Spring 7-10-2024

Exploring the Productivity Puzzle: The Relationship between Technology Investment and Organisational Productivity in UK SMEs

Maria Kutar
University of Salford, m.kutar@salford.ac.uk

Marie Griffiths
University of Salford, m.griffiths@salford.ac.uk

Tony Syme
University of Salford, r.a.syme@salford.ac.uk

Subrahmaniam Krishnan-Harihara
University of Salford, S.Krishnan-Harihara@salford.ac.uk

Aadya Bahl
aadyabahl10@gmail.com

See next page for additional authors

Authors

Maria Kutar, Marie Griffiths, Tony Syme, Subrahmaniam Krishnan-Harihara, Aadya Bahl, and Toluwanimi Ojutiku

Exploring the Productivity Puzzle: The Relationship between Technology Investment and Organisational Productivity in UK SMEs

Maria Kutar, Marie Griffiths, Tony Syme, Subrahmaniam, Aadya Bahl, Toluwanimi Ojutiku
Salford Business School, University of Salford, UK

Abstract

The UK has suffered declining growth in productivity over many decades and there have been several attempts to study the reason for this declining growth in UK productivity. Various potential reasons including the transition to lower productivity sectors and the lack of sufficient high-skilled workers have been suggested to explain the productivity puzzle. One factor affecting productivity is firm investment in technology, an area where the evidence remains decidedly mixed. This paper presents the background to an ongoing project investigating the link between technology adoption, decision making and in-firm productivity. The project proposes to pair organisations with high productivity with organisations with low productivity and seeks to find out whether mentoring between senior managements teams from the high productivity category can yield a positive outcome for organisations with low productivity.

Keywords: Technology adoption, digital adoption, productivity, productivity puzzle, technology leadership,

1. Introduction

The UK's productivity puzzle – the declining growth in productivity - remains unsolved over many decades and continues to be a conundrum for the foreseeable future. This paper, unapologetically, contributes to the growing volume of research and analysis on productivity. Conversely, we make the observation, that this important aspect of business growth, has sadly dropped in favour from Information System publications. Information System scholars such as Lucas (1999) and Pinsonneault and Rivard (1999) and Dos Santos and Sussman (2000) who have historically contributed to this area, maybe finding a more natural home in Operational Research journals? Considering the widely held perception of the relationship between productivity and IT investment as a crucial factor for economic development (Schreyer, 2001), we argue that this gap warrants further attention albeit in a different study. Scholars and policymakers alike have sought to understand the

determinants of productivity (Venturini, 2015), particularly in the context of the United Kingdom. With technology advancing faster than ever before, there has been an increased interest in understanding its impact on productivity. However, the relationship between technology and productivity is not straightforward and it these dynamics, specifically, that is the focus of our study. Despite the longstanding perception that technological innovation should lead to enhanced productivity (Brynjolfsson and Petropoulos 2021), the evidence to support this is mixed. In fact, the term 'productivity paradox' (also referred to as 'Solow's paradox') emerged following studies that suggested that there was no significant effect on firm performance following investment in information technology (Loveman, 1994; Morrison, 1997; Barua, Kriebel and Mukhopadhyay, 1995). However, we argue that recent research proposes that the relationship between technology investment and productivity is more nuanced – it is not simply that financial investment will or will not lead to productivity gain, rather the organisational context including management and innovation approaches can influence the impact of that investment.

This project has been funded by The Productivity Institute, via UK Research and Innovation (UKRI). The study aims to understand the differences in approach to technology investment between SME organisations with high productivity and organisations with low productivity, and whether mentoring between senior managements teams from the high productivity category can yield a positive outcome for organisations with low productivity. The long-term goal is to improve strategic decision-making of SME management in relation to technology investment, enabling related productivity gains to be realised.

We have framed the following research questions:

- What are the organisational factors that contribute to technology investment decisions that improve productivity in organisations?
- How can this knowledge and expertise be captured and be shared with other SMEs?

The questions are addressed through a 6-month project to pilot a mentoring scheme for SMEs in a UK location recognised as having low productivity. The project firstly defines a firm selection methodology which assesses the productivity of SMEs, then closely oversees a clearly defined mentoring scheme, which is then evaluated. The outputs and evaluation of the mentoring scheme are used to gain an understanding of the organisational factors impacting technology investment decision making, and how

this influences firm level productivity. In the long term, the longitudinal data can be examined to identify whether there is an impact on firm productivity.

In this paper we set out the background to the research and provide an overview of the firm selection methodology and mentoring scheme. We explain the expected outputs which will be realised during project delivery. The project is currently in progress. It will be completed in March 2024; results will be presented at the conference. A literature review with two strands follows. The first strand takes the productivity puzzle as its theme, looking at economic growth and necessary skillsets. The second strand explores the nuanced relationship between technology investments and productivity. A full explanation of the project and associated methodology is provided, as are the project deliverables, but actual results will be presented at the conference following project completion.

