The Pissarides Review into the Future of Work and Wellbeing

August 2023

Organisational Adoption of Automation Technologies Literature Review

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Acknowledgements

This paper was prepared for the Pissarides Review into the Future of Work and Wellbeing, led by Professor Sir Christopher Pissarides (Institute for the Future of Work and London School of Economics). I gratefully acknowledge financial support from the Nuffield Foundation. The Pissarides Review into the Future of Work and Wellbeing is a collaboration between the Institute for the Future of Work (IFOW), Imperial College London and Warwick Business School. The views expressed herein do not necessarily reflect the views of the Nuffield Foundation, nor those of the Institute for the Future of Work.

Citation

J. Hayton, *Organisational Adoption of Automation Technologies Literature Review,* Institute for the Future of Work, August 2023.

DOI: 10.5281/zenodo.8073499

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Abstract

This paper provides a review of research on technology adoption, and its impact on work and workers. We summarise key strands of evidence about technology adoption, from the diffusion of innovations paradigm, rational choice models of technology adoption, the sociotechnical systems perspective, and the social construction of technology perspective. While diverse in approach, research points to the importance of decision maker perceptions concerning the perceived returns from a new technology, the technical challenges, and the fit with their organisation. These factors are impacted by organisational characteristics and contextual factors such as workforce, geography and institutional support. The degree of employee involvement and readiness are significant factors influencing adoption. Relative to recent interest in the impacts of technology on the labour market, there has been less attention paid to technologies' impacts on the conditions and experience of work. What is apparent is that technology can both enhance and diminish the conditions of work – either increasing autonomy and learning opportunities, or equally, increasing monitoring and routinisation. Neither implementation nor impacts on jobs, work and workers are deterministic but are a function of managerial choices made in the contexts of their organisations and social institutions. We close with a description of the next phase of the research project within the Pissarides Review into the Future of Work and Wellbeing, which builds from this evidence.

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1. Introduction

A wide range of estimates of the impact of new technology upon work have been produced in recent years (see Crafts et al., 2018 for a summary). These have ranged from the dire (e.g., 47% of all occupations by Frey and Osborne, 2013) to the more tolerable (e.g., Price Waterhouse Cooper's 10-30%; PWC, 2018). Differences in estimates are caused by differences in time-scale, focus (addressing occupations rather than tasks produces more negative estimates) and methodological details. It is important to recognise that most estimates reflect the technical feasibility of automation. However, obviously new technologies are not universally adopted immediately upon demonstration of feasibility.

Research in a wide range of fields demonstrates significant variability in the adoption of automation technologies, digital technologies, and information systems (e.g., Rogers, 2010). According to a British Academy report on AI (BA, 2018): "There is limited evidence on the factors that may influence the adoption of AI, beyond its technical capabilities. Business adoption is likely to be influenced by economic considerations, regulatory concerns, individual preferences, and social norms, and by the need to reorganise production processes to take advantage of AI." There are many reasons why specific forms of automation are or are not adopted in an economy (e.g., Cowan, 1988; Noble, 1984; Thomas, 1994; Wajcman & MacKenzie, 1988). Examinations of these reasons have ranged across the innovation diffusion literature (e.g., Rogers, 2010); the view of technology adoption as a managerial decision (e.g., Gopalakrishnan & Damanpour, 1997; Zmud, 1982); technology adoption as a process within organisations influenced by diverse and significant forces (Van de Ven, Angle & Poole, 2000) including political forces (Thomas, 1994), and factors such as ideology extending far beyond organisational boundaries (Forsythe, 2001; Noble, 1984); as a sociotechnical problem in which technical innovation is embedded within both micro macro-level social environments (Trist & Bamforth, 1951; Passmore, 1995); or viewing technology itself not as an objective phenomenon, but as a problem of social construction and a process of 'structuration' (Giddens, 1984) involving changing roles and relationships (Barley, 1986; Orlikowski, 1992). These are the literatures that this review will focus upon as a primary aim in order to capture as broad an understanding of the factors influencing adoption of automation technologies as possible.

As this is a very broad and diverse literature, our goal is to focus primarily upon the key strands of thought. Secondarily, we will look for evidence, from within these diverse strands of literature, of the expected impacts of technology adoption on organisations, work and workers. The wider project of which this paper represents one component, is addressing the impacts of new automation technologies. Some define technology itself as having a substituting effect. For example, Blau et al (1976, p.21) define technology as "the substitution of equipment for human labour." Others take an even broader definition to include any workflow (Thompson, 1967) or transformation of some raw material (physical or intangible) into some new, value-added product or service (Perrow, 1967). Orlikowski argues that such broad definitions obscure as much as they expand "By aggregating task, technique, knowledge, and tools into a single construct – technology interaction among these constituting components and with humans is ignored" (1992). In this review, we limit our consideration of 'technology' in a narrower, material sense in which it is embodied in physical machines or devices or includes software programs within other machines. While other 'social' or organisational technologies (organisation of work) might be adopted, we are interested in the material forms in this review.

While it is possible to conceive of robotic and AI-based automation technologies in terms of product innovations of their developers/vendors, our perspective is to assume that they principally represent process or enabling technology innovations which are adopted by organisations not responsible for their initial creation (Davila et al., 2012). This distinction is salient because we are focusing on the adoption of technologies typically generated outside of the focal organisation, as opposed to product innovations which will have a more significant internal locus for initiation. Thus, the central salient literatures are those which focus on the adoption of technology (Damanpour, 1992; Van de Ven & Poole, 1989).

Several scholars argue that technology adoption is not a single decision, but in fact involves multiple stages. From Rogers' (2010) perspective, innovation diffusion is a problem of communication involving five stages: Knowledge of the innovation; persuasion that the technology has desirable characteristics; deciding to adopt; implementing the technology; and finally, confirmation of whether the desired effects are achieved in practice. In other literature on innovation the focus is upon the decision process and involves two or three identifiable stages (Gopalakrishnan & Damanpour, 1997; Zmud, 1982). First, the initiation stage which, as with Rogers' model, involves becoming aware of an innovation; forming an attitude towards that innovation itself, or its potential applications (Moore and Benbasat, 1991); and the organisational level evaluation of the technology. This is followed by a decision to adopt which initiates the implementation stage. The implementation stage itself includes a trial stage and the sustained implementation stage (Gopalakrishnan & Damanpour, 1997). Meyer and Goes (1988) similarly divide technology adoption into three stages: (a) the identification of a technology class to adopt; (b) the evaluation of alternatives; (c) the implementation of the innovation. Meyer and Goes (1988) refer to these as the Knowledge-awareness stage; evaluation-choice stage; and adoption-implementation stage respectively. All of these frameworks take the technology itself as given, and do not consider either causes, or consequences which extend beyond the boundaries of the organisation (Bailey & Barley, 2020).

A significant criticism of the 'managerial' perspective on technology adoption is that it ignores influences on the technology, such as the philosophy of the designers, or the wider ideological setting within which technologies initially develop and are selected (e.g., Bailey & Barley, 2020; Noble, 1984). Consequently, there is a tendency to treat technological characteristics as given and fixed rather than chosen, and malleable. Similarly, most literature focuses upon the immediate performance of an adopted technology, relative to initial expectations, but fails to consider downstream influences on work and organisation, for example (e.g., Barley, 1986). "Like most studies of technology use, the emerging work on intelligent technologies stops at the boundary of the organisation. Researchers neither attend to the design of the technology prior to its implementation nor consider the ramifications for institutions beyond those of the organisation" (Bailey & Barley, 2020, p.6). This implies a narrow definition of technology and the factors influencing adoption, which inevitably carries serious implications for the correctness of our understanding.

As far as is reasonable in this review, we will attempt to consider the entire relevant timeline of innovation and technology adoption because all are relevant to the ultimate outcomes in terms of impacts on work and institutions (Bailey & Barley, 2020; Van de Ven & Poole, 1989). However as will be clear from the following review, the emphasis of much literature is upon adoption and implementation, and their more immediate consequences.

