building managerial and workforce skills through training),
    b. corporate culture (e.g., by changing from a sales to a customer focus), and
    c. business relationships and networks (e.g., supply chain management and managing open innovation from networks and ecosystems); and
4. **brand capital**, 'arising from investments in marketing and sales that build and improve brand equity' (e.g., broadcast or targeted promotions to gain new and retain existing customers).

Consistent with intangible assets being the drivers of innovation, since the 1990s, first in the USA and then in the UK, investment in intangibles has been consistently greater than investment in tangible assets (Haskel and Westlake, 2018: 23-27; Hazan et al., 2021: 1). The ICT sector produces both tangible and intangible outputs that contribute to the intangible economy; indeed, 'the digital economy goes hand in hand with the growing importance of intangibles' (Haskel and Westlake 2022: 220) without necessarily being synonymous with the intangible economy or its cause; indeed, the intangibles-rich economy predates and may have led to the development of modern ICT (Haskel and Westlake (2018: 29-30 and 220).

Nonetheless, the ICT sector makes more intensive use of intangibles than all other sectors except mining (Haskel and Westlake, 2022: 151; Hazan et al., 2021: 9-11).[42] Over the period 1995 to 2019, across the USA, nine EU countries and the UK, the average annual intangibles investment share of GVA for the ICT sector was 21.1 per cent, comprising: innovation capital (8.1%); data and analytics capital (6.1%); human and relational capital (4.5%); and brand capital (2.5%) (Hazan et al., 2021: 10). Accordingly, we now explore some of the implications for the ICT sector of its intangibles intensity.

12.2 Intangibles and industrial structure

We have seen that "digital Stoke" is characterised by one giant firm (bet365) and mainly SMEs, micro firms and freelancers. This industrial structure can be understood through the lens of intangible assets.

In recent decades, at both country and industry level, productivity dispersion between the most successful firms and the rest has been growing. Moreover, this has been a particular feature of the most intangible-intensive industries, notably in the ICT sector (Haskel and Westlake 2022: 29-30, 72 and 219). In turn, this may be related to firm size: for ICT, Table 4 (above) documents a continuous increase in turnover per employee from firms with no employees to 1-49, 50-249 and 250 or more employees.

A tendency towards polarisation in the ICT sector between the emergence of both a few large firms and many smaller firms has been related to features of intangible assets. The supply-side effects of scalability, spillovers, and synergies combine with demand-side network effects to favour the emergence of a few large firms (Haskel and Westlake 2018: 65-67, 105-06).

On the supply side, among the characteristics and implications of intangible assets are the following.

- Intangible assets tend to be *scaleable*, because – unlike tangible assets – they can be used simultaneously in different locations at relatively little cost (e.g., software, product designs, and operating procedures).
- Intangible assets enhance firms' "open innovation" (i.e. search for, together with technical and commercial exploitation of, intellectual property from outside the firm) by creating both search capability and "absorptive capacity" (i.e. capabilities to exploit knowledge and know-how *spillovers* from outside the firm). For example, R&D and training build capabilities to scope and exploit knowledge from outside the firm, while strategic hiring allows know-how – i.e., tacit knowledge – to be imported. Consistent with the importance of open innovation for SMEs in the ICT sector, Radicic and Pugh (2017) report evidence that R&D personnel (a proxy measure for absorptive capacity) make a

[42] Mining investment reflects mineral exploration, which is classed as intangible investment in national accounts.

major contribution to innovation performance (measured by the share of sales arising from new products and/or processes).

- Intangible assets promote *synergies* within the firm: (i) between intangible assets, such as R&D and design, or new ways to organise a business and market products; (ii) between tangible and intangible assets, such as using software to organise supply chains; and (iii) by way of the absorptive capacity to exploit complementarities between internal and external knowledge sources (Radicic et al. 2019).

On the demand side, as put by Haskel and Westlake (2018: 66): 'Scalability becomes supercharged with "network effects".' This is manifested in digital platform companies whose products connect otherwise fragmented groups of users to make markets ("transaction platforms" such as Amazon and Uber) or provide 'a common technology platform upon which others can build' ("innovation platforms" such as provided by Microsoft) (Wikipedia, *Platform Economy*). The network effect arises as each additional user makes the digital platform more valuable for existing and potential users, which incentivises platform companies to invest heavily in attracting new users. Global reach – impeded by regulatory regimes rather than geography – adds to the potential of platform companies to grow very large relatively quickly and thus tends towards industry concentration, 'a relatively small number of dominant large companies' (Haskel and Westlake 2018: 67).

Platform economics, however, also makes room for smaller businesses. 'This process includes the use of Application Programming Interfaces (APIs), which connect the data of third parties to the platform, and Software Development Kits (SDKs), which allow third parties to integrate their software with the platform' (Wikipedia, *Platform Economy*). Indeed, a successful platform can provide low-cost infrastructure for digital ecosystems (Choudary et al. 2013):

> In the context of digital platforms, ecosystems are collections of economic actors not controlled by the platform owner, yet who add value in ways that go beyond being a regular user. A common example is the community of independent developers who create applications for a platform, such as the many developers (both individuals and companies) that create apps for Facebook. With Microsoft, significant components of their ecosystem include not just developers, but computer hardware peripheral manufacturers, as well as maintenance and training providers (Wikipedia, *Platform Economy*).