2. Literature Review

2.1. The Productivity Puzzle

The "productivity puzzle" in the UK, which refers to a declining growth in productivity, has long intrigued researchers, with many theorising the reasons behind its decline. Remes, Mischke and Krishnan (2018) studied the trends in productivity, noting three major waves, with "digitalisation" being the most recent one. They stated that the benefits of the third wave have not fully materialised due to adoption barriers, lag effects and transition costs, and identified a shift to relatively low-productivity sectors such as services, and the public sector in areas of healthcare and education. Identified top sectors that also contributed to declining productivity in the UK were manufacturing, ICT, and finance and insurance. Coyle and Mei (2023), too, reached a similar conclusion by decomposing growth into contributions from different subsectors, and sectors, rather than adopting a firm-level perspective. Using the Tornqvist framework, they used data from the Office of National Statistics (ONS) to measure changes in productivity growth between 1998 and 2019. The findings attributed the productivity growth slowdown to transport equipment and pharmaceuticals within the manufacturing sector and to the computer software and telecommunication sub-sectors within ICT.

The UK Government, Skills and Productivity Board in the UK (which was dissolved in 2022, becoming Unit for Future Skills UFS) also proposed that productivity varies across a wide range of economic sectors, and that some regions may perform badly due to their specialisation in low productivity industries. The Levelling Up White Paper (HM Government, 2022), supporting this finding about regional productivity disparity, suggested six "capitals" that drove this including human capital (alongside social, financial, physical , institutional and intangible). McCann (2018) further added low levels of innovation and knowledge diffusion as causes of declining productivity, citing inadequate management and workplace relations as important contributing factors.

2.2. Skills and Qualifications

When we investigate empirical literature around skills exclusively, there is an emerging theme around job polarisation and a skills mismatch. For the former theme, Acemoglu and Autor (2011) examine the relationship between technological change, the nature of tasks performed in the workplace, and the demand for different types of skills. The analysis primarily focuses on the American economy but also references countries in Europe, including the UK. The study found that technological change has a polarizing effect on the job market, as skill demand for routine tasks, both manual and cognitive in nature, is declining due to automation. In contrast, the demand for non-routine jobs, including knowledge roles that involve problem-solving and creative activities, such as professional, managerial, technical, and creative occupations, has increased. This shift in demand has favoured workers with higher levels of education and skills, leading to increasing wage inequality. The rise in skill-based technological change has contributed to this wage disparity, as the demand for skilled workers has outpaced the supply. However, the study also notes that there is a growing skill demand in non-routine manual roles that require interpersonal and environmental adaptability, such as food preparation and service, home health aides, and ground cleaning and maintenance. These jobs generally do not require extensive formal education beyond high school qualifications or extensive training, but necessitate adaptability and responsiveness that are challenging to automate or offshore. The combination of these effects has resulted in a hollowing out of middle-skill jobs, pushing labour into two polarising extremes. This shift has fostered employment growth in both high-wage, high-skill occupations and low-wage, low-

skill occupations. Cavaglia and Etheridge (2020) use price wage changes to draw the same conclusion, adding that the difference between price and average salary changes is the largest in high-skill non-routine occupations.

Montresor (2019) corroborates the claim that hollowing out for middle-skills jobs is due to growing technology; however, the paper attributes the growth of high-skill non-routine jobs to an increase in the number of graduates as opposed to technology. It finds that the rising supply of graduates intensifies competition for jobs along the employment distribution. Thus, middle-skilled individuals who lose their jobs, are more prone to finding a lower-skilled job, however, this loss can also reduce the chance lower-skilled workers have of climbing up the ladder. Multiple Organisation for Economic Co-operation and Development (OECD) working papers have further analysed the impact of skills and qualifications mismatch on productivity (Desjardins and Rubenson, 2011; McGowan, and Andrews, 2015). It suggests that qualifications alone may not reflect a skills mismatch, as they do not account for differences in the quality and orientation of education, additional training, and skills gained or lost beyond formal qualifications. The paper highlights the importance of considering the relationship between skills and productivity. The theoretical underpinnings of the research suggest indirect and direct channels through which the skills mismatch affects productivity.

According to other researchers like Green and Zhu (2010) and Battu, Belfield and Sloane (1999), overqualified or overskilled workers would have an incentive to move on to a job that better reflects their education and experience, suggesting that they experience lower job satisfaction. Lower job satisfaction would then lead to decreased job effort, higher absenteeism, and lower productivity. This can lead to a higher job turnover where over-skilled workers are more likely to change jobs, and less likely to take part in training compared to their well-matched workers with the same qualifications. Their review of the literature also suggests that skills shortages reported in various industry-level studies lower productivity growth, technological adoption, and investment drastically.