We are ultimately interested in the relationships between technology adoption, work and workers. This has been identified as an important focus for policy (Craft et al., 2018) although to date research on the impacts of new technologies – robotic and digital automation which relies upon artificial intelligence and machine learning, remains quite limited. For example, there is a preoccupation with macro-level impacts on the market for labour and identification of the occupations and demographic groups who might be affected (Acemoglu, Daron, Claire Lelarge, 2020; Brynjolfsson et al., 2018; Dauth et al., 2017; Georgieff & Milanez, 2021; Santi Deliani Rahmawati et al., 2020). There is far less attention to the impact on the experienced conditions of work. When we examine the limited evidence, what is immediately apparent is that technology can both enhance and diminish the conditions of work – either increasing autonomy and learning opportunities, or equally, increasing monitoring and routinisation (e.g., Eurofound, 2017). Indeed, while many have emphasised the negative aspects of new technologies, it has equally been argued that:

> *"working people in general have many reasons to approach computerized technology with a positive attitude. Robot technology, for example, automates the dirtiest and most dangerous jobs in factories and relieves operators of tedious, repetitive work. Similarly, numeric control machinery typically automates the most routinized and least skilful aspects of production work, allowing operators to concentrate on tasks requiring high levels of skill and judgment."* (Mirvis et al., 1991).

Much more recently, Davenport and Miller (2022) conclude, after reviewing a number of real-world case studies, that AI tends to augment rather than fully automate jobs, and that it doesn't appear to be resulting in job losses. Despite the optimism/pessimism debate over the impact of new technologies on the labour market, technology alone does not determine outcomes for work and workers (e.g., Barley, 1986; Cowan, 1988; Thomas, 1994). What becomes very clear as we move from literature which treats technology as objective and fixed, towards a more socially constructed view (Orlikowski, 1992), is that neither the implementation nor the impacts on jobs, work and workers (Barley 1986; 2020) are pre-determined (Wajcman & MacKenzie, 1988), but themselves are a function of managerial and social choice (Trist & Bamforth, 1951)

Our review proceeds as follows. We will sequentially review a set of six literatures, the diffusion of innovations paradigm, the technology acceptance model, the technology-organisation-environment model, process perspectives on technology adoption, the sociotechnical systems perspective, and finally the social-construction of technology perspective. These might be divided into 'variance' perspectives which seek to understand the factors impacting technology adoption by looking across a large number of individual observations at a point in time (i.e. cross-sectional designs); versus process perspectives, which tend to examine single or small numbers of cases, to understand the forces that impact and interact with adoption of technologies, and their consequences, within cases over time (Gopalakrishnan & Damanpour, 1997; Orlikowski, 2009). Similarly, they may be subdivided into schools of thought which treat technology as objective and therefore deterministic, or subjective and subject to negotiation, politics and choice (Bailey & Barley, 2020; Orlikowski, 2009).

From the outset, it is important to note that because we attempt a broad view that takes in many diverse theoretical perspectives, our review must necessarily be partial and selective within any one domain. The goal then, is not to present a systematic review of every study that has been conducted on the adoption of technology, for this will be impractical. Rather, we offer an indicative review and hope to distil what is known in order to suggest directions for further investigation in the context of the overall goals of the Pissarides Review.

2. Perspectives on technology adoption

2.1 The Diffusion of Innovations paradigm

Perhaps the most widely known perspective on technology adoption, is what quickly became known as the 'diffusion of innovations' (DOI) perspective. This literature, summarized by Everett Rogers, (2010) began within rural sociology, seeking to understand factors influencing the adoption of new agricultural technologies (e.g., Ryan & Gross, 1943). Technologies of interest included new disease resistant seeds, antibiotics, hormonal feed additives, and mechanical equipment, all intended to enhance agricultural productivity. Given the importance of agricultural productivity to economic and social wellbeing, and the investments being made to create these technologies, the important question to answer was why they were not adopted at a consistent rate and what could explain differences between early and late adopters.

As early as 1903, it had been observed that the adoption of new technologies follows an s-shaped curve with a low rate of initial adoption, which after an accumulated adoption of 20-25% accelerates before slowing once again and eventually flattening (Rogers, 2010; Tarde, 1903). A central research question was, which factors differentiated early and late adopters? At its heart, Rogers describes diffusion of innovation as a matter of communication over time among members of a social system. The initial flat, low-rate of adoption depicted in the s-curve reflects the activities of those few, more entrepreneurial, risk tolerant individuals who often took a leap of faith in the first adoption of a technology, having no role models or examples of prior success to motivate them other than their own vision and belief. These venturesome individuals are risk takers who tend to be less well connected in their social systems. Indeed, their lack of connection is partly a reason for their ability to experiment with ideas that may be controversial or break with existing beliefs. At the same time, these persons willingness to take on controversial ideas can set them further apart from social acceptance and reinforce that social disconnectedness.

Once a new technology has shown evidence of initial success among these experimenters, when they are adopted by forward thinkers who are more respected, better-connected, early adopters, the wider community takes notice, slowly at first and then with increasing rapidity. The adoption decisions are hypothesised to be centred around the communication of benefits and understandings of the new technology. Such communication rests upon the social positions, status, and communication abilities of adopters, reflecting an almost inevitable calculus of adoption captured in this s-curve model. The adoption process theorised in this view has been likened to an unstoppable epidemic effect (Cool et al., 2000).

Based upon a review of many hundreds of studies, Rogers (2010) identifies five characteristics of an innovation which impact its rate of diffusion. First, the relative advantage of the new technology over existing tools and methods – the degree to which an innovation is perceived as an improvement over prior technology. Relative advantage also includes the perception that an innovation might be perceived as enhancing social status.

Second, the compatibility of the new technology with existing norms, culture, values, and needs of potential adopters. Third, the perceived complexity of the technology with respect to existing knowledge and abilities. Complexity is defined by Rogers and Shoemaker (1971) as “the degree to which an innovation is perceived as relatively difficult to understand and use” (p. 154). Fourth, the observability or transparency of the workings of the technology, and the degree to which the results of the technology are observable to others. Fifth, the trialability or opportunity to test and experiment prior to choosing to adopt a given technology. These five dimensions have been arrived at through the aggregated results of hundreds of studies (e.g., Rogers, 2010).

While the same five factors are identified repeatedly (although not always concurrently) across many scores of studies in the narrative reviews of Rogers, in their quantitative meta-analysis of 75 studies, Tornatzky and Klein (1982) estimate significant population correlations with technology adoption only for three of the five: relative advantage, compatibility, and complexity. These three factors together reflect the perceived benefits (relative advantage), and the perceived ease of use from a social (compatibility) and technical (complexity) perspective.

Over the years, there have been many criticisms of the diffusion on innovations perspective, both conceptual and empirical (Cool et al., 2000; Downs & Mohr, 1976; Tornatzky & Klein, 1982). In their meta-analytic review, Tornatzky and Klein (1982) reported that 90% of prior studies explained adoption or implementation in a *post hoc* rather than a predictive fashion, and 60% measured characteristics of innovations through researcher inference rather than ratings by decision makers or expert judges. In addition, frequently (46.7%) studies have focused on only a single characteristic of the innovation and have studied individuals (57%) rather than organisations (33%) as adopting units. Possibly of most significance, just 5 out of 75 studies considered adoption and implementation, with 93.3% considering only adoption. Meyer and Goes (1988) similarly note that few studies have examined choice processes preceding adoption, or implementation after adoption, concluding that much implementation literature is ‘impressionistic’ rather than being of rigorous design.

This literature has also been repeatedly criticized for a general instability in results (Damanpour, 1987; Dewar & Dutton, 1986; Downs & Mohr, 1976; Fennell, 1984; Kimberly & Evanisko, 1981; Meyer & Goes, 1988; Miller & Friesen, 1982; Zmud, 1982). Downs and Mohr (1976) argue that this stems from the fact that the relevant attributes of innovations and organisations are secondary attributes – in other words are perceived and subjective rather than intrinsic and objective. The comparable advantage of a new technology is not stable but will vary across organisations. Therefore, Downs and Mohr argue that we need to conceive these attributes as characterizing the relationship between an innovation and an adopting organisation: “The unit of analysis is no longer the organisation but the organisation with respect to a particular innovation, no longer the innovation, but the innovation with respect to a particular organisation… From this perspective, secondary attributes can be viewed as variables that characterize the circumstances surrounding a particular decision to innovate” (Downs & Mohr, 1976, p.706).