In turn, large firms' platforms provide infrastructure that encourage entry of ICT start-ups and the emergence of SME, micro firms, and freelancers both (i) by providing access – without geographical limitations – to high growth markets and (ii) by lowering the costs of entry (for example, cloud computing facilities offered by companies like Microsoft and Amazon means that businesses no longer need to own their own tangible infrastructure of servers, software, etc. but can pay by use). Indeed, according to Yang et al. (2013) entry barriers in general are lower in the ICT sector than in non-ICT sectors.

Larger firms also make room for SMEs by influencing their business models. Rather than grow itself, the aim of the business may be to pioneer a new product and sell out to a large company (Haskel and Westlake 2022: 227). On the one hand, for larger firms, acquisition is a means of open innovation, which can enhance absorptive capacity and so alleviate innovation bottlenecks arising from limits on management attention ('the attention allocation problem', such that large firm managers can't focus on all the ideas and investments that might be needed to identify and exploit potential synergies) (Haskel and Westlake 2018: 83 and 110-11). On the other hand, while the need for synergies creates opportunities for start-ups (Haskel and Westlake, 2018: 105-06) the dependence of small firms on asset-based collateral makes it difficult to finance expansion (intangible assets are difficult to offer as security for a loan, because not only are they hard to value but also because they are typically sunk costs, meaning that they are difficult or impossible to liquidate in the event of default) (Haskel and Westlake 2018: 163-64; Haskel and Westlake 2022: 152). In addition, large firms create room for freelancers, who may be employed on a project basis without incurring the costs of permanent employment.

12.3 Open innovation, networking and cooperation

Opportunities for SMEs, micro firms, and freelancers in the ICT sector arise not only indirectly, via the characteristic scalability of intangible assets and the corresponding conditions created by platform firms, but also more directly from the characteristics of intangible assets. Because intellectual property is hard to protect (Haskel and Westlake 2018: 74-77), 'at least some knowledge comes into the firm by no investment at all' (Haskel and Westlake 2018: 53) – i.e., by way of spillovers. Consequently, compared to tangible assets, it is relatively easy for businesses to take advantage of intangible investments they do not make themselves: e.g., R&D, whereby one firm's innovations enable imitators to quickly follow (smart phones and their operating systems are a commonly cited example); while organisational and marketing innovations, and training methods can all be copied (Haskel and Westlake 2018: 72-73).

Open innovation allows smaller companies to identify and exploit knowledge "spillovers" and thus more easily achieve unique synergies – by combining ideas and technologies – and correspondingly differentiated products. Radicic and Pugh (2017: 78) summarise the open innovation literature on this point (supporting citations omitted):

> By accessing external knowledge sources to foster the introduction of new products and services, firms can experience cost and time savings ... shorter time to market ... and can create synergies in available internal and external resources and in developing new approaches to market ...

Open innovation is promoted by strategically important networks involving other businesses (customers, suppliers, competitors), external knowledge suppliers (consultants and other suppliers of professional services, research organisations, colleges, and universities), and public institutions:

> Being well networked, knowing about important developments in one's field, and having the standing to bring together collaborations, ask for favours, and coordinate partnerships becomes more important in a business where investments have greater spillovers (Haskel and Westlake 2018: 78).

For the ICT sector, these observations may apply with particular force in the presence of rapid technological and regulatory changes, which may otherwise make it difficult for SMEs to keep up and remain competitive. Moreover, these observations receive empirical support from Radicic and Pugh (2017: 90 and 97) who report that SMEs ‘operating in the ICT sector ... experience positive performance effects by using external knowledge from other firms’ and conclude that ‘ICT firms may benefit from the low cost and flexibility of trust relationships’.

In general, the literature suggests that SMEs – consistent with their limited financial and managerial resources – rarely exploit the more costly sources of external knowledge, such as IP licensing, but mostly engage in customer involvement and external networking, particularly informal networking (see Radicic and Pugh 2017 for supporting citations). Correspondingly, SMEs tend to be less involved in formal networks, defined by contractual relationships to prevent network partners from engaging in opportunistic behaviour, and more dependent on informal networks based on the shared experience of network partners and corresponding mutual trust and moral obligations, which can allow firms to explore and exploit tacit knowledge.

The importance of cooperation within networks for SME innovation generally identified in the research literature is summarised by Radicic et al. (2019: 3; citations omitted):

> SMEs innovate differently compared to large firms. Their main hampering factors are associated with the limited human and financial resources. While both SMEs and large firms can explore collaborations with different partners as a complementary source of innovation ... SMEs might be prone to use external knowledge to a larger degree than large firms ... Nowadays, firms can be found cooperating with a diverse network of parties, which enables them to access external knowledge and resources and, in that way, complement their internal innovation activities. The cooperation relationships investigated include: between firms within an enterprise group; with suppliers, customers, and competitors; with other private-sector firms (consultants, commercial labs and private R&D institutes); with Higher Education Institutions (HEIs); and with public-sector agencies.