While previous research has primarily focused on within-firm productivity improvements, one paper takes a broader perspective and examines productivity at the economy-wide level. Desjardins and Rubenson's (2011) findings indicate that over-skilling within a given firm can harm overall productivity, as more productive firms may struggle to expand due to a lack of suitable labour. The skill level was measured

using a self-assessment method limited to literacy and numeracy. However, it does give us some insight into the relationship between skills and productivity. Desjardins and Rubenson (2011) use regression analysis to investigate the impact of the skills mismatch on productivity, controlling for country and industry fixed effects. The results show that over-skilled workers have a negative and statistically significant impact on overall productivity. Likewise, underqualified workers have a negative and statistically significant impact on within-firm productivity. Over-qualified and under-skilled workers, however, do not have a statistically significant impact on either. Furthermore, qualification mismatch has an inverse significant relationship with overall productivity, while skills mismatch does not. When controls for the overlaps between the components of qualification and skills mismatch are considered, the paper shows the following as having statistically significant and negative impact on overall productivity: overqualified and underskilled, underqualified and well-matched in skill, and well-matched in qualification but overskilled. However, underskilled and underqualified workers reduce within-firm productivity, while over-qualified and overskilled workers increase within-firm productivity. The paper also focuses on allocative efficiency, where workers who were well matched in terms of qualifications but over-skilled, have a negative relationship with allocative efficiency. This implies that being over-skilled alone may have a greater effect on productivity than just being over-qualified. Further, the research suggests that the strong association between under-qualification and within-firm productivity is explained by differences in managerial quality. However, the paper recommends focusing on policy factors that promote efficient reallocation of labour to tackle overall productivity. This includes improving residential mobility, and most importantly, investing in targeted training programmes.

Overall, these insights emphasize the complexity of the productivity puzzle in the UK and the multifaceted factors contributing to its decline. Addressing productivity challenges requires a comprehensive approach that considers sector-specific dynamics, regional disparities, job polarisation, and the role of skills and qualifications. Further, they reemphasise the importance of studying productivity at a local level.

2.3. Investment in technology and firm productivity

A large body of research delves into the relationship between technology diffusion and economic growth and productivity (Mithas and Lucas (2014). The growth model first explored by Solow (1956), used data from the US to conclude that about four-fifths of the growth in output per worker was attributable to technical progress. Romer (1990), too, contended that there is a close relationship between economic development and technical progress. While higher levels of input can lead to the bolstering of the economy, productivity improvements will be scant or non-existent in the absence of innovation. Technical innovation can lead to increasing returns to scale as the average cost of the infrastructure around it declines with an increase in uptake. Thus, the possibility of higher returns on investment is created by widespread technology dissemination (Arthur, 1996).

Productivity can be measured both at the aggregate level and at the firm level. While studies at the aggregate level point towards a growth in productivity due to investment in technology, results from firm-level studies have been inconsistent, varying based on the model specifications used, time periods covered and industries reviewed (Stiroh, 2002). In fact, as several studies undertaken in the past did not find evidence of a significant relationship between investment in technology and firm productivity, the term ‘productivity paradox’ was coined. For example, most studies based on the manufacturing sector suggested that information technology does not have any significant effect on firm performance (Loveman, 1994; Morrison, 1997; Barua, Kriebel and Mukhopadhyay, 1995). However, Dasgupta, Sarkis and Talluri (1999) undertook a similar analysis using different underlying assumptions. While a large number of studies assumed constant returns to scale, they tested under both constant and non-constant returns to scale assumptions and found that investment in technology in the manufacturing sector has a negative impact on firm productivity. Further, their findings for the service sector showed that investment in technology either had no effect, or a negative effect on productivity within firms. This result matched empirical literature which suggested the same.

More recent studies, on the other hand, have found that spending on information technology has a significant positive impact on firm productivity. Brynjolfsson and Hitt (1998) stated that productivity growth has historically stemmed from technological advancements including the steam engine and electricity. Using a firm effects model, they found that half of the realised benefits from IT investments were

due to characteristics unique to the firm, suggesting that organisational factors impact productivity greatly.

Building on this idea, Brynjolfsson and Hitt (2000) suggest that organisational transformation contributes to higher in-firm productivity in two ways. Investments in organisational practices including business processes are said to complement technology investments, which lead to improved outcomes, lower costs, and positive changes among intangible aspects of the output, and ultimately, improved productivity. According to Milgrom and Roberts (1990), for businesses to be successful, computer adoption must be a part of a "system" or "cluster" of organisational changes that reinforce one another. Any benefits of computerisation are far outweighed by adverse interactions with current organisational practises, so incremental change, either by investing in computers without implementing organisational change or only partially implementing some organisational changes, can result in significant productivity losses (Brynjolfsson, Renshaw, and Van Alstyne, 1996).