A further criticism of the traditional diffusion perspective is that it focuses primarily upon the demand-related aspects of innovation diffusion, by attending to early adopters and promoting effective communication within a network. This view assumes that all members of a social system have an equal opportunity to adopt the technology – ignoring differences in access or capacity. It also treats a technology as static, rather than something which evolves with time, reflecting improvements in capability or cost that can increase its attractiveness. Thus, later adopters may rationally postpone adoption, knowing that early bugs will be ironed out and uncertainties over the eventual utility or value will be eliminated one way or another. Equally, the institutional environments, as well as the availability of complementary resources, faced by potential adopters are not always identical, and this may impact the ability or willingness to adopt a particular technological innovation (see Cool et al., 2000). A further dynamic that has not effectively been incorporated within the traditional diffusion model is the notion of critical mass, bandwagon, and network effects, whereby the value of a given innovation is influenced by the extent to which it has been adopted by others (Markus, 1987).

Moore and Benbasat (1991) offer a test of the diffusion model focused on the adoption of personal workstations (PWS) by individuals within organisations. An important contribution of this study was the development of a measure of the five dimensions with evidence of strong psychometric properties of internal consistency reliability and construct validity, thereby responding to earlier critiques by Tornatzky and Klein (1982). In addition, the measures focus not on objective, but on the secondary characteristics, or perceived qualities of the technologies, thus responding to the critique by Downs and Mohr (1976). In terms of decision stage, the measure is designed to focus upon the initial adoption stage where adoption is voluntary, rather than later user reactions to involuntary adoptions in response to organisational policies.

Moore and Benbasat (1991) make an important additional point relevant to the question on adoption of technology. The salient question, for understanding innovation, is not the attitudes or beliefs with respect to the innovation itself. Rather, it is the perceptions of using the innovation which are central. It is quite possible to hold different beliefs with regard to an object and an associated behaviour (Fishbein & Ajzen, 1975). For example, it is possible to dislike an individual, but still hire them in the belief that it will produce a positive outcome. The attitude towards hiring is inconsistent with the attitude towards the person. Similarly, one may have a negative attitude towards the automation technology and yet simultaneously believe that its adoption will have positive consequences. Moore and Benbasat argue that it is the belief regarding using a technology that is most salient when trying to determine factors predictive of adoption.

In sum, the diffusion of innovations model begins to build an understanding of issues of concern, including the need to consider secondary rather than primary characteristics, to be aware that technology adoption occurs over time, and that adopters differ significantly between early and late adopters. It also highlights three important characteristics or factors which are taken up in later research: the desirability or value; and the usability, from both a technological complexity perspective (i.e., knowledge resources) and social compatibility (i.e., values fit) perspective. These ideas became influential within the next literature which we review.

2.2 The Technology Acceptance Model

Within the information systems field the question of whether and why users will adopt a given technology has led to a theoretical framework grounded in the theory of reasoned action and theory of planned behaviour (Davis, 1986; 1989; Fishbein & Ajzen, 1975; Lederer et al., 2000). This view suggests that behaviours are a function of behavioural intentions, which in turn are influenced by beliefs about the desirability and feasibility of a course of action. The first element of this framing is whether individuals perceive that a given technology will help them perform their job better. This is perceived usefulness: "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989, p.320). The second consideration is beliefs about whether the new technology is easy or hard to use, such that any performance benefits are outweighed by the effort of learning and using a new approach. This is perceived ease of use: "the degree to which a person believes that using a particular system would be free of effort." (Davis, 1989, p.320).

Davis (1989) explicitly acknowledges the connection between perceived ease of use and the concept of complexity carried from the DOI perspective. In order to fully understand individual decision making, this needs to be coupled with perceived usefulness, which itself is compatible with the concept of relative advantage (Moore & Benbasat, 1991; Rogers and Shoemaker, 1971; Rogers, 2010). It is clear that in many ways, the TAM is an evolution of the DOI perspective, in that it identifies similar core variables, despite emphasising individual motivational assumptions at its core, versus communication theory. The focal point for TAM is the individual adoption decision, rather than overall population adoption, or technology diffusion. The full TAM framework suggests that technology adoption is a function of beliefs about benefits and usability, which in turn influence behavioural intentions and ultimately use of a technology (Lederer et al., 2000).

Studies have examined the adoption of a variety of digital technologies from computer hardware (e.g., Igbaria et al., 1995), automated technologies (Haynes & Thies, 1991), the internet (Morris & Dillon, 1997; Teo et al., 1999), email (e.g., Adams et al., 1992; Gefen & Straub, 1997; Straub et al., 1995), and a wide a variety of software (Adams et al., 1992; Davis, 1989; Davis et al., 1989; Hendrickson & Collins, 1996; Mathieson, 1991). While the DOI approach focuses primarily on the characteristics of the technology, the TAM is explicitly an individual level explanation and focuses upon individual beliefs concerning two principal characteristics of the technology. Thus, the TAM is framed as an individual, rather than an organisational decision process. Overall, it is broadly established that individual adoption decisions are influenced by beliefs regarding the perceived usability and usefulness of the technology. As such, it overcomes several of the limitations of prior work by explicitly addressing innovation characteristics as secondary, perceptual variables which are evaluated relative to an individual's own needs and context. Yet, the TAM does not fully address the organisational context. This is developed further in the next literature we examine.

2.3 The Technology, Organisation, Environment (TOE) Model

In an attempt to better understand the adoption of Information Technology (IT) by SMEs, several studies have drawn upon both DOI and TAM in an expanded consideration to include environmental factors in addition to technological and organisational factors. In this stream of research, the perceived benefits of the technology are considered to be characteristics of the technology which impact adoption decisions. These include both direct and indirect benefits of adoption. Direct benefits would include operational savings which enhance efficiency. Indirect benefits would include perceived strategic or tactical advantages which might impact relative performance (Kuan & Chau, 2001).

In the TOE framework, the perceived ease of use of the technology is framed in terms of organisational readiness rather than individual abilities. Organisational readiness includes having sufficient financial resources to be able to afford the new technology in terms of initial installation and perceived future development or running costs. In addition, having the technological sophistication to support the management and use of the new technology. Within the TOE it is notable that organisational readiness focuses on financial and technological readiness but ignores the dimension of normative or values fit with the organisation which was first identified through the DOI research. It is not clear that this is the result of any explicit empirical or theoretical reason, or whether it is a case of the technological view 'deleting the social' (Forsythe, 2001; Markoff, 2015). Finally, the most significant development beyond the TAM, is that external pressures are introduced as significant drivers of adoption. The external pressures included in the TOE framework are product market competition and the extent to which trading partners are pushing for the adoption of new technology.

Iacovou et al (1995) examined the factors influencing adoption of Electronic Data Interchange (EDI) technology by seven SMEs across different industry sectors. They report that in the SMEs they studied, relatively low organisational IT sophistication, and overall lack of resources undermine organisational readiness; low perceived benefits undermine the perceived usefulness of the technology; and pressures from partners, as well as external competition positively impact the willingness to adopt EDI among SMEs. They observe that, because of generally lower levels of sophistication and resources, and lower perceived contribution to profits, SMEs were less likely to adopt, with external pressures becoming a key factor in adoption.

Chwelos, Benbasat and Dexter (2001) propose and test a similar three factor model as a predictor of the adoption of EDI, involving perceived benefits, perceived readiness, and external pressure. All three dimensions were significant. Competitive pressure was the most impactful source of external pressure, followed by trading partner power. Notably, EDI as a technology is inherently interdependent between organisations, raising the significance of this concept of trading partners, which may be less salient for technologies that do not depend on interorganisational collaboration (Chwelos et al., 2001).

In a study of 575 SMEs, Kuan and Chau (2001) also examined a TOE model which included two technology factors (perceived direct and indirect benefits); two organisational factors (perceived financial cost and perceived technical competence); and two environmental factors (perceived industry pressure and perceived government pressure). Their focus was again the adoption of EDI. They found that all factors except perceived indirect benefits were significantly predictive of adoption vs. non adoption of EDI by the SMEs in the study. Although not expressly framed in terms of the TOE model, researchers at MIT have similarly shown that environmental factors, as well as organisational and technological, all influence the adoption of industrial robots in manufacturing SMEs in the US. Berger and colleagues (2021) report that high costs, the lack of availability of needed technical skills, were inhibiting adoption. External market forces were evident: only when there was a new job which could not be performed in any other way – for which there was no way to adapt existing equipment - and which could make the purchase economically viable, would they be made. The other situations in which new robotic technologies were acquired was where they were innovating to extend their current product range. New projects that required new technologies would be an important driver – which speaks to the orientation of management to innovation and entrepreneurship and the perceived benefits of a new technology.

