Implementing Automation: a study of the shopfloor politics of technology change in the Canadian aerospace sector

by

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Submitted to

Cardiff University

in February 2023 as a thesis towards the degree of Doctor of Philosophy by advanced study

in

Business Management

Abstract

This study examines how varying managerial and trade union strategies shape different social patterns of workplace technological change through a comparative study in the Canadian aerospace sector. Recent advances in technologies such as internet enabled devices, data storage, advanced robotics, and additive manufacturing, among others, have spurred a renewed interest in technology change in the workplace among social scientists. Previous research demonstrates that a key moment in workplace technological change occurs in the implementation and debugging phase, when workplace actors negotiate how a technology will be deployed on the shopfloor. Despite many studies in the labour process and industrial relations traditions examining the implementation of new technologies on the shopfloor, a theoretical framework for grasping the social patterns of debugging has remained lacking. This thesis develops such a framework through the comparative study of four technological changes at two factories operated by a Canadian aerospace firm and thus deepens our understanding of how workplace actors can shape the trajectories of technological change.

I explain the observed variations in patterns of implementation through an examination of actor strategies. Here, managerial strategies are defined as a relationship between forcing and fostering while trade union strategies are categorised according to the presence or absence of a considered, timely, and organised union response. Cross classifying managerial and union strategies gives rise to the central theoretical contribution of this study: four social patterns of implementation and debugging each with implications for speed of rollout, efficiency improvements, and worker autonomy. First, a managerial forcing strategy and a developed union strategy produces a *contested pattern* of implementation characterised by a relatively slow rollout, limited efficiency gains, and limited but generalised worker upskilling. Second, a managerial forcing strategy in the absence of a developed union strategy results in a *unilateral pattern* of implementation associated with a rapid rollout, managerial satisficing on efficiency gains, and limited worker autonomy. Third, a *co-ordinated pattern* is the result of a developed union strategy in the context of managerial fostering and produces a steady rollout of the new technology with observable efficiency gains and high levels of worker autonomy. Finally, a *co-opted pattern* arises from managerial fostering in the absence of a developed union strategy with a rapid rollout, limited efficiency improvements, and isolated worker empowerment at managerial discretion.

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Acknowledgements

I am deeply indebted to my three brilliant supervisors, Professor Marco Hauptmeier, Professor Jean Jenkins, and Professor Christian Lévesque for their friendship, intellectual guidance, and fierce advocacy throughout doctoral studies. Complaining about supervisors is a staple of conversation among graduate students, but for the last five years, whenever the topic has turned to inattentive, obtuse, or dull supervisors, I have found myself with nothing to contribute. I originally applied for a studentship at Cardiff Business School because I wanted to study under Marco, having read his work on whipsawing and the political economy of work. His tutelage has made me a much more systematic thinker and a more cautious researcher. His friendly approach, intellectual thoroughness, and apparently inexhaustible patience have helped me navigate a sometimes chaotic five years and produce this thesis. I asked Jean to join my supervisory team after being tasked with analysing one of her papers for a graduate seminar. Her kindness, clarity of thinking, and political conviction have been a formative source of guidance for me. Christian joined my supervisory team when I was awarded a scholarship by the CRIMT network to conduct my fieldwork in Canada. His generosity opened countless doors for me in North America, and we had a few excellent nights out, too. We were guided ably by Professor Caroline Lloyd who served as chair of my committee.

I also want to express my gratitude to Cardiff Business School and the CRIMT Network for funding my doctoral studies. The various scholarships awarded to me allowed me to read books and papers and conduct my research in a level of frugal comfort, while having limited expectations on my time for paid work, a utopian experience many graduate students are not lucky enough to enjoy. The staff at both Cardiff Business School and HEC Montréal helped me navigate the often-oppressive bureaucracy of contemporary universities. I would particularly like to thank Sol Salah and Phil Davies in Cardiff and Nicolas Roby in Quebec for all their help. I would never have been able to get my studentship at Cardiff in the first place without the encouragement and support of my colleagues at the University of Melbourne where I worked prior to my PhD, especially Professor Brian Howe, Professor Peter Gahan, Andreas Pekarek, and Josh Healy.

Over the course of my studies I have lived in eight houses across three continents. I have made countless new friends, and shared living space with no less than 12 housemates. There are too many important people to mention here in any detail, but I would like to express my appreciation for a few people specifically. First, my colleague Muhao “Muhey” Du, whose sharp intellect, sly sense of humour, and brilliant sense of style managed to brighten even the dreariest winter days in South Wales. My housemate Lewis Godwin, who was as kind and generous as he was chaotic, got me through some really difficult months. My friend Isaac Wright, who moved from Melbourne to London only a few weeks after I moved to Cardiff and was a pilar of support and friendship

throughout my years in the United Kingdom. Our travels together around Europe are some of my happiest memories. Finally, my comrade Karel Muselek, who become my lockdown buddy and kept me sane through the worst months of COVID-19. Thanks to him, whenever I think of the years I lived in Cardiff, I think of long walks up the Taff River with a backpack full of cheap lager.