12.4 ICT ecosystems

Among the standard characteristics of innovation networks is geographical proximity (similar to clusters), allowing face-to-face exchange of often tacit knowledge (Haskel and Westlake 2022: 60), and promoting social capital as an enabler of knowledge transfers and business arrangements. Above all, the key success factor of innovation networks is trust between network partners (Radicic and Pugh 2017; Haskel and Westlake 2018: 155-564). In the case of ICT, in particular, a theme less explored – to the best of our knowledge – is whether local networks are still important or whether they have been supplanted by – and, if so, to what extent – virtual or online networks? More than in any other sector, ICT comprises businesses naturally inclined towards virtual networking, hence highlighting in the context of the “Digital Stoke” project ‘the importance of examining the interaction between local and global networks’ for ‘future research and policy making concerning innovation networks’ noted by Lazzeretti et al. (2024: 8).

Together, the related theories referred to so far in Section 12 – knowledge spillovers, open innovation, formal and informal innovation networks, social capital (in particular, trust), and cooperation – suggest the importance of an environment — or ecosystem — conducive to innovation. Whereas the "cluster" concept tends to focus on geographic proximity, in line of descent from Marshal's "industrial districts" dating from the 1870s, for ICT businesses the innovation ecosystem may better be conceptualised as comprising two dimensions: i.e., both territorial (physical proximity) and virtual (digital platforms – as noted above – online forums, etc.).

An innovation and/or entrepreneurial ecosystem embraces institutions that co-evolve, so that each one co-determines the conditions in which the others develop. Accordingly, businesses are embedded in a dynamic system – i.e., one with multiple connections and feedback mechanisms – embracing other businesses (e.g., suppliers, customers, competitors), knowledge providers and brokers (e.g., universities, consultants, and professional services), the availability of human capital (e.g., schools, colleges and universities), financial institutions (e.g., banks and venture capital), and institutions – both private (e.g., media) and public (e.g., politics and government) – that shape the cultural and political environment. In turn, culture, politics, and corresponding public attitudes influence the regulatory environment, business taxation, and the degree of policy support for business. (On the importance of culture and political legitimacy for an intangibles-rich economy, see Haskel and Westlake 2022: 253-60.) From this perspective, the success of an individual business is the outcome not only of its own internal capabilities but also is conditioned by the other businesses and institutions within the ecosystem.

The territorial dimension of an ecosystem refers to physical or geographic proximity, cities, shared spaces, and technological infrastructures, while the virtual dimension encompasses digital platforms, online forums, and networks, some of which can be associated with leading companies (e.g., Apple, IBM, and Microsoft) (Feng et al. 2021) and/or promoted by political institutions (e.g., the EU's EU4Digital Initiative).[43] Of course, the territorial and virtual dimensions need not be separate but can be integrated; for example, Science Parks providing location-specific tangible assets such as facilities 'as well as intangible assets such as networks, know-how, and expert human resources' (Hibino et al. 2023: Abstract).

Among the territorial – or cluster – aspects of a thriving ecosystem is human capital. Intangible investments are particularly dependent on cognitive labour (software developers, designers, scientists, etc.) (Haskel and Westlake 2018: 28). In turn adequate labour supply depends on schools, colleges, and universities. However, in the case of the ICT sector, perhaps more than any other, the importance of local labour supply may have been reduced by remote working (Haskel and Westlake 2022: 259); indeed, at the extreme, working from home may mean that some ICT firms do not require a local workforce.

A range of possibilities may also apply to infrastructure. A successful cluster will force up house prices, yet affordable housing matters to the retention of key workers and thus the

[43] The EU4Digital Initiative 'aims to connect Eastern Partnership (EaP) innovation and start-up ecosystems to EU networks and close gaps between the two ecosystems to support innovation and start-ups, drawing on EU best practices, principles and standards'. ICT Innovation and Start-up Ecosystems - EU4Digital (eufordigital.eu)

sustainability of clusters (Haskel and Westlake 2018: 148). Moreover, affordable housing might attract workers to one location who work for ICT firms based in other locations but who are able to work remotely (or at least flexibly). If a location offers in addition to affordable housing affordable workspace, and local planning regulations promote both (Haskel and Westlake 2018: 149), then locally based ICT firms may additionally benefit from an enlarged pool of locally available labour.

12.5 Cities and the benefits of proximity

Cities may be attractive to ICT firms not just for their infrastructure – housing, transport, workspace, broadband, etc. – but also because knowledge spillovers and synergies are promoted by proximity (Haskel and Westlake 2018: 139):

> Cities provide an opportunity to profit both from spillovers (that is to say, benefitting from intangible investments made by other firms) and synergies (combining different intangibles to produce unexpectedly large benefits) ... In a world where intangibles are becoming more abundant and a more important part of the way businesses create value, the benefits to exploiting spillovers and synergies increase. And as these benefits increase, we would expect businesses and their employees to want to locate in diverse, growing cities where spillovers and synergies abound.