Waldman-Brown (2020) identifies three distinct cases of tech adoption in SMEs. First, when a well-proven technology can pay for itself within a short period of time, ideally in the context of a single ‘anchor’ contract. Second, where a technology is complementary to existing workflows and creates minimal disruption, including to the workers. Third, where a new technology offers a significant immediate improvement which is demanded by exogenous pressures such as cost competition, or the opportunity to pursue new markets or develop novel products. These observations reflect the significance of relative advantage, organisational compatibility, and external forces which is entirely consistent with prior theory and evidence across the DOI/TAM/TEO evolution previously described. This research highlights an important and relevant challenge, especially for SMEs, where labour is more frequently non-routine, and flexible across tasks. This makes it both harder to automate, and also changes the calculus when task automation becomes possible. Flexible labour is more readily redeployed than narrowly skilled labour. Waldman-Brown suggests that “Our interviews indicate that overall worker impacts may depend less upon which specific tasks a given technology can displace, and more upon the business strategies adopted by firm owners—although more evidence is needed.” (2020; p.21)

In general, the evolution of thought, from the DOI, through TAM, to the TOE frameworks has some notable consistent threads. First and foremost, the perceived relative advantage or benefits from the new technology over existing technology, and the perceived ease of use based upon fit with existing financial and technical resources. These factors have been recurrently observed and empirically supported and fit with a variety of models of decision making and motivation. Second, the agreement that perceived characteristics of the technology in use, and in context, are the most important point of focus for understanding adoption and implementation decisions. The three streams of research also highlight differences of perspective, from the broad sweep of adoption through a social system over time in the DOI perspective, to the individual decision to adopt (TAM) versus the organisational adoption decision (TOE). This in turn implies the need for additional considerations of organisational level factors, including the operating environment and characteristics of the organisations themselves.

In a significant meta-analysis of organisational level factors influencing technology adoption, Damanpour (1992) examined 13 factors selected based upon prior theory. Across 23 empirical studies, those factors found to exert a positive influence on adoption of innovation were: the degree of specialisation within the organisation, which provides enhanced cross fertilisation of ideas due to the larger concentration of technical specialists (Kimberly & Evanisko, 1981; Hage & Aiken, 1971); functional differentiation which is expected to strengthen internal coalitions of professionals who then introduce change within the technical systems (Baldridge & Burnham, 1975); higher levels of professionalisation which are expected to increase boundary spanning and proactive behaviour (Pierce & Delbecq, 1977); a favourable managerial attitude towards change is expected to promote successful implementation; deeper technical resources promote absorptive capacity (Dewar & Dutton, 1986); administrative intensity (proportion of managers) aids the needed coordination, leadership and support (Daft & Becker, 1978; Damanpour, 1987); slack resources enable the absorption of failure and other costs associated with innovation (George, 2005; Rosner, 1968); an external orientation promotes environmental scanning and knowledge acquisition (Miller & Friesen, 1982; Zahra, Hayton & Salvato, 2004); and internal communication facilitates the dispersion of ideas and promotes diversity of thought (Hage & Aiken, 1971; Hayton, 2006). On the negative side, centralisation and concentration of decision making reduce awareness, commitment and involvement of organisational members (Thompson, 1965; Zahra et al., 2004). These factors are often interdependent. Centralization may moderate effect of managerial attitude towards change (Dewar & Dutton, 1986). Managerial attitudes towards change are especially important for adoption or pursuit of radical innovations.

Of particular significance in Damanpour's meta-analytic results are the observed differences by type of organisation. In manufacturing organisations, formalization facilitates innovation while hierarchy inhibits it. On the other hand, in service organisations, formalization inhibits, and hierarchy promotes innovation. This observation suggests caution when attempting global models of factors driving technology adoption. In contrast to organisational type, the type of innovation did not moderate the effect of the various organisational characteristics.

Organisational size is an important factor in adoption of technology (Berger et al., 2021; Damanpour, 1992; Dewar & Dutton, 1986; Iacovou et al, 1995; George, 2005; Thong, 1999; Zahra et al., 2004). Organisational size and complexity are positively associated with the adoption of innovations because these increase the availability of deep and broad human capital/knowledge and specialized knowledge (Dewar & Dutton, 1986). There is strong evidence that smaller firms are less likely to adopt technology of all kinds (e.g., Berger et al., 2021). This is due to a number of factors, including CEO centralization, with the CEO tending to make most of the critical decisions. Such centralization is known to inhibit innovation (Damanpour, 1992; Zahra et al., 2004). In addition, smaller organisations tend to employ more generalists and fewer technical specialists, which inhibits their capacity for identifying, evaluating, and implementing new technologies (Thong, 1999). Smaller firms lack the needed financial resources, which have been shown to be necessary for the investigation and experimentation, and subsequent development and utilization of new technologies (Berger et al., 2021; Damanpour, 1992; George, 2005; Thong, 1999). Innovation of all types tends to benefit from a long-term orientation (Zahra et al., 2004), and yet smaller firms are often constrained, by resource limitations, to attend to near term goals at the expense of longer-term objectives. In sum, firm size matters: there appear to be systematic differences between large, medium and small firms in the adoption and impact of adoption of technologies. This is observed in terms of outcomes as well. For example, large firms shed more jobs over recent years than small firms (Waldman-Brown, 2020).

The effect of labour unions on innovation has received a good degree of attention over the years (e.g., Doucouliagos & Laroche, 2012; Menezes-Filho & van Reenen, 2003). However, the association is not as straight forward as may sometimes be assumed. If innovations are perceived as negatively impacting employment opportunities, then naturally it is expected that unions may seek to limit their adoption. However, if innovations are expected to improve conditions, for example safety or eliminating physically onerous work, then unions are expected to be more supportive (Gruenhagen & Parker, 2020).

Menezes-Filho and Van Reenen (2003) describe the theoretical direct and indirect effects of Union representation on technology adoption. Direct effects include ‘Luddism’ or the opposition to any labour-saving technology on principal. However, there are direct positive effects of unions where support for innovation may be mobilised through the collective voice effects identified by Freeman and Medoff (1984). Specifically, unions can support organisations by enhancing morale, reducing turnover, and positively enhancing investments in training. Each of these contributions can contribute to creating an environment in which process technology can be more effectively adopted. Such effects will be moderated by union power (stronger, more representative unions have a stronger effect) and the character of bargaining relations, with less adversarial relations being more conducive to support for innovation.

Indirect effects of unionisation include factors of union hold-up and strategic R&D which both look at strategic decision making by firms and unions in their bargaining and investment strategies. Menezes-Filho and Van Reenen conclude that “although there are many reasons to suspect that increases in union power may reduce the incentive to invest in innovation this is not a foregone conclusion. There are some countervailing incentives and ultimately the sign and direction of the union effect is an empirical question” (2003, p.12, emphasis added). Of this empirical evidence, they report consistently strong and negative impacts of unions on R&D in the United States but no negative effects in European studies. In their meta-regression analysis of 38 distinct studies, Doucouliagos and Laroche (2012) report a consistently negative association which is moderated negatively (i.e. mitigated) by labour market regulation. That is, more regulated labour markets evidence lower levels of resistance to technology by unions. The evidence they present suggests that the union effect has been declining in all countries over time, leading to a reduction in resistance to technology adoption (Doucouliagos & Laroche, 2012).

A further influence on technology adoption are the demographics of the workforce within the organisation. Meyer (2013) examines the adoption of new or significantly improved technologies in knowledge and/or ICT intensive SMEs in Germany. The adoption of new technologies is negatively associated with the proportion of older workers in firms (Bertschek 2004; Aubert et al., 2006; Beckmann, 2007 - all in Meyer, 2013). Rouvinen (2002) also reports a negative relationship between workforce age and adoption of new process technologies. Noishimura et al (2004) find that in manufacturing (but not non-manufacturing) there is a negative relationship between proportion of older, educated workers, and rate of technological progress. There is thus extensive evidence for a negative relationship between worker age and use of computers and computer skills. Meyer (2013) hypothesises that older workers may resist innovations where their human capital is made obsolete or becomes depreciated.