Research based on intra-firm level data from the UK, too, states that both investment and productivity have a favourable association with management and leadership quality (Ollivaud, Guillemette and Turner, 2016). Between the UK and its overseas counterparts, there are also glaring evidence-based inequalities in management and leadership quality and investment levels (Bender et al., 2016; Bloom, Sadun and Reenen, 2012; Bloom and Van Reenen, 2006). Thus, it becomes increasingly important for firms to have the right organisational setups and business practices to ensure that they are investing in innovation in a way to that helps them best realise the productivity gains. For instance, there is evidence of more positive innovation outcomes when firms invest in acquiring knowledge from other organisations (Klueter, Monteiro, and Dunlap 2017). Studies further display the high value of collaborating with other organisations by improving knowledge-sharing, upgrading innovative quality, and improving the managing or structuring of external collaborations (Driffield et al, 2021). These workplace practices impacting productivity positively involve work teams, training in multiple jobs, and flexible job assignments (Ichniowski, Shaw and Prennushi, 1995).

Many researchers believe that investment in and the adoption of digital technologies have a positive and significant impact on productivity (Cardona, Kretschmer Strobel, 2013; Cusolito, Lederman and Peña, 2020; Tastan and Gonel, 2020; Lopez, 2023).

Across sectors, the adoption of digital technologies has contributed to increasing efficiency and firm productivity. Cardona, Kretschmer Strobel (2013) conducted a literature survey on ICT and productivity and concluded that there is strong evidence for productivity enhancement resulting from ICT adoption. Cusolito, Lederman and Peña (2020) did a study on various developing countries and found that the adoption of technologies like email, business websites and subsequent integration between IT systems can help firms improve productivity not least because they could reduce production costs while also providing opportunities to expand their market although they argue that the adoption of different forms of technology is associated with varying levels of productivity gains. Moreover, not all of the productivity uplift is directly attributable to the adoption of technology itself (Boothby, Dufor and Tang, 2010) and the efficiency gains are at best only partially attributable to the adoption of general technologies such as email and websites, or even specialised systems such as ERP and CRM. One possible reason for firms being able to improve their productivity after the adoption of digital technologies is that technology plays an enabling role (Cusolito, Lederman and Peña, 2020). The results of a largescale study conducted by Gal et al (2019) also showed that digital adoption is strongly associated to productivity gains. When digital technologies are adopted, firms often make a shift towards capital intensive production practices, create new products and services and attract workers with more skills, all of which collectively contribute to improving efficiency (Boothby, Dufor and Tang, 2010; Tastan and Gonel, 2020).

These findings find resonance amongst other researchers (Lopez, 2023; Mosiashvili and Preussen, 2020), who have stressed the importance of 'complementarity', which is an important theme in productivity research. Complimentarity is the notion that mere adoption of technology does not itself boost productivity significantly; rather, it is the addition of complementing factors yield the most productivity benefits. Such complementary factors could be the use of technologies which complement each other or the provision of skills or training for staff when new technology is used. The UK's Office for National Statistics (ONS, 2018) did a review of the link between the information and communication technology and found that frequent use of technology that adopting complementary technologies and the intense use of the technologies that the firm has invested in are likely to afford the highest productivity premium. The ONS (ibid) also found that enabling factors for technology use, for example, the availability of high-speed internet also had a positive impact of firm productivity.

Other researchers have also explored the benefits of complementarity. Lopez (2023) analysed the importance of improving organisational practices along with technology adoption while Boothby, Dufor and Tang (2010) and Tastan and Gonal (2020) highlight the importance of training and skills development for employees. This could be because ICT adoption changes the nature of skills needed to work within the organisation and there is a need for workers with higher level skills. In their research, Gal et al (2019) found that although digital technology adoption does improve productivity, the results are weaker in the presence of skill shortages within the firm. Where firms invested in complementarities between digital technologies and skills development, they gained the most. Robinson, Siegel and Liao (2021) conducted a survey of SMEs based in Kent and concluded that the availability of skilled workers and/or development of skills were essential requirements for improving productivity.

Here are the key takeaways from the literature review above:

• Shift to Low-Productivity Sectors: The UK has seen a shift towards relatively low-productivity sectors such as services and the public sector such as healthcare and education. This transition has contributed to the declining productivity growth.

• Drivers of declining productivity: While the above shift has contributed to falling productivity growth, it is the manufacturing, ICT and, finance and insurance sectors that were identified as the top sectors responsible for this decline.