Even in the presence of global connectedness and virtual networks, cities may present additional – and potentially more intense – opportunities for interaction and collaboration (Haskel and Westlake 2018: 79). This may in part reflect the importance of spillovers not only within industries but even more so between industries, such that 'ideas or opportunities from one sector are extracted into another' (Haskel and Westlake 2018: 138-39). Indeed, between-industry spillovers may offer more potential opportunities for ICT firms than for firms in other sectors, because of the strategic role of ICT throughout the creative sector (see Section 11 above) and the economy-wide digitalisation agenda. In this case, an important feature of cities intending to promote their ICT ecosystems is to promote the provision of attractive places and convenient transport for people to come together to exchange ideas and find ways to cooperate (Haskel and Westlake, 2018: 149 and 155-56).

12.6 Inward investment and some policy implications

ICT clusters may be leveraged by attracting large private- and public-sector intangible investments (Haskel and Westlake, 2018: 222-23). On the one hand, from

> ... large, dominant firms that seem to have an ability to not only gain from their own investments but also to appropriate the benefits of other firms' investments ... what firms like Google or Facebook are doing when they spend liberally on supporting "start-up ecosystems" in major cities ...

In addition to self-interest, public policy can be leveraged to encourage inward investment: e.g., '... big tech companies of the future that enjoy effective monopolies due to networks will be encouraged to invest in R&D and other intangibles as part of their license to operate'.

On the other hand, there may be structural reasons why spillovers from public-sector investment may be becoming more important for ICT ecosystems. In the past decade or so, the growth of intangibles investment has slowed, contributing to productivity slowdown across the developed economies, thereby generating fewer spillovers (Haskel and Westlake 2018: 107-09 and 116). Accordingly, spillovers from public sector investments – including from universities and intermediate knowledge-dissemination institutions – may be becoming more important for ICT ecosystems. (Haskel and Westlake 2018: 224-25 provide evidence on the benefits of university research both for national productivity and for universities' local economies, showing that the local benefits are related to (i) local firms' absorptive capacity, especially the skills base, and (ii) the close relationships between firms' technology and university research that might be expected in a well-functioning ecosystem.) Because, in the UK, many of the policy levers for attracting inward investments are in the hands of central government, local authorities may need to promote promising ecosystems by making them "readable" (Haskel and Westlake 2018: 156), particularly when these are emergent and as yet not strongly associated with the location.

Together with inward investment into the local ICT ecosystem, local authorities have a role to play in attracting the interest of financial institutions and human resources. Despite the opportunities provided by open innovation to benefit from spillovers and so lower the costs of innovation, other structural factors associated with intensive investment in intangible assets tend to keep firms small. In general, the barriers to SME growth are outlined by Radicic and Pugh (2017: 4):

> In general, the innovation literature suggests that SMEs innovate differently than do large firms because of differences in resources. The main disadvantage of SMEs in this respect is associated with limited financial resources (lack of internal financial funds for innovation, credit constraints) and human resources (lack of management and entrepreneurial competences, issues in employing and retaining skilled workers, lack of marketing expertise) ...

These barriers apply with particular force to SMEs in the ICT sector. As indicated above, the sunk cost nature of intangible assets makes it difficult to finance expansion. Moreover, emergent properties of intensity in intangibles assets amplify the demands on human capital. Management competences become more important in the pursuit of competitive advantage, particularly the ability to scale up companies and to identify and exploit synergies (Haskel and Westlake 2018: 186-87):

> It's pretty unusual that a tangible asset is going to be a source of distinctiveness ... It's much more likely that the types of intangible assets we have talked about ... are going to be distinctive: reputation, product design, trained employees, providing customer service. Indeed, perhaps the most distinctive asset will be the ability to weave all these assets together ...

Likewise, increasing intensity in intangibles gives rise to increasing demands on entrepreneurial competences such as the ability to spot commercial opportunities and risk taking.

- On the one hand, although conditions for creating synergies can be managed (e.g., by organisational forms that encourage internal information flows and external networking), the unpredictable emergence of potential synergies requires an entrepreneurial response to new opportunities.

- On the other hand, an emergent property of intensity in intangibles is increased business uncertainty (Haskel and Westlake 2018: 87): in the presence of spillovers and imperfect IP protection, intangible assets are difficult to value; and to the extent that intangible assets are likely to be unique to the firm, with little or no external value, they are sunk costs, such that if investments do not succeed they are worthless.

The corollary is increased demands on entrepreneurial risk taking.

Whereas local authorities have some policy levers with which to influence the supply of skilled workers and managerial talent – e.g., planning regulations to shape the provision of attractive housing and workspace, education and training policy – attracting and embedding finance into an ecosystem cannot be quickly achieved (Haskel and Westlake 2018: 87). Bank finance is constrained because intangible assets are typically sunk costs (as explained above), while equity finance is not much available to SMEs (and owners typically dislike giving up equity) (Haskel and Westlake 2018: 163-68). Venture capital – based on equity not debt – is suitable for potentially fast-growing SMEs; and even more so if SMEs are 'plugged into open innovation networks', because (Haskel and Westlake 2018: 176):

> Particularly in fields like software and Internet services, the value of an intangible investment depends heavily on how it fits into a wider technological ecosystem: a new app may be worth a lot more if it integrates with Google Calendar; an analytical software business may be worth more if it can develop a partnership with an online ad distribution business.