In sum, this literature then provides a large number of factors, which fall under the sub-dimensions of technology, organisation, or environment, and which have been identified collectively as explaining rates of adoption of new technologies in general. Earlier literatures tended to focus on technological factors, while a large body of work has developed more recently around the organisational factors. In addition, there are a number of salient environmental factors which contribute significantly to the decision to adopt technology.

While there have been prior critiques of instability, the meta-analytic results indicate that there has been some accumulation of knowledge over the course of dozens of studies. Having noted this, there are some very apparent lacunae in this literature. The significance of social fit – compatibility of new technology with the norms and values of the social system – was identified early within the DOI paradigm. However, later developments of that literature seem to have lost this dimension. There is little to no discussion of such fit, nor of the social or political aspects of the problem of technology adoption, at least within the 'variance' approaches to understanding adoption (Gopalakrishnan & Damanpour, 1997). This is in contrast to process approaches which seek to understand the continuous evolution of a technology within and beyond the boundaries of an organisation. The social process school of thought thus tends to be more inclusive of social and political considerations, in contrast to the more technically oriented 'organisational technologist' and variance focused sociological approaches reviewed up to this point. A second distinction of this process approach is that it more clearly acknowledges and examines the impacts of technology on work and organisations, something which is more or less completely absent from research using the DOI, TAM or TEO perspectives. We now turn to these process approaches to understanding technology adoption.

2.4 Process approaches to technology adoption

In a study which reveals the significance of ideology and institutions as significant determinants of the outcomes of process innovation, Noble (1984) provides a rich history of the origins and trajectory of the automation of machine tools. In the earliest stages of the development in this field, one of the principal champions of a form of record-playback (R-P) technology, John Parsons, came from industry. In seeking to develop the technology for commercial application, he obtained financial support from the United States Air Force (as a potential beneficiary of the innovation) and sought technical assistance from academics at MIT. However, Noble describes how both MIT and key industry partners (e.g., General Electric), for different reasons, sought to move to a more advanced form of automation using computer based numerical control rather than 'pattern recording' and playback technology. In particular, the technology-first ideology of the MIT academics and Air Force partners, and the desire for control over the production system by industry partners, led to investments being made in numerical control technology, despite its many limitations in comparison to the record-playback technology. As a result, there was limited investment in the R-P technology, and it failed to be successfully commercialised. The major point that is revealed in Noble's rich narrative is that significant institutional (e.g., adversarial labour relations) and ideological (e.g., 'technology first'; managerial control over production) forces were responsible for which technology became available and which met a premature demise. Furthermore, as with many 'dominant design' stories it was not necessarily the technically optimal solution which won (McGrath, MacMillan & Tushman, 1992; Suarez & Utterback, 1995). Most significantly, the ideologies and institutional contexts in which technologies develop precede any opportunities for employers to choose solutions which may be more or less friendly to the work design and workforce outcomes.

Friedland and Barton (1975) describe in detail the forces leading to the adoption of mechanical tomato harvesting equipment in California. This work highlights several important issues. First, as with the emergence of machine tool automation, the factors which eventually led to automation were varied and significantly 'upstream' from the decisions of employers. The mechanical harvesting equipment was first conceived prior to World War II, decades prior to its eventual adoption. The key actor in this development was motivated by concerns over labour shortages in the California labour market. Consequently, he designed a mechanical system which could substitute for some of this labour. Those shortages were initially mitigated by legal interventions in the form the of California's bracero program allowing immigrant labour from Mexico. Having run since 1951, this program was ended in 1965 due to its perceived negative impacts on the local labour market.

A second factor was the stimulation of university agricultural extension research, in particular the development of new varieties of tomato which would be more suited to the particular rigours and methods of mechanical harvesting. As documented by Friedland and Barton (1975) many of the decisions and actions carried with them unintended consequences, especially social consequences and not least the propagation and sale of firmer, less tasty tomatoes. However, the technical innovators focused only on technical issues and the impacts on workers and work organisation were not fully recognized until the new systems began to be deployed. Those impacts include a reduction in workers needed from 50,000 in 1964 to 18,000 in 1972; an increase in the vertical hierarchy and number of jobs from five to eight distinct jobs with a more varied range of skills and often improvements in pay for the new higher skilled roles; a shift from one challenging physical environment (8-12 hours of stooping and carry heavy loads) to another challenging physical environment (8-12 hours of standing with restricted movement) and, importantly a shift from self-paced to machine-paced work. The workforce characteristics also shifted from a largely homogeneous male, Mexican, immigrant workforce to a more diverse, mostly female, domestically settled workforce. The main point of their critique - aimed primarily at the agricultural innovation domain, but applicable beyond it - is the need to take a wider and long-range view of the potential consequences of new technologies for work, workers and society.

In a series of in-depth case studies of the adoption of new process technologies, Thomas (1994) demonstrates the significance of organisational politics in the process of technology adoption. In the context of electronics, aerospace and computing technologies, Thomas (1994) presents evidence that internal organisational politics and power struggles are of great significance for decisions around process technology adoption, as well as eventual implementation. Among the key observations were that in all cases examined, the initial interest in adoption came from the middle tiers of the management hierarchy rather than being imposed by senior executives; and their motives were often as much about obtaining status and influence within the broader organisational hierarchy as they were about the specific advantages of the technology itself. While new technologies may be sold internally (and upwards) by the language of cost and efficiency, flexibility and control, Thomas observed that it was often a function of the desire of relatively lower status production engineers to build their power and influence vis a vis higher status, centralized manufacturing engineers.

Turning to the implementation process, rather than eliminating labour, the focus was very much on working with existing production employees to ensure the new technologies worked and fit within the existing production systems. This is backed up by recent research by Berger and colleagues (2021). A central finding from Thomas' case studies involving effective implementations was that the importance of active involvement of stakeholders across both vertical and horizontal lines, including collaborations with line workers and manufacturing engineers. A partnership orientation led to more effective integration and exploitation of the knowledge held by line workers and managers. At the same time, there were no negative impacts upon demand for labour or the narrowing of work tasks documented by Thomas (1994).

Each of these cases, and numerous others (e.g., Wajcman & MacKenzie, 1988) illustrate that it is important to examine the adoption and impacts of technologies with a 'wide lens' as suggested recently by Bailey and Barley (2020), since a variety of factors often far from the eventual decisions around adoption and implementation can have significance for downstream outcomes in terms of work and organisation. In addition, it becomes clear that very often the eventual impacts on work and workers are not technologically determined, but are the result of ideological and design decisions made by other actors involved in the development of technologies.

2.5 Sociotechnical Systems Theory

A significant and seminal body of research on the adoption of new work process technology emerged as a result of field research intended to understand productivity problems within British coal mines in the aftermath of World War II, where absenteeism, turnover and labour unrest were consistently high, and morale was often very low (Trist & Bamforth, 1951). The research involved studying an exceptional mine, which had, due to the physical characteristics of the particular coal seam, adopted a different approach to mining and contrasting with a more typical, low performing mine. Due to improvements in mining technologies (new forms of roof control), it had become possible to mine a seam using a 'shortwall' technique. This was a deviation from the 'longwall' techniques which had emerged with mechanisation and become the predominant method for extracting coal. It was along with the large-scale mechanization of the longwall technique that labour unrest grew and productivity failed to grow at the rates expected with the new technology (Trist, 1980).

The new short-wall technique was in many ways a recasting of the older, pre-mechanized techniques and involved autonomous, self-managed, multi-skilled/multi-functional teams, with team members working interdependently, with responsibility for the whole cycle of shoring, clearing, 'getting' and transporting coal from the face to the surface. Although the initial idea of pursuing the short wall approach came from the area manager, the working methods and manning arrangements had been the result of from the miners themselves, with union support. As it turned out, in addition to higher productivity, this approach was associated with significantly higher levels of morale, lower levels of absenteeism, turnover, and labour unrest. This led to the question of whether and how these ideas might be adopted elsewhere.