I also want to mention my outstanding PhD colleagues Shou Sun, Tracey Rosell, Felix Xi, Wojdan Omran, and Philippe Demougin, whom I hope I helped a fraction of how much they helped me. Other academic colleagues who helped make the last five years so stimulating—many of whom I met on University and College Union picket lines—include: Jonathan Preminger, Cassie Bowkett, Sara Pérez-Lauzon, Professor Keith Whitfield, Mona Aranea, Professor Tom Entwistle, Nikos Kapitsinis, Esther Muddiman, and Aggelos Panayiotopoulos. And of course, my many housemates and friends who have been there for me along the way, in no particular order: Ffion Griffiths, Nick and Cassie King, Sara Di Caroli, Alfredo De Romana, Jessica Strachan, Amedeo D'Aprano, Owen Wrangle, Rima Tawil, Suze Metheral, Aarin Moon, Kenny Cheng, Cinzia Myatt, and little Jack Howard (and his big adventures).

Since returning to Australia, I have worked as a National Research Officer for the Australian Manufacturing Workers' Union. Members of the national leadership team have made it possible for me to make a serious contribution there while also finishing my thesis. Here, I am particularly grateful to Assistant National Secretary Glenn Thompson. My mum and dad, Carmel and Tony, have been a constant source of warmth and reassurance. I hope this thesis lives up to the sober radicalism and deep optimism they tried to instil in me. Finally, and most importantly, my wife Katherine Mella Escobar. We met while I was on holiday back in Australia in January 2019 and Kat was moving to Melbourne from Chile on a working holiday visa. Just over three years later we got married in a small ceremony in a room above a pub on a Friday evening. I am constantly in awe of her beauty and her wisdom, and she has always been more patient and generous than I deserve. Words can't begin to express how lucky I feel to have her in my life, and I can't wait to spend my weekends with her instead of with this thesis.

I dedicate this thesis to the Unifor and Machinists' union shop stewards who made me feel so welcome in Canada, their families, and their unions.

So we have a target for the new equipment's performance, when the target is reached, [implementation] is done. But unless you know what your target should be, then you don't know if you have to move on or not, to carry on or not. And sometimes, it means that you may say, "Okay, that's good enough for me, I will stop supporting people to learn and we will just run production." But you haven't seen yet all the problems that could occur, and all the things we could actually achieve if we gave workers more control of the equipment. So, it really depends on what you want from your machine.

Interview 34, Operations Supervisor, Laurier Quebec, 29-08-2019

During my time as a trade unionist, we have had three tools in our toolbox when it came to technological change. First, we sought assurance that nobody would lose their job. Second, we bargained for retraining for our members on the new equipment. And, third, if those things failed, we made sure we got our people some money to go away with—a decent severance package. I am now convinced that we need new tools to tackle this next wave of automation.

Canadian President, International Association of Machinists and Aerospace Workers, Speech to the Quebec Congress of the Union, 15-05-2019

CHAPTER ONE: Introduction

This study is concerned with how new technologies are implemented in the workplace, and how the strategies of workplaces actors—especially managers and trade unions—shape the process of implementation. Social scientists have long acknowledged that technology change plays a central role in shaping the contours of our working lives. Under capitalism, technological change at work involves patterns of conflict and compromise between labour and capital, or more concretely between workers and managers. These struggles occur at different levels: the design of technologies; their selection; and their implementation and debugging (Wilkinson 1983). Struggles over implementation and debugging occur on the shopfloor, and these shopfloor conflicts are the focus of this thesis. How a particular technology is used in the workplace is shaped in significant part

by the process of implementation and debugging. While technologies arrive in the workplace with a limited range of applications and uses inherited from the design and selection phases (Wilkinson 1983; Vidal 2019), they can nonetheless be subject to significant reconstitution in their use, especially during the process of implementation (Orlikowski 2007; Edwards and Ramirez 2016). Different patterns of implementation can thus have observably different outcomes for the speed and efficacy of rollout, the efficiency of production, and worker autonomy.

When a new technology is introduced to the workplaces—a robotic welder, for example—the task of the new equipment (the joining of materials) is already established, but the process of implementation will play a significant role in establishing the work processes that surround the robot. Will shopfloor workers have the capacity to program, retool, and troubleshoot the new robots or will those tasks be concentrated with supervisors? Will the new robots generate tangible efficiency gains, or will they be poorly integrated into the production process and create bottlenecks? Patterns of conflict and compromise between workers and management during the process of implementing and debugging the new robotics will play a significant role in determining the answers to these questions. In our day-to-day working lives, shopfloor struggles over technological implementation shape the tasks we perform and the skills we use to perform them. They help dictate how fast we work and how we co-operate with others. They shape the efficiency of work processes, and who benefits when productivity improves. They determine how we use different tools to perform our work and who has control over this equipment. The outcomes of these struggles can mean the difference between successful enterprises and failed businesses. These struggles can make the difference between meaningful work and tedious drudgery.