• Impact of Subsectors and Industries: Coyle's study decomposed growth into contributions from different subsectors and sectors. It attributed the productivity slowdown to specific subsectors within manufacturing and ICT, such as transport equipment, pharmaceuticals, computer software, and telecommunications. This suggests that addressing productivity challenges requires a sector-specific approach.

• Regional Disparities: The Skill and Productivity Board and the Levelling Up White Paper highlight regional disparities in productivity, emphasizing the role of specializations in low-productivity industries. Factors such as low levels of innovation, knowledge diffusion, inadequate management, and workplace relations contribute to declining productivity in certain regions.

• Job Polarisation and Skills Mismatch: Acemoglu and Autor's research indicates that technological change has led to job polarization, favouring high-skill non-routine jobs and low-skill occupations while hollowing out middle-skill jobs. The rise in skill-biased technological change has contributed to wage inequality. The emerging theme

of job polarization and skills mismatch underscores the need to address the evolving demands of the labour market.

• Impact of Skills and Qualifications Mismatch: The OECD working paper emphasizes that qualifications alone may not reflect skills mismatch accurately. Skills, including additional training and gained or lost skills beyond formal qualifications, play a crucial role in productivity. Over-skilled and underqualified workers have negative impacts on productivity, while overqualified and overskilled workers do not. Allocative efficiency is negatively affected by being over-skilled alone, suggesting its greater impact on productivity compared to being overqualified.

• Importance of Policy Factors: The research highlights the need for policy interventions to tackle the productivity challenge, such as investing in targeted training programs and improving residential mobility to promote efficient reallocation of labour. Additionally, enhancing managerial quality is crucial for addressing within-firm productivity issues associated with under-qualification.

• Importance of organisational change on productivity: Any benefits of computerisation are far outweighed by adverse interactions with current organisational practises, so incremental change, either by investing in computers without implementing organisational change or only partially implementing some organisational changes, can result in significant productivity losses.

• Evidence that investment in technologies enhance productivity: Many researchers believe that investment in and the adoption of digital technologies have a positive and significant impact on productivity. Though this is arguable.

•Importance of management and leadership quality: Increasingly important for firms to have the right organisational setups and business practices to ensure that they are investing in innovation in a way to that helps them best realise the productivity gains.

3. Project Design

3.1. Project Location Rationale

The project is situated in Rochdale, a borough of Greater Manchester. This is an area which is identified as having lower productivity and is a priority area for regional improvement. Greater Manchester has a productivity deficit relative to the national average. Within Greater Manchester, the boroughs in Greater Manchester's North East - Rochdale and Oldham - have lower productivity than the other parts of Greater

Manchester. Rochdale also has some of the most deprived wards in England and is ranked the 15th most deprived in England. For all these reasons, Rochdale is a priority area for investment under the UK Communities Renewal Fund and UK Shared Prosperity Fund. Focusing on Rochdale allows us to investigate the barriers that businesses face in a low productivity location, coupled with the management decision making processes that govern the adoption of technologies that can assist in improving productivity. The findings from this project will be used to create a repeatable framework that can be mirrored across Greater Manchester and beyond.

3.2. Methodology for Identifying Firm Level Productivity

Estimation of firm level productivity is possible using data within the profit and loss account and balance sheet within company accounts. This project sourced that data from FAME, an online database organised by Bureau van Dijk. Filters were applied such that only companies were selected that had a primary trading address in Rochdale and had between 10 and 250 employees. This resulted in a sample population of 76 active SMEs in Rochdale for which there was sufficient data to estimate firm-level productivity.

Gross Value Added (GVA) at the firm level can be calculated via the income approach. Namely, GVA = Earnings Before Interest, Tax, Depreciation and Amortization (EBITDA) + Employee Costs GVA per employee is the adopted measure of labour productivity at the firm level within this project. Using a three-year average, this metric provides an initial categorisation of Rochdale SMEs into different productivity bands from which the mentors and mentees can be drawn.

The next stage was to cross-reference this sample of firms with information held in Greater Manchester Chamber of Commerce's own CRM system so that firm level characteristics such as expansion plans, investment, recent increase (or decrease) in the number of employees and engagement with Chamber initiatives can be assessed. These aspects offer a window into the firm's decision making on productivity enhancing initiatives. This process supported the identification of organisations which have higher productivity to act as mentors to mentees from organisations that fall outside this category.

Along with this, data from other SME support projects delivered by Greater Manchester Chamber of Commerce will be used to understand whether the identified Rochdale based businesses have undertaken training to develop management competencies and if so, what specific types of training have been undertaken. Since one of the barriers to improving productivity is not merely the adoption of technology but the ability to utilise the adopted technology, it is important to understand whether firm management have the knowledge, aptitude, and skills for managing technology and digital transformation projects. Learning from this pragmatic approach will also inform future delivery of the scheme, but it is not intended to be a core element of the mentoring framework.