Embedding venture capital is a long-term project, because 'the social ties on which venture capital depends seem to take time to establish in new industries' (Haskel and Westlake 2018: 178). Nonetheless, local authorities can make their ecosystems more attractive by a long-term sustained approach to investing in infrastructure to improve the functioning of ecosystems, business support policies (including subsidies), intelligent procurement, and facilitating publicly funded university research into basic intangibles, which venture capital is reluctant to fund because spillovers make the returns too difficult to appropriate. To underpin consistent policy priorities, local authority leaders will most likely need to work to create a business-friendly culture and corresponding political consensus (Haskel and Westlake 2022: 257-58).

12.7 Bifurcated industrial structure: the articulation of businesses of different sizes

Because the ICT sector is intensive in intangible assets it tends towards a bifurcation between (i) a small number of successfully scaled-up platform businesses and (ii) many SMEs, micro businesses, and freelancers. Stoke apparently fits this pattern being host to one very large platform firm (bet365) and many (much) smaller businesses. Accordingly, to understand the ICT ecosystem, we will need to analyse the articulation of businesses of different sizes. Lines of enquiry will ask whether there is a bet365 effect. One potential effect is via the local labour market. If bet365 attracts ICT employees to the area, might some of these eventually leave to start up new businesses? (Although the incentive to do so might be limited to the extent that bet365 employees derive their value from its proprietary synergies; Haskel and Westlake 2018: 86). Alternatively, could the presence of bet365 drive up wages and thereby have a dampening effect on business formation? Could there be an "anchor institution" effect, creating conditions for start-ups and inward investment?

12.8 Monopolistic competition

Whereas large platform firms such as bet365 are in competition with a relatively few similarly large competitors and so may be characterized as oligopolies, in this Section we focus on the many SMEs, micro firms and freelancers in digital industries that share the distinguishing features and heterogeneity of firms in the creative sector more generally (see Section 8 above).

Typically, firms in the creative industries are of small size [44] producing novel and thus highly differentiated products [45] (Caves, 2002; UNCTAD, 2010; Bird et al., 2020). We can make a similar judgement for the ICT sector. For ICT firms, Manjón et al. (2016: 1)

> consider innovation as a key issue for business strategy. Because it is expected that it triggers competitiveness and firm performance … firms that do not innovate face underperformance or dissolution.

Innovation for SMEs in particular, 'involves near continual updating and expansion of software', which is driven on the demand side by customers' needs and tailored projects – 'specific customer needs … in close interaction with clients' – as well as on the supply side by technical and organizational capabilities (Manjón et al., 2016: 1 and 6-7).

ICT firms like creative industry firms more generally have their origin in individual creativity and skill (for ICT firms, see Haskel and Westlake 2018: 28; for the creative sector, see Section 11 above). Moreover, in this Section (above) we have established that ICT firms typically make intensive use of intangible assets. And, according to Haskel and Westlake (2022: 226):

> … intangible capital tends to be heterogenous: one idea, one brand, one operating process is usually not like any others. One consequence of this heterogeneity is that the tactics that intangible-rich businesses use to maintain competitive advantage … are also highly varied …

Together, the stylized facts suggest that the theory of monopolistic competition can yield insights about the functioning of most businesses in the digital industries. (In North Staffordshire, for example, the typical ICT business in Stoke-on-Trent is "small" [11-50 employees] and in both Newcastle-under-Lyme and Staffordshire Moorlands "micro" [0-9 employees]; see Table 12 above.)

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[44] More than 9 in 10 firms in the creative industries are microenterprises. Additionally, in the representative sample of creative industry firms in Austria gathered by Müller et al. (2008), 35% are sole traders and the median number of employees is three.

[45] Bird et al. (2020: 3) note: 'Producing novel outputs and services is the essence of any enterprise in the creative industries.'

Monopolistic competition is a form of market structure arising from firms whose functioning combines monopolistic elements in the short run and – as other firms adjust – competitive elements in the long run. Continuous innovation is the enabler of sustained profitability for firms competing in monopolistically competitive markets.

In the short run, first-mover creative firms innovate products for clients that – because they are novel – give them a temporary monopoly and thus the market power to charge a high price and appropriate high profits. However, this state cannot persist. **In the long-run**, because ICT firms – like creative firms generally – tend to be small and numerous, competitors produce more or less close substitute products, which – as they are brought to market – increase supply, which causes the first movers to suffer from falling demand, reduced market power and, hence, lower prices and falling profits. Worse, because new entrants will have been attracted by the initially high profits of the first mover, firms in such an industry tend to suffer from chronic over-capacity (i.e. typically, there are insufficient new orders to keep their resources – labour and capital – fully occupied).[46] In the long run, therefore, the small firms in such an industry may typically just about cover costs, including just sufficient profit to stay in business but not to invest and grow.