The academic study of patterns of conflict and compromise between labour and capital at the point of production is the study of the labour process. Marx (1976, p. 179) described the labour process as how human beings turn nature into useful things, or "human action with a view to the production of use values." With each major wave of technological change, labour process scholars turn their attention afresh to the relationship between work and technology. Right now, significant advancements in areas like internet enabled devices, data collection and storage, advanced robotics, and additive manufacturing—among other technologies—promise to reshape work in novel ways. The extent to which these new technologies represent a significant break from the past, both in terms of the technologies themselves and their impact on work processes, is subject to significant conjecture. While some authors suggest we are standing on the precipice of a new industrial revolution (Frey 2019; Mason 2015; Schwab 2016), others maintain that predictions of dramatic industrial and social upheaval are overblown and see current developments as a continuation of previous trends (Briken et al. 2017; Pardi et al. 2020). A brief survey of the managerial literature

nonetheless suggests that—whatever the empirical reality—employers hope that contemporary technological change can represent a significant leap forward both in terms of efficiency and managerial methods (for discussion see Lévesque et al. 2021; Moeuf et al. 2018; Pfeiffer 2017).

The physical and managerial technologies used to make products and deliver services do not emerge and change in isolation. Their development is shaped by the institutions of the society where they emerge or are deployed and reflect the ideas and interests of social actors like employers, governments, financiers, and trade unions. For most workers, efforts to influence technology change take place on a highly uneven terrain. Employers, as the owners of the means of production, maintain a dominant position in relation to the design and selection of technologies. This is particularly the case in liberal market economies, where (notwithstanding limited voluntarist exceptions) the managerial prerogative is institutionally enshrined, and unions have limited levers at their disposal to exercise influence over how work is organised (Turner 1991; Hall and Soskice 2001; McCann et al. 2010). In this context, managers face the choice of coercively forcing changes on their workforce—forcing strategies—or pursuing a strategy that aims to gain the consent of workers by involving them in the process of change, known as fostering strategies (Walton et al. 2000).

Despite inherent institutional limitations, workers maintain significant (often latent) capacity to influence the process of implementation and debugging. It is broadly recognised that workers have the most influence over their working lives when they are organised collectively. From the Luddites who engaged in "collective bargaining by riot" (Hobsbawm 1968, p. 57) by smashing machines, to the burgeoning movement to unionise gig-economy workers and the notion of "digital picket lines" (Forsyth 2022, p. 12), workers and their organisations have deployed novel strategies to shape the impact technology has on their working and economic lives. Yet in studies of technological implementation and debugging, several scholars have noted that trade unions often fail to develop and execute coherent or effective strategies to influence the process of technological change at the point of production (Wilkinson 1983; Thompson and Bannon 1985; Delbridge 2000; Bilsland and Cumbers 2018). This is despite others demonstrating that unions can and do carry out timely and organised shopfloor strategies to shape the process of technological implementation and debugging (Taylor and Bain 2001; Danford 2005; Murphy and Cullinane 2021). This thesis argues that the interaction between managerial strategies and union strategies generates different social patterns of implementation and debugging new technologies with demonstrable impacts on efficiency and worker autonomy. First, however, it is necessary to introduce some of the "new new technologies" (Holtgrewe 2014, p. 9) that will be studied in this thesis.

New Production Technologies

The highly publicised proliferation of internet enabled devices, the collection of unprecedented amounts of data, the rapidly growing capacity of machines to 'learn', and major advancements in robotics and other technologies have drawn the attention of scholars of work in recent years. Every wave of technological change brings with it claims from observers that 'this time is different' (Healy et al. 2017; Pitts and Dinnerstein 2020), arguing that nothing short of the complete reorganisation of the economy and society is imminent (for recent examples see: Brynjolfsson and McAfee 2014; Dunlop 2016; Frey 2019). There is little doubt that technology is supporting the significant reorganisation of some industries and jobs. For example, platforms like Zoom and Microsoft Teams have enabled many workers to work remotely much more than previously (Budnitz and Tranos 2021; Felstead 2022). Similarly, smart phone applications like Uber and Deliveroo have restructured how we use driving and delivery services (Healy et al. 2017; Veen et al. 2020).