3.3. Methodology for Mentoring Pilot

The mentoring scheme connects mentors and mentees from different SMEs in the same area, controlling for comparable size. The mentoring programme is designed to focus on improving productivity outcomes of strategic decision-making processes, and the participants are senior managers or staff with responsibility for investment decision making. Mentoring pairs are cross-sector to support a fertilisation of ideas and avoid matching direct competitors. The mentoring scheme is designed to operate over 6 meetings – a startup meeting followed by 5 meetings in which participants explore the functional aspects of productivity and how these feed into planning and strategy at the organisational level. The meetings are a collaboration from one business leader to another, sharing insights, transferring knowledge, agreeing on ideas how they can embed good practice it into their operations to add value. The participants are guided to discuss the following in the meetings:

- How do they engage in strategic planning and decision making for productivity?
- Where are the barriers and blockages to make or implement decisions to improve productivity, and how are they being addressed?
- How do business leaders make decisions around investment and activity on five key productivity drivers?
- How is productivity included in strategic planning?
- How do different functional leaders address productivity in their strategic planning?

The meetings are recorded and transcribed enabling a qualitative analysis to be conducted. This stage will focus on drawing together the findings from the meetings, and from and end of scheme workshop for all participants. Each topic will be dealt with individually and a summary across each of the five areas developed. These results will be provided at the conference. The Productivity Mindset Mentoring Framework will be developed for use in future projects based on the learning from this project.

3.3. Results

To be presented at conference following project completion.

4. Conclusions

The literature review highlights the complexity of the productivity paradox, with declining growth attributed to lower productivity sectors, regional disparities, job polarisation and a skills mismatch. However, much of this research has been conducted at a national level, overlooking potential variations in productivity at the local level. At the firm level, while earlier studies found no relationship between technology investment and productivity, recent research emphasises the critical role of complementary organisational changes in realising the benefits of technology investments. The latter evidence indicates that managerial quality, business processes, knowledge sharing, and workplace practices impact productivity outcomes.

Our research aims to bridge the gap by addressing the local variations and add to firm level insights. The mentoring pilot programme seeks to uncover differences in strategic decision-making around technology investments between higher and lower productivity firms. It will elucidate the organisational factors that enable more productive technology investments. The qualitative analysis of the mentoring meetings will provide rich insights into these issues at the local level. The repeatable framework we aim to design from this process will help us better understand the productivity challenges plaguing this region and equip firms with the tools and

techniques needed to overcome this challenge. This provides opportunities for IS scholars to examine the productivity paradox in more detail and, as emphasised in the introduction, we invite fellow IS researchers to develop and enhance the work of others works such as Brynjolfsson's. Overall, the research promises actionable insights for various stakeholders aiming to tackle the UK's productivity paradox and provides the opportunity for significant impact if an effective mentoring scheme can be developed and rolled out at scale.

5.0 References

Acemoglu, D. and Autor, D., 2011. Skills, tasks and technologies: Implications for employment and earnings. In Handbook of labor economics (Vol. 4, pp. 1043-1171). Elsevier. DOI: https://doi.org/10.1016/S0169-7218(11)02410-5

Arthur, W.B. (1996) Increasing Returns and the New World of Business, Harvard Business Review. Available at: https://hbr.org/1996/07/increasing-returns-and-the-new-world-of-business.

Barua, A., Kriebel, C.H. and Mukhopadhyay, T. (1995) 'Information Technologies and Business Value: An Analytic and Empirical Investigation', Information Systems Research, 6(1), pp. 3–23. Available at: https://doi.org/10.1287/isre.6.1.3.

Battu, H., Belfield, C.R. and Sloane, P.J., 1999. Overeducation among graduates: a cohort view. Education economics, 7(1), pp.21-38. DOI: https://doi.org/10.1080/09645299900000002

Bender, S. et al. (2016) 'Management Practices, Workforce Selection and Productivity', Journal of Labor Economics, 36(1), pp. 371–409. Available at: https://www.nber.org/papers/w22101.

Bloom, N., Sadun, R. and Reenen, J.V. (2012) 'Americans Do IT Better: US Multinationals and the Productivity Miracle', American Economic Review, 102(1), pp. 167–201. Available at: https://scholar.harvard.edu/rsadun/publications/americans-do-it-better-us-multinationals-and-productivity-miracle (Accessed: 20 September 2023).

Bloom, N. and Van Reenen, J. (2006) 'Measuring and Explaining Management Practices Across Firms and Countries', The Quarterly Journal of Economics, 122(4), pp. 1351–1408. Available at: https://doi.org/10.3386/w12216.