A distinguishing characteristics of socio technical approaches is the attempt to explain these phenomena by studying three levels of analysis, work systems, work organisations and the broader 'macro' social context in which the organisation operates, such as the community within which a coal mining operation exists (Trist, 1980). One insight of this work was that mechanization had led to organisation of work which was inconsistent with the traditional form of work organisation. This had led to task specialisation with distinct tasks being undertaken in shifts, separating the whole job into the distinct specialized parts of preparation of the coal face with shoring and other activities, the extraction and transportation of the coal, and the moving of machines and equipment over a series of temporally and organisationally separated shifts. This led to a breakdown in coordination, undermining feelings of control and responsibility, with an increase in errors and disputes, and a decrease in the intrinsic value of the work as a collective effort. A notable element of the observations of Trist and Bamforth is that these features also conflicted with strongly collective social values of the pit communities which were themselves a reflection of the mutual responsibilities of this dangerous work.

The result of this early investigation was a theory of sociotechnical systems (STS) in which it was proposed that the successful implementation of new technologies requires consideration of the social context, within and beyond the boundaries of the organisation. The work also identified the importance of worker participation in decisions concerning the adoption of technology and design of work, as these were seen as central in both selection of appropriate work organisation solutions and acceptability of the new technologies themselves.

In contrast to other approaches to understanding technology adoption, STS was highly focused upon the impacts of the implementation on work and work organisation. Early in the development of the STS perspective, Emery (1964; 1976) identified six characteristics of tasks required to support positive social system integration with the technical system: Job content should be challenging and provide task variety; there should be ongoing opportunities for learning on the job; there should be a degree of personal autonomy and discretion with respect to decisions about one's work; the need for social support and recognition of the value of the work; for work to be meaningful, it must contribute to personal identity and afford dignity; and for work to be understood to contribute to "some sort of desirable future" (not necessarily promotion) (Trist, 1980).

Among the principles that emerged from their observations were an emphasis on self-managing work groups as the central unit of organisation, an emphasis on discretionary rather than prescribed work roles with supervisors serving to address boundary conflicts rather than internal regulation of activities. STS incorporated ideas from Von Bertolanffy's (1950) Systems Theory, and from Weiner's (1950) concept of cybernetics. Consistent with the latter, the philosophical perspective of the relation between humans and technology was one of complementary rather than substitutive: "It treated the individual as complementary to the machine rather than as an extension to it" (Trist, 1980, p. 9). Another relevant principle that emerges from the STS perspective is that of organisational choice or equifinality – that there are always multiple ways of designing organisations to achieve given goals. Thus, the notion of technological determinism is antithetical to STS theory.

Although not strictly adopting STS as a framework, as early as 1958, Melman studied the work practices at Standard Motor Company (Coventry, UK) which, despite employing 12,000 workers, was very flat in terms of hierarchy with just 70 foremen, and just 16 people working in the personnel department. Work organisation was in 15 large groups (known as gangs) of 50-500 of workers divided according to their general functioning within the manufacturing process. The gangs were responsible for negotiating their pay and conditions within a plant-wide union agreement. The few foremen that there were, were responsible not for managing people within their work, but addressing boundary issues between functions. Most significantly, the company outperformed other auto manufacturers of the period in terms of market share, paid higher wages, had lower unit costs, remained profitable, and most significantly, adopted new technologies earlier and faster than its competitors (Melman, 1958).

What is also clear from this body of work (e.g., Trist, 1980) is the fragility and temporary nature of any given solution, with either new technologies, new executives, or union negotiations each serving to undermine any achieved equilibrium of workers and technologies (Guest et al., 2022; Mumford, 2000; Passmore, 1995). A criticism of this literature is that it has relied heavily upon action research techniques which produce idiosyncratic solutions that have not found widespread adoption, nor have they produced empirically rigorous tests of the theoretical propositions. Passmore et al (1982) reviewed 134 experiments in application of STS theory and note that while most reported 'experiments' are supportive, there had been relatively few which actually involve technological innovation. A similar criticism is raised by Guest et al (2022) who suggest that despite its label and its roots, the emphasis of much of this work has been on the social relations of work rather than the technical aspects.

In their review, Passmore et al (1982) state that "Given that technological changes are reported in relatively few sociotechnical systems experiments, we must conclude that much of the long-heralded success of sociotechnical interventions may have owed more to changes in the social system and qualifications of personnel than with the joint optimization of social and technical systems" (p. 1195, emphasis in original). For example, technical changes were a factor in only 9 percent of the studies reporting an increase in productivity. In addition, while technical changes were only successful 60 percent of the time that they were studied, social changes were successful on every occasion that they were studied (Passmore et al., 1982).

A central principle of STS is that the design of systems should consider quality of working life framed as work which is challenging, involves a variety of skills, permits autonomy or self-direction, recognition and social support (Passmore et al., 1982). These elements later found their way into the Quality Work Life (QWL) movement, which subsequently were incorporated in theories of job design and enrichment (Hackman & Lawler, 1971; Hackman & Oldham, 1975), and more recently in definitions of 'good work' (e.g., Cazes, Hijzen & Saint-Martin, 2015; IFOW, 2017; ILO, 2020; Taylor, 2017; Warhurst et al., 2017).

The QWL perspective suggests that features such as fair wages, safe conditions, the opportunity for future growth, autonomy, skill variety, doing meaningful work ('whole tasks'), social integration and support, and democracy in the workplace (free speech, privacy, equity, due process) are all essential to a working life that is fulfilling, healthy and a source of human dignity (Cruddas, 2021; Hodson, 2001). This latter point rests upon the centrality of work to life, both in terms of being a source of meaning, but also simply in the proportion of a life span spent working. This view also generally takes the perspective that work with these characteristics will also lead to better organisational and employee outcomes such as higher work effort, lower absenteeism and turnover, more intrinsic motivation and higher quality of work, and ultimately better productivity for the organisation. These broad tenets emerged from STS, were embodied in QWL, and then perhaps reached their most rigorous empirical analysis within the job characteristics research of Hackman, Oldham, and Lawler (Hackman & Lawler, 1971; Hackman & Oldham, 1976; 1980; Spector, 1985).

The job characteristics model is focused on five core dimensions of jobs: skill variety (the number of skills required to perform a job); autonomy; task significance or meaning in terms of its impact on other people; task 'identity' or the completion of a whole job or piece of work (as opposed to a fragment of a larger job); and task feedback or knowledge of results. These five core characteristics influence psychological experience of meaningfulness (task significance; task identity; skill variety); the experience of autonomy; and knowledge of results. According to the job characteristics model, the experience of these psychological states are expected to correlate with high levels of motivation, need satisfaction, and job performance. These hypothesized relationships have generally been supported although they may be moderated by individual differences in 'higher order' need strength (e.g., Spector, 1985).

The relevance to the present review is that, to the extent that technologies either promote or undermine these core job characteristics, or 'good work' more generally, we would expect either positive or negative employee outcomes in terms of attitudes (e.g., satisfaction), behaviours (absenteeism, turnover), and outcomes (work effort, wellbeing). Of interest here is the implication that, under certain conditions employees may wish to encourage greater automation of routine, repetitive or strenuous work where it is clear that they will not lose income, security, or status (Walton, 1973). As has now become clear, whether or not new technologies lead to enhanced or diminished discretion, variety, and meaning is likely to be driven in part by the HR philosophy of the employer (Lepak et al., 2007). This is consistent with the socio-technical perspective which suggests that employee support for the automation of work is most likely to exist when management preference is towards investment in people and skills, egalitarian values, and shared control over work (Walton, 1973). Combining the evidence from STS research with earlier work, we can now say that managerial attitudes towards both technology (e.g., Damanpour, 1992) and towards investment in people can be expected to jointly influence the outcomes in terms of effective adoption, and the consequences for work and workers.

2.6 The Social Construction of Technology

While process studies have made clear that technology does not have a deterministic impact on outcomes, the perspective known as 'social construction of technology' takes this one step further. Barley (1986) examined the impact of the adoption of CT scanners on the work and organisation of radiologists using an ethnographic approach. His in-depth study reveals how the same technology, involving the same roles (technologists, radiologists) led to different structuring of work relationships and different outcomes, according to the local definition that was entirely context driven. Barley argues for a social interpretation of technology in which uncertainties created by the introduction of the technology, uncertainties which can be magnified by the novelty and complexity of the technology, create opportunities for social construction of the meaning of the technology for work organisation. In other words, the outcome is not technologically determined, but is the result of the interaction between the social world and the features of the technology and context in which it is being deployed.