In the manufacturing industry—the focus of this study—many of the conversations around technology change have centred on the notion of 'Industry 4.0'. The concept was launched at the Hannover Trade fair in 2011 and was heralded as a new production paradigm with the potential to dramatically overhaul work processes in the manufacturing industry (Kagermann et al. 2013). Yet Industry 4.0 is a contested concept with multiple, sometimes contradictory meanings. A literature survey by Moeuf and colleagues (2018) identified more than 100 definitions. In the broadest terms, however, Industry 4.0 promises to connect different parts of a factory, as well as connecting producers to suppliers and customers by making real time data available to various parties through internet enabled devices (Pfeiffer 2017; Moeuf et al. 2018; Lévesque et al. 2021). Other advances likely to impact the manufacturing industry include 3D printing, a method for additive manufacturing which creates an object layer-by-layer based on a digital model and advanced robotics which use a combination of sophisticated computer programming and smart sensor technology like ultrasonic, touch, and light sensors, to interact with the real world around them in ways that were not previously possible.

Taken together, some claim these technology changes are likely to completely revolutionise production processes across different manufacturing sectors (e.g.: Gregolinska et al. 2022). Though the empirical evidence from actual workplaces suggests that the deployment of these technologies is highly varied and in its early stages (Pardi et al. 2020; Rutherford and Frangi 2020; Lévesque et al. 2021), it is argued in this study that—to the degree that these technologies are actually in use in the production process—there is little empirical evidence to suggest that they represent a fundamental paradigm shift from previous manufacturing technologies. Rather, they can more accurately be seen

as a continuation of previous trends in technological change in the manufacturing sector. In this respect, this thesis echoes the findings of a recent study by Pardi and colleagues (2020, p. 6) for the International Labour Organisation (ILO) on the impacts of recent technological changes in the manufacturing industry that rejected "the idea that a fourth industrial revolution is under way and that a radical break will happen in the coming years," but argues that "more subtle changes are taking place on the shopfloor of… factories that might result in deskilling and work intensification."

The Shopfloor Politics of Technology Change

While some authors grant technology the power to make and remake social conditions of its own accord, this study views technologies as the result of human choices, mediated by social institutions and reflecting the interests of powerful social actors. As argued above, patterns of implementing and debugging new technologies in the workplace are primarily shaped by struggles between employers—and their managerial representatives—and workers. The relationship between workers and their employers under capitalism is characterised by what Edwards (1986, p. 5—6) called a "structured antagonism" whereby workers create value in their labour process but some of that value is appropriated by their employer. This does not mean that the interests of these two groups are always diametrically opposed. A new technology could theoretically improve productivity in a way that increases profits, grows market share, *and* improves employment security. Thus (all other things being equal) the technology has benefitted both workers and management at the firm. But this does not mean that the fundamental antagonism has dissolved. There remains an underlying divergence between the interests of workers and the interests of the capitalists who employ them. In the context of this structured antagonism, patterns of conflict and co-operation between workers and managers heavily influence the development and deployment of production technologies.

The central focus of this study is the patterns of social struggle that surround the deployment of new technologies on the shopfloor: with implementation and debugging. The potential influence that capital has over how a technology is implemented is reasonably straightforward, as the owners of the means of production capital generally retains most decision-making power over how technologies are deployed in the workplace. In the managerial literature, the managerial drive to revolutionise the means of production is sometimes framed purely around the drive to improve the efficiency of production (see for example Hecht 2018). By contrast, in the labour process literature, the analysis of managerial strategies towards implementing and debugging new technologies tends to emphasise the need for management to maintain control of the workforce and the work process (Braverman 1974; Noble 1984; Bélanger 2006). This thesis follows Vidal (2019) to analyse managerial strategy towards technology change as encompassing a tension between deploying coercive or

forcing strategies to maintain control of the work process and consensual or fostering strategies that empower workers to generate greater efficiency outcomes.

The strategies of labour—and trade unions in particular—around the implementation and debugging of new technologies are often framed along similar lines. Turner, (1991, p. 223) for example, studied technological work reorganisation in North American and German automotive plants and framed trade union approaches in terms of "integrated" and "adversarial" approaches. These loosely reflect Walton et al.'s (2000) forcing and fostering strategies. This framework is of more limited value on the labour side, however. Several scholars have noted that unions are often largely absent from the social and political processes of implementation and debugging, even opting not to use power resources at their disposal to influence the process (see for examples: Thompson and Bannon 1985; Delbridge 2000; Bilsland and Cumbers 2018). This is despite other studies demonstrating that certain union strategies can begin to "prise open new bargaining agendas" (Murphy and Cullinane 2021, p. 288) even in the absence of institutional frameworks supporting these interventions (Taylor and Bain 2001; Danford 2005; Murphy and Cullinane 2021). Empirical evidence on unions prising open such new bargaining agendas often involves the union deploying forcing and fostering strategies simultaneously (see for example Wilkinson's (1983) study of the Rubber Moulding Works