Boothby, D., Dufour, A. and Tang, J., 2010. Technology adoption, training and productivity performance. Research Policy, 39(5), pp.650-661. DOI: https://doi.org/10.1016/j.respol.2010.02.011

Brynjolfsson, E. and Hitt, L.M. (1998) 'Beyond the Productivity Paradox', Communications of the ACM, 41(8), pp. 49–55. Available at: https://doi.org/10.1145/280324.280332.

Brynjolfsson, E. and Hitt, L.M. (2000) 'Beyond Computation: Information Technology, Organizational Transformation and Business Performance', Journal of Economic Perspectives, 14(4), pp. 23–48. Available at: https://doi.org/10.1257/jep.14.4.23.

Brynjolfsson, E. and Petropoulos. G. (2021) 'The coming productivity boom', MIT Technology Review, Available at: https://www.technologyreview.com/2021/06/10/1026008/the-coming-productivity-boom/ (Accessed: 20 October 2023).

Brynjolfsson, E., Renshaw, A. and Van Alstyne, M. (1996) The Matrix of Change: A Tool for Business Process Reengineering, MIT Sloan School of Management . Available at: http://web.mit.edu/marshall/www/papers/MoC.pdf (Accessed: 20 September 2023).

Cardona, M., Kretschmer, T. and Strobel, T. (2013). ICT and productivity: conclusions from the empirical literature. Information Economics and policy, 25(3), pp.109-125. https://doi.org/10.1016/j.infoecopol.2012.12.002

Cavaglia, C. and Etheridge, B., 2020. Job polarization and the declining quality of knowledge workers: Evidence from the UK and Germany. Labour Economics, 66, p.101884. DOI: https://doi.org/10.1016/j.labeco.2020.101884

Coyle, D. and Mei, J.C., 2023. Diagnosing the UK productivity slowdown: which sectors matter and why?. Economica. DOI: https://doi.org/10.1111/ecca.12459

Cusolito, A.P., Lederman, D. and Peña, J., 2020. The effects of digital-technology adoption on productivity and factor demand: Firm-level evidence from developing countries. World Bank Group, Middle East and North Africa Region, Office of the Chief Economist.

Dasgupta, S., Sarkis, J. and Talluri, S. (1999) 'Influence of Information Technology Investment on Firm productivity: a Cross-sectional Study', Logistics Information Management, 12(1/2), pp. 120–129. Available at: https://doi.org/10.1108/09576059910256493.

Desjardins, R. and Rubenson, K., 2011. An analysis of skill mismatch using direct measures of skills. DOI: https://doi.org/10.1787/19939019 Available online: https://www.oecd-ilibrary.org/content/paper/5kg3nh9h52g5-en [Accessed on: 28 October 2023]

Driffield , N. et al. (2021) Understanding productivity: Organisational Capital Perspectives. The Productivity Institute. Available at: https://www.productivity.ac.uk/wp-content/uploads/2021/11/WP013-Organisational-Capital-scoping-paper-FINAL-151121.pdf.

Dos Santos, B., & Sussman, L. (2000). Improving the return on IT investment: the productivity paradox. International journal of information management, 20(6), 429-440.

Durbin, S. (2004) Review of Workplace Skills, Technology Adoption and Firm Productivity: A Review, New Zealand Treasury Working Paper, No. 04/16, New Zealand Government, The Treasury, Wellington

Gal, P., Nicoletti, G., Renault, T., Sorbe, S. and Timiliotis, C., 2019. Digitalisation and productivity: In search of the holy grail–Firm-level empirical evidence from EU countries. DOI: https://doi.org/10.1787/18151973

Green, F. and Zhu, Y., 2010. Overqualification, job dissatisfaction, and increasing dispersion in the returns to graduate education. Oxford economic papers, 62(4), pp.740-763. DOI: https://doi.org/10.1093/oep/gpq002

HM Government (2022) Levelling Up the United Kingdom: executive summary available online https://www.gov.uk/government/publications/levelling-up-the-united-kingdom [Accessed: 25 October 2023]

Ichniowski, C., Shaw, K. and Prennushi, G. (1995) 'The Effects of Human Resource Management Practices on Productivity', American Economic Review, 86, pp. 291–313. Available at: https://doi.org/10.3386/w5333.

Klueter, T., Monteiro, F. and Dunlap, D. (2017) 'Standard vs. Partnership-Embedded Licensing: Attention and the Relationship between Licensing and Product Innovations', Mack Institute for Innovation Management, 6(9), pp. 1629–1643. Available at: https://mackinstitute.wharton.upenn.edu/2017/standard-vs-partnership-embedded-licensing/ (Accessed: 20 September 2023).