This theory implies that, even more than firms in other sectors, creative firms are continuously confronted by competitive threats to their profitability. Conversely, if small creative firms are to thrive and grow then they must continuously innovate so that they are perpetually in the short term. In this case, continuous innovation means continuous renewal of monopoly positions and the market power needed to maintain high profitability. Moreover, given that cognitive ability cannot be collateralised for bank loans, high profitability and corresponding retained earnings are likely to be particularly important for firm growth in the creative sector. Accordingly, given that entrepreneurs do not set up businesses to be content with covering costs,[47] the imperative to innovate is particularly strong in the creative sector.[48] Consequently, policy makers concerned with firm growth and employment in the creative sector need to understand (i) the nature of innovation in the creative sector and (ii) what public policy can do to promote it.

An alternative business model to continuous innovation for a creative firm may be to do one big "radical" innovation and then sell-out to a larger company. This model may be particularly feasible for digital firms (e.g., software engineers). However, from the

[46] This is an informal interpretation of the "excess capacity theorem".
[47] However, some findings do suggest that financial gains might not be the most important goal for all firms in the creative industries. The location choices of creative firms can be based on the lifestyle preferences of the entrepreneurs (i.e. locating firms in rural areas) (Chaston, 2008). Chaston (2008) finds that, in the small firms operating in the creative industries, the importance of other factors (e.g., self-expression, work-life balance) can be greater than that of financial gain. Looking at different subgroups, the author concludes that for some small creative industry firms financial performance is indeed important, while for other subgroups less so.
[48] Compared to the rest of the economy, the firms in the creative industries are more engaged in all types of innovation: (1) product innovation (33% in creative industries compared to 22% in the rest of the economy); (2) new to the market innovation (14% compared to 8%); (3) process innovation (21% compared to 16%); (4) organisation innovation (52% compared to 44%); and, finally, (5) ongoing innovation activities (32% compared to 20%) (Gkypali and Roper, 2018).

perspective of policy makers – especially at the regional or local level – takeover may effectively sever whatever links there are between the creative firm and the local economy. The local innovation ecosystem may suffer damage from the removal of a particularly innovative firm, while employment opportunities and potential tax revenue may be lost.

12.9 Innovation-led competition and productivity dispersion

The previous section hypothesises that firms in the digital sector, because they produce heterogeneous products that can be more or less rapidly substituted by competitors, are necessarily engaged in innovation-led competition. If so, then further characteristics of the digital sector may be observed.

Baher (2017: 2) notes that 'large productivity dispersion within narrowly defined sectors has been widely documented'. Aghion et al. (2021: 58-60) summarise recent theory and empirical evidence to explain why innovation-led competition may tend to bifurcate firms into two groups:

- firms that are 'close to the technological frontier in their sector, meaning that their productivity is close to the maximum level of productivity in the sector'; and
- firms that are 'far from the technological frontier, meaning that their productivity is far below the maximum productivity in the sector'.

The frontier or "best practice" firms earn substantial profits, while those lagging best practice have low or zero profits (i.e. profits just sufficient to keep the firm in business but insufficient to invest and grow).

There may be multiple causes of such bifurcation. For example, varying degrees of absorptive capacity – in turn influenced by factors such as management quality (hence, organisational responsiveness to open innovation opportunities) (Grandinetti, 2016), investment in R&D personnel (Radicic and Pugh, 2017), and the extent and quality of external collaboration (Radicic and Pugh, 2017; Radicic et al. 2019) – will determine, in turn, variable rates of diffusion of best practice, varying innovation performance and thus varying positions with respect to the technological frontier. Moreover, these differences – whatever their cause(s) – may be reinforced by innovation-led competition.

According to Aghion et al. (2021: 58-59), competition tends to '*incite'* firms at the frontier to innovate, while firms behind the frontier are likely to be '*discouraged*'' as the performance distance increases with advances among the frontier firms.

> Strikingly, empirical studies confirm firms ... close to the technological frontier innovate more in order to escape competition, whereas firms that are far from the technological frontier will be discouraged by competition ... [49]

[49] In turn, this tendency towards bifurcation may be reflected in wage differentiation (Aghion et al., 2021: 85-87): '... at all ages, the wages of an unskilled worker are noticeably higher in an innovative firm than in a noninnovative firm.' The same is observed, albeit to a lesser extent, for workers with intermediate skills, although not for highly skilled employees.

Moreover, 'an increase in the difference in productivity between "leader" firms and "laggard" firms in the various sectors of the economy', is consistent with the observation that (Aghion et al., 2021: 119):

> ... firms that have become leaders in a given sector ... are then more inclined to invest in innovation in order to increase their technological lead over the laggards, knowing that the laggards will have less chance of catching up with them ... The result is that the gap between leader and laggard firms has widened on average.

The theory and international evidence advanced by Aghion et al. (2021) that links innovation-led competition with dispersion of firms' productivity within sectors chimes well with evidence for the UK advanced by the Productivity Institute (Coyle et al., 2023: 10; see also 33):

> The UK business landscape is characterised by a relatively long tail of less productive firms ... the 50 per cent of firms in the lower half of the productivity distribution (... most of them small firms) only contribute one-tenth of a percent to aggregate productivity ...