Orlikowski (1992) makes a similar point with her structurational model of technology, arguing that "By aggregating task, technique, knowledge, and tools into a single construct – technology interaction among these constituting components and with humans is ignored" (Orlikowski, 1992, p. 2). Orlikowski invokes Giddens' (1984) structuration theory. According to this view, human actions are both constrained, as well as enabled by social structures. Social structures themselves are the result of prior human actions. Giddens view tries to maintain both the objective and subjective perspectives in a single whole. It is argued that while rules and social structures externally influence behaviour, these are themselves constructed by human social action and interpretation. New technologies are interpreted within the context of a social structure, but also introduce the possibility for change in that structure (Barley, 1986).

A defining characteristic of this perspective is that technology represents not a direct cause of a change, but a trigger or catalyst for a social process which itself constructs the change. Orlikowski (1992) argues that earlier views which treat technology as either entirely objective and exogenous, or entirely socially constructed, reflect a false dichotomy. This perspective does not entirely contradict the findings of earlier variance studies, nor of other process studies (e.g., Thomas, 1994), but the form of analysis allows deeper theorizing about why this is the case. Barley (1986) notes that because the indeterminacy of outcomes is driven by local conditions, large sample, cross-sectional studies may miss these differences. This could explain earlier observations of instability in the results of these variance studies (e.g., Downs & Mohr, 1976).

A significant contribution of the approaches of Barley and Orlikowski and others is to a methodology of understanding the impact of technology on work in context. It motivates us to consider that cross-sectional surveys will be insufficient to fully understand the impacts of technology on work and work organisation. This approach suggests that we should examine the evolution of a technology and work over time, and engage with diverse stakeholders to understand how work roles and relationships may be transformed over time.

3. The impact of technology adoption on work and workers

It is striking that impacts on work and workers tends to be overlooked by the more 'traditional' variance approaches to innovation adoption. However, this does not mean that we do not know anything about the impacts of technology on work and workers. Speaking of the adoption of computers across industry over 30 years ago, Mirvis and colleagues note:

> *"A growing body of studies and some 25 years of experience in industry show that computerization can change the nature of work in many jobs, influence people's morale, affect relations with co-workers and supervisors, and improve (or worsen) levels of accomplishment. It can change the processes of analysis, forecasting, problem solving, and communication in companies and can also affect work schedules, staffing levels, and the location and structure of work units and departments. On a broader basis, technology can have a bearing on the shape and layers of hierarchy in companies, on the centralization versus decentralization of responsibilities, and on the strategies and competitiveness of an enterprise." (Mirvis et al., 1991, p.113)*

There is evidence that in many cases, technologies can enhance the quality of working life. Buchanan & Boddy (1982) show how the introduction of word processing technologies expanded the range of tasks for secretarial staff. This is not to say that outcomes are always positive. In a second study in a bakery, Buchanan and Boddy (1983) report that for some job roles, new computer-based equipment served as a complement to skills, 'informating' (Zuboff, 1988) the work, while for other roles skills were made obsolete. Buchanan and Boddy's (1983) conclusion is that the outcomes are driven by both management objectives and existing organisational structures and practices, as well as the capabilities of the technology itself.

Computerization can result in either centralization, or decentralization depending not only upon the capabilities of the technology, but significantly, both managerial philosophy and the prior history of industrial relations in the organisation (Thomas, 1994). Barley (1992) observes that the impacts of new technology on the work organisation of radiologists resulted in centralisation in one context, but decentralization in another. The effects being a function of power and influence, and prior social relations. Thomas (1994) finds that in addition to managerial goals, prior industrial relations are a significant influence on a cooperative attitude to the adoption of technology, and the empowerment of employees through the use of new technologies.

There are numerous potential downsides of automation, including is loss of control over the pace of work (Ettlie, 1986; Friedland & Barton, 1975) which can undermine physical and mental wellbeing; jobs may become more rather than less routine (Brod, 1988); work can be subject to even closer supervision (Mankin, 1983); and social relations can be disrupted (Nussbaum, 1980).

A lesson from the process school is that management values and ideology are a significant driver of the eventual outcomes (Forsythe, 2001). For example, Noble (1984) describes in detail how the desire by GE executives to reduce the company's exposure to labour unrest which had become a significant challenge in post-war industrial relations in the United States, led the company to actively invest in technologies that would eliminate their reliance on skilled machinists. At the time, two competing automation technologies were emerging, the first to be developed was the 'record-playback'(R-P) equipment which took inputs from a skilled machinist to develop an initial recording which would then guide automated machine tools in mass-producing their finished products. While this technology would reduce the reliance on human inputs in the final manufacturing process, and brought significant efficiencies, it still relied on shop floor inputs from skilled workers to function. The alternative technology was numerical control (N-C), in which the specifications of the finished product would be programmed by technical and professional employees – i.e. managers – and the machines themselves would then operate without any inputs from shop floor workers. This latter technology received the investments explicitly because of the potential to circumvent powerful and antagonistic labour union members, and increase control by executives. This is despite the fact that the R-P technology was arguably more effective, lower cost, and market ready, in contrast to the nascent N-C technology which required major investments in computing and programming equipment involving skills and technical competence which were at that stage quite scarce within industry (Noble, 1984).

Kozlowski (1988) argues:

> *"Because of management bias toward central control, embedding content solutions to the deployment of technical content have the potential to go the way of increased Taylorization with all its negative consequences (Moss, 1982). Alternatively, with appropriate managerial innovation, the implementation and routinization process can result in a redesigned, restructured, socially innovative workplace that enhances human aspirations (Brooks, 1982, OTA, 1984). Resolution of this dilemma is strongly dependent on the orientation of management and its willingness to experiment with different forms of organisation (cf. Chao and Kozlowski, 1986)."*

Kozlowski proposes that two factors are important: (1) the climate for innovation (social and technical), allowing experimentation and minimizing resistance; (2) The investment in training programs and skills that facilitate adaptation by the workforce. A culture supportive of innovation requires a long-term view which recognizes the potential of innovation for value creation and the achievement of business goals (e.g., Hayton, George & Zahra, 2004; Zahra, Hayton & Salvato, 2005).

Mirvis et al., (1991) similarly argue that four factors are relevant to whether new technologies are successfully implemented, and whether they have a positive or net negative impact on work and workers. First, the extent to which the organisation has the necessary technical capabilities to exploit the new technology; second whether consideration is given to training, employee support, implications for job security and compensation – in other words the concerns of workers which will in turn influence success or failure of implementation; third, user readiness in terms of their understanding of the need for the new technology, its technical benefits and its benefits (if any) for them; and fourth, the existing organisational culture, prior experiences with technology introduction and change management, employee participation and cooperative or adversarial relationships. In sum, Mirvis and colleagues argue that the presence of high-road people management practices, including an investment orientation to employee training, and employee involvement, voice and participation in decision making, help drive commitment and at the same time lead to a more positive outcome in terms of work design. Something that is often overlooked in typical managerial studies of technology adoption and work, although which has been picked up in economic studies, is that 'geography matters':

> *"Graetz & Michaels (2018) suggests that differences between their findings and Acemoglu & Restrepo (2017) may be explained by the different geographic focus of the two studies. Differences in managerial attitudes and organisational structures (e.g. firms in the United States being 'more aggressive than European counterparts in promoting and rewarding high performing workers and removing under-performing workers', Bloom, Sadun & Van Reenen, 2012) or in institutional arrangements (public policy, the decline of unions being more pronounced in the United States than in many European countries) could explain why robots are linked with a decrease in overall employment in the United States but not elsewhere." (from BA report, 2018).*

Not unrelated is the fact that 'education matters' (Blundell, Green and Jin, 2018). As suggested by Berger and colleagues (2021), workplaces may only adopt technologies when educational levels in the labour force are sufficiently high. Naturally, workforce education levels and geographic effects intersect. In the context of local government organisations, Damanpour & Schneider (2006) report that urbanization, community wealth, and population growth are positive drivers of innovation adoption, while unemployment is a suppressor of innovation adoption.

4. Discussion and conclusion

Taken as whole, we must picture the association between managerial decisions about technology and work outcomes as an intersection of multiple factors rather than simply a causal straight line from managerial will to employee outcomes.