Loveman, G.W. (1993) 'An Assessment of the Productivity Impact of Information Technologies', in T.J. Allen and M.S.S. Morton (eds) Information Technology and the Corporation of the 1990s: Research Studies. Oxford : Oxford University Press, pp. 84–110.

López, A. (2023): The role of information technology and workplace organization in firm productivity: evidence from Spanish firms, Economics of Innovation and New Technology, DOI: https://doi.org/10.1080/10438599.2023.2172000

Lucas Jr, H. C. (1999). Information technology and the productivity paradox: Assessing the value of investing in IT. Oxford University Press.

McCann, P. (2018) Productivity Perspectives Available online : https://productivityinsightsnetwork.co.uk/app/uploads/2018/06/P-McCann-Final-synthesis.pdf [Accessed on: 20 October 2023]

McGowan, M.A. and Andrews, D., 2015. Skill mismatch and public policy in OECD countries. DOI: https://doi.org/10.1787/18151973 Available online: https://www.oecd-ilibrary.org/content/paper/5js1pzw9lnwk-en [Accessed on: 28 October 2023]

Milgrom, P. and Roberts, J. (1990) 'The Economics of Modern Manufacturing: Technology, Strategy, and Organization', The American Economic Review, 80(3), pp. 511–528. Available at: https://www.jstor.org/stable/2006681.

Mithas, S., & Lucas Jr, H. C. (2014). Information Technology and Firm Value: Productivity Paradox, Profitability Paradox, and New Frontiers.

Montresor, G., 2019. Job polarization and labour supply changes in the UK. Labour Economics, 58, pp.187-203. DOI: https://doi.org/10.1016/j.labeco.2018.05.009

Morrison, C.J., 1997. Assessing the productivity of information technology equipment in US manufacturing industries. Review of Economics and Statistics, 79(3), pp.471-481. DOI: https://doi.org/10.1162/003465300556887

Mosiashvili, N. and J. Pareliussen (2020), "Digital technology adoption, productivity gains in adopting firms and sectoral spill-overs: Firm-level evidence from Estonia", OECD Economics Department Working Papers, No. 1638, OECD Publishing, Paris, https://doi.org/10.1787/ba9d00be-en.

Ollivaud, P., Guillemette, Y. and Turner, D. (2016) *Links between weak investment and the slowdown in productivity and potential output growth across the OECD*, *Library Catalog (Blacklight)*. Paris: OECD Publishing. Available at: https://searchworks.stanford.edu/view/11731955 (Accessed: 20 September 2023).

ONS (2018). Information and communication technology intensity and productivity. Office for National Statistics. available online at https://www.ons.gov.uk/economy/economicoutputandproductivity/productivitymeasures/articles/informationandcommunicationtechnologyintensityandproductivity/2018-10-05 [accessed on 16 October 2023]

Pinsonneault, A., & Rivard, S. (1998). Information technology and the nature of managerial work: From the productivity paradox to the Icarus paradox?. MIS quarterly, 287-311.

Remes, J., Mischke, J. and Krishnan, M., 2018. Solving the productivity puzzle: The role of demand and the promise of digitization. International Productivity Monitor, (35), pp.28-51. Available online: http://www.csls.ca/ipm/35/remes-mischke-Krishnan.pdf [Accessed on: 28 October 2023]

Robinson, C. & Siegel, C. & Liao, S. (2021). "Technology Adoption and Skills A Pilot Study of Kent SMEs," Studies in Economics 2114, School of Economics, University of Kent.

Romer, P.M. (1990) ' Endogenous Technological Change', *Journal of Political Economy*, 98(5), pp. 71–102. Available at: http://www.jstor.org/stable/2937632

Schreyer, P. (2001) Measuring productivity: measurement of aggregate and industry-level productivity growth. OECD Manual. Available at: https://www.oecd.org/sdd/productivity-stats/2352458.pdf.

Solow, R.M. (1956) 'A Contribution to the Theory of Economic Growth', *The Quarterly Journal of Economics*, 70(1), pp. 65–94. Available at: https://doi.org/10.2307/1884513

Stiroh, K.J. (2002) 'Information Technology and the U.S. Productivity Revival: What Do the Industry Data Say?', *American Economic Review*, 92(5), pp. 1559–1576. Available at: https://doi.org/10.1257/000282802762024638

Taştan, H. Gönel, F. (2020), ICT labor, software usage, and productivity: firm-level evidence from Turkey. J Prod Anal 53, 265–285. https://doi.org/10.1007/s11123-020-00573-x

Venturini, F. (2015) 'The modern drivers of productivity', Research Policy, 44(2), pp. 357–369. Available at: https://doi.org/10.1016/j.respol.2014.10.011