In the UK, sectoral productivity dispersion is related to geographic productivity dispersion (Coyle et al., 2023: 15).

> There is overwhelming evidence that firms which underperform on productivity are concentrated in less-well performing regions, which clearly links to the wider point about persistent productivity underperformance in areas outside London and the South East ... One UK specific feature is the significant underperformance of major second-tier cities.

The confluence of sectoral and locational productivity dispersion has been noted by the UK's "Levelling Up" White Paper (HM Government, 2022: 166).

> Despite its excellent research base, the UK is 30th in the world for knowledge diffusion and has a significant "long tail" of low-productivity firms ... Evidence suggests that companies in London and the South East tend to be quicker to adopt and disseminate new technologies than those in ... places with a large proportion of SMEs, which tend to be further from the productivity frontier.

According to Ioramashvili et al. (2024: 1-2), such a geographic productivity dispersion within the ICT sector could arise as 'promising small businesses' concentrate in major tech hubs, for one or both of two reasons: (i) attracted by their 'localised markets for ... acquisition by larger companies'; or (ii) by 'the financing ladder for digital companies', because the 'venture capital needed for growth is spatially located in a few places'. While Ioramashvili et al. (2024: 3) focus on the US, Big Tech (i.e., Microsoft, Apple, Oracle, Adobe, Amazon, Alphabet and Facebook) acquisitions beyond the US are also concentrated on major tech hubs: from 48 acquisitions in the UK between 1987 and 2020, 34 were located in London and 9 in the South East. Moreover, venture capital is likewise concentrated in London, although venture capital investments into fast growth businesses elsewhere are 'happening not only in the South East, but across the Midlands, North and Scotland' (KPMG 2022: 2).[50] In turn, because venture capital – by way not only of finance but also of associated guidance, mentoring and networking – boosts the innovation and growth of supported firms relative to similar non-supported firms (Aghion et al., 2021: 239-40), the geographic concentration of venture capital may exacerbate geographic productivity dispersion.

One reason why productivity dispersion is important for geographic locations – whether nations, regions or cities – is that the presence of highly productive firms increases the export base while a concentration of low-productivity firms reduces export potential. Current thinking in the international trade literature links the productivity dimension of firm heterogeneity to participation in foreign markets. According to Melitz (2003) high-productivity firms can surmount the additional fixed costs of operating in international markets and so self-select into export markets, whereas less productive firms are less able to surmount these additional fixed costs and so remain confined to the domestic market. Moreover, following Aghion et al. (2021), we may conjecture that low-productivity firms may be "discouraged" from innovation by foreign competition and so suffer increasing risk of being out-competed even in their home market.

A related reason why productivity dispersion is important, is that it conditions the resilience of both sectors and locations to external shocks. Aghion et al. (2021) theorise that frontier firms experience increased competition as "incitement" to innovate, while firms behind the frontier may be "discouraged" from innovating. Accordingly, Aghion et al. (2021: 256) hypothesise that the shock of increased competition from Chinese exports "should have had a particularly negative effect on firms far from the technological frontier but a positive effect on those close to the frontier". This prediction is supported by the following evidence:

> This is in fact what we find in France for the period 1995-2007. On average, the effect of the Chinese import shock on gross revenues, employment, and survival probability is negative ... But when we distinguish between firms close to the technological frontier and those far away, our conjecture is confirmed: the Chinese shock had a negative effect on innovation in firms far away from the technological frontier (defined as the least productive 10 percent) but a positive effect on those closest to the frontier (defined as the most productive 10 percent).

The corollary for cities and regions is that the presence of highly productive firms improves their resilience to shocks while a concentration of low-productivity firms increases the vulnerability of their sources of employment and wealth creation. According to Aghion et al. (2021: 256) a policy corollary is that trade barriers are not a useful response to increased competitive pressure – indeed, are likely to prove counter-productive. Instead, policies are needed 'to encourage investment in innovation' – such as subsiding R&D (Aghion et al. (2021: 260) – 'while reallocating resources and jobs from less productive to more productive

[50] According to KPMG (2022: 2): 'There was a total of 745 deals for UK scaleups completed in Q1 2022, raising over £6.9 ($9) billion. In London, £5.2 ($6.8) billion was invested across 411 deals; and the wider UK regions and nations attracted £1.7 ($2.2) billion across 344 deals.'

firms'. In turn, this suggests that the appropriate policy level may be local or regional rather than national.

Within the UK, Stoke is an area of relatively low productivity (78% of the UK average: see Figure 4: Subregional productivity in the UK - Office for National Statistics (ons.gov.uk); see also above – Section 4.2, Table 7; and Appendix C). Accordingly, a particular concern for Stoke is that it might be host to a concentration of digital businesses behind rather than at or near the technological frontier (Coyle et al., 2023: 10):

> ... the underperformance of many small firms is a concern from a social and well-being point of view, especially in regions that do not have many of the most productive firms.