It would appear that external factors, in terms of market competition, large customers, institutional support, and labour markets are important forces in shaping managerial preferences. At the same time, internal work organisation, and philosophy with respect to the management of people will exert a significant influence upon outcomes. Furthermore, time matters, since historical relationships and past practices will determine the degree of trust and commitment, and willingness of employees to engage positively with changing technologies on the part of impacted employees. That engagement is clearly important when it comes to implementation of new process innovation (e.g., Schraeder, Swamidass, & Morrison, 2006; Thomas, 1994).

The literature helps us in many ways, once we boil down the key components. The logical decision making, all else equal, clearly involves an assessment of the perceived potential benefits of a given technology, alongside evaluation of the challenges, in terms of technological know-how, and organisational fit or readiness for adopting the technology. Having said this, it is apparent that these decisions are framed by several other forces.

First, the decisions about technology adoption will be significantly influenced by the proposed benefits, which in turn reflect the goals and ideology of the developers and sponsors of new technologies (Forsythe, 2001; Kidder, 1981; Markoff, 2015; Noble, 1984). In its most basic terms, new technologies are either substitutive for labour, or complementary to it. Markoff contrasts the ideology of intelligence augmentation, which intends to promote the development of technologies which improve human capabilities, with artificial intelligence, which aims to replicate and substitute for human thought and action. These are more than purely a play on words and can be seen in the words and deeds of their respective champions. On the one hand, we have innovators such as Alan Kay (developer of the graphical user interface) and Doug Engelbart (creator of the computer mouse and modern human computer interaction) who sought to build technologies that would enhance and enable humanity. On the other, are innovators such as John McCarthy (founder of the discipline of AI) and Sebastian Thrun (autonomous vehicles), who focus on the capacity of AI to be able to perform human tasks without the need for human intervention. Adopters of technology are exposed to these viewpoints indirectly via the stated goals and benefits of a technology via the vendors.

Second, the awareness of technological opportunities is often a bottom-up process. The championing of new technologies will often be undertaken by someone other than the person with budgetary control (Thomas, 1994). These technology champions must be motivated to engage in the promotion of new technologies, with the concomitant career risk associated with promoting an uncertain technology (Day, 1994). This is a topic which has received a lot of attention within the innovation literature but appears to have had less attention in cases of the adoption of external innovations. Yet, Thomas' (1994) case studies indicate how important these behaviours are for framing opportunities for technology development, as well as providing motives and an organisational rationale. Such rationales are potentially important for the eventual outcome in terms of jobs and work organisation, in that they can stimulate investment or cost savings activities.

Third, the readiness of the existing workforce is expected to be a major driver of whether either champions, or executive sponsors of process innovation decide to promote or support new technology projects respectively. Readiness in fact involves two different considerations. First comes the question of whether sufficient technical expertise exists to implement and maintain new technologies, as well as to derive sufficient benefit from them. Second comes the question of readiness in terms of willingness to accept and commit to the effective implementation of the new technology. The sociotechnical systems literature provides striking examples of how the social fit can drive exceptional positive results from new technologies.

Fourth, the impact of new technology on work outcomes is far from determined. The same technologies can lead to greater decentralization, empowerment, and enhanced richness and meaning in work, or it can lead to greater centralization, loss of control and loss of work. The eventual outcomes reflect choice, but within the constraints identified above. They are likely to be impacted by the human resource philosophy and culture of the focal organisation (Lepak et al., 2007; Mirvis et al., 1991). The outcomes for the firm are also impacted by these management choices. For example, Brynjolfsson and colleagues refer to the Productivity J-Curve, whereby radical new technologies require investments in business process redesign, worker reskilling, and organisational transformation to access the potential productivity benefits. The shape of the curve reflects the observation that there is initially drop in productivity in the short run before productivity improvements are achieved. This signals the importance of managerial practices in implementation phase. However, literature from diverse perspectives from TOE, to STS to process views, all converges on the observation that a well-developed workforce will also influence the absorptive capacity of the organisation for identifying, understanding and testing new technologies, all of which precede eventual implementation.

Finally, the greatest challenge may not be that of employees being substituted by technology and losing their jobs. Rather, it is whether individual firms are able to adapt and automate at all. A significant number of employers (SME represent 98% of all firms and employ 50% of the workforce) are likely to be constrained in technology adoption by several factors. In particular, workforce ability to adapt and be retrained in ways that increases efficiency over the older methods of working. If production remains at a fixed level, then over time the adoption of technology will reduce demand for labour. However, in most cases, technology adoption does not simply replace, but augments existing jobs meaning that incumbents will remain in place (Berger et al., 2020). In their study of the impacts of new automation technologies in manufacturing, Berger et al (2020) note that strategic innovation exerts a significant influence on work outcomes via two routes: by extending the range of products, which then drives adoption of new technologies for production and delivery, which is followed by hiring more skilled workers; or extending production capabilities by integrating previously outsourced work using new technologies, again followed by extending hiring of skilled workers. Why don't incumbents lose their jobs? Because they have a lot of valuable task and tacit knowledge; because machines are not able to perform 100% of tasks, let along all tasks required; and because a piecemeal strategy is used in adoption. This in turn implies that employers are facing a number of frictions, just as workers do: access to needed technology and associated resources (including human resources); the ability to absorb new technology - in particular the management and organisational capabilities to adapt their systems; and access to valid information about technology and the skills required to make the most of the technology.

The many decades of research on innovation have provided us with insights concerning the drivers of technological innovation for improving organisational performance and pursuing new market opportunities. What is far less well developed are our understandings of the interaction of these forces and management practices in the driving outcomes for work and workers. The research reviewed here suggests a few conclusions with respect to enhancing that understanding.

First, research will need to consider a diverse range of factors. At a minimum, it must consider perceived characteristics of the technology (e.g., perceived comparative advantage), organisational fit and readiness, and the presence of major environmental factors (e.g., geographic labour market conditions, market competition, influential trading partners). However, in addition, the industrial relations and human resource philosophy are clearly an important factor in their own right, and are likely to influence considerations of whether an organisation is prepared to adopt a new technology. All of these antecedent characteristics are expected to exert direct and indirect effects upon the outcomes for work and workforce. In particular, these outcomes might be considered in terms of the most important work characteristics giving rise to experienced autonomy, meaningfulness, and feelings of competence (Deci & Ryan, 1995; Hackman & Oldham, 1975).

Second, it is not possible that a single research design can reveal everything we still need to understand about the factors influencing technology adoption or the impact of new technology on work. On the one hand, in order to understand whether geography or other environmental factors matter in a systematic way, we must consider cross-sectional 'variance' designs where we can examine these factors acting across many individual technology adoption decisions. In order to understand both the direct and indirect effects and test the relationships summarized above, requires a large-scale survey design.

However, such a design is insufficient to understand the deeper contingencies among the various interacting 'parts' of this complex system (Trist & Bamforth, 1951). Such understanding is best developed through deeper process-oriented case analysis. Qualitative case-based research that examines individual technology adoption instances will provide the necessary information about context for better developing our understanding of the complex interactions between the social and technical domains (Barley, 1986; 2020; Orlikowski, 1992; 2009; Trist, 1980).

Fortunately, the research project under the Pissarides Review will include both a large-scale survey and a series of cases which are together designed to help shine a light on the influences on technology adoption and its consequences for work and wellbeing. These will be described in forthcoming papers.

Endnotes

1 Interestingly, such record playback approaches have returned to prominence in more recent robotic and social-robot or co-bot solutions.

2 An interesting historical footnote is that it was his exposure to the record-playback technology when working as a publicist for General Electric, which led Kurt Vonnegut to write his dystopian novel Player Piano which depicts 'lights-out' factories in which engineers hold all of the social power, and workers find themselves displaced by advanced automated machine technologies.

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The Pissarides Review into the Future of Work and Wellbeing

Automation technologies are transforming work, society and the economy in the UK in ways comparable to the Industrial Revolution. The adoption of these technologies has accelerated through the COVID-19 pandemic, and the impact of automation is unevenly distributed, with a disproportionate impact on demographic groups in lower pay jobs.

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If you have a professional or research interest in the subject of the impact of automation technologies on work and wellbeing and have insights to share, please contact Abby Gilbert, Director of Praxis at the Institute for the Future of Work at abby@ifow.org

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