Yet, as we concluded our analysis of the available data (Sections 5.1 and 5.2), the average productivity of digital sector firms in Stoke is at or even well above the national average. Nonetheless, behind these averages, the evidence also suggests considerable productivity dispersion. Accordingly, in Stoke as nationally, there is likely to be a more or less long "tail" of digital firms operating with lower-than-average productivity and which, therefore, are likely to benefit from publicly supported knowledge transfer programmes.

12.10 Some policy challenges

A reason for stressing the concept of the ecosystem rather than clustering is that the development of the digital sector in Stoke has been organic – market-led – rather than planned or policy-led by national or local government (see Section 5.2). However, this does not mean no role for public policy.

In Section 9.8 we explained the existential importance of innovation for creative sector firms. Theory suggests that the ***managerial corollary*** for digital firms is two-fold:

1. non-technological innovation, especially marketing strategy, may prolong the short term of premium price and high profits but cannot maintain it indefinitely; and
2. technological innovation – new processes and new products – is necessary to command premium prices and high profits over time, and therefore to enact a strategy for firm growth.

The corollary for ***public policy***, particularly in partnership with colleges, universities and other providers of management education and consultancy advice, is likewise two-fold: (i) to support non-technological innovation to help firms maintain existing markets and enter new markets (including export markets); and (ii) to support activities and infrastructure that enable technological innovation.

At the local level, these ends are most effectively promoted within a well-functioning digital ecosystem. In turn, this presents multiple challenges to local and regional governments, including:

- through planning, education, and strategic investment policies, creating or enabling infrastructure, whether tangible (e.g., low-cost housing and workspace, broadband coverage and transport), intangible (e.g., education and skills, knowledge transfer, a business-friendly culture, and an environment in which face-to-face interactions and social capital can flourish), or both (e.g., Science Parks);

- attracting inward investment from both the private and public sectors, including by making the attractive features of the local ecosystem "readable" – i.e., by profile raising; and
- aligning procurement, business support policies, and working with local universities to promote (i) publicly-funded university research into basic intangibles and (ii) knowledge transfer initiatives to develop the ICT ecosystem into an attractive environment for start-ups and venture capital.

Moreover, the policy environment needs to consistent and sustained over time – much longer than the electoral cycle – and underpinned by political legitimacy.

The innovation ecosystems literature suggests that the role of public policy may be less related to the creation of innovation ecosystems and much more to do with their well-functioning and consolidation (Radicic et al. 2020). In this case, the role of public policy – especially at the local level – is to be systems conforming rather than systems creating.

In the following Part 4, we draw upon both the preceding analysis of secondary data and the theoretical discussion to inform exploratory empirical investigation of "digital Stoke".

Part 4. Next steps: Using the secondary data analysis and the characteristics of digital industries and firms to inform data capture instruments

13 Procedure

This section provides an "audit trail" for how we used our secondary data analysis and assessment of digital sector characteristics to derive (i) Research Themes/Questions/Objectives and (ii) corresponding draft survey and interview questions. Accordingly, we explain and document how we developed our data capture instruments for investigating the emerging ICT sector in Stoke-on-Trent: namely, a survey questionnaire; and an interview schedule with variants for businesses, business support institutions, and local policy makers. The findings generated by these data capture instruments will be reported together with other primary research findings in Report 2.

Our procedure entails the following steps.

Step 1. A concordance table was compiled (i) to list themes from the secondary data analysis and assessment of digital sector characteristics and (ii) to match these with corresponding Research Themes/Questions/Objectives (see Appendix F). Secondary data analysis and digital sector characteristics suggested 15 broad themes for exploratory research:

1. Business demographics, including age, origins and growth of businesses in Stoke's digital sector;
2. Business characteristics suggested by market structure conjectures;
3. Innovation;
4. Business models and business support;
5. bet365 effects;
6. Business assets (inputs) (I): People;
7. Business assets (inputs) (II): the mix of tangible and non-tangible assets;
8. The ecosystem (I): virtual (i.e. not tied to any particular location);
9. The ecosystem (II): local;
10. Access to finance;
11. Open innovation;
12. Networks;
13. Infrastructure;
14. Inward investment; and
15. Productivity – level, growth and dispersion.

Most of these themes were judged to be best addressed initially by closed survey questions for digital businesses. However, two – bet365 effects and Inward investment – were judged to be best suited to open-ended interview questions (partly because we have fewer guidelines on what we need to ask, and partly because these questions will be addressed not only to the broad range of digital firms but also to bet365 and local policy makers). However, administering the questionnaire first will provide a platform for all these themes to be followed up and developed by subsequent interviews. In exploratory research, not all themes can be anticipated by analysing existing data and/or ICT sector characteristics. Accordingly, this survey followed by interview sequence allows for emergent themes to be explored by means of extensive semi-structured interviewing.

Step 2. For each of the 15 Research Themes/Questions/Objectives, Appendix G sets out the corresponding first-draft survey questions (these are grey shaded). These draft questions were later refined via intensive discussion and piloting to produce the final versions. Finally, some draft questions were later dropped to keep the survey and interview questions to a feasible number, while others were added.

The implemented Questionnaire Survey and Interview Schedules will be posted separately on the project website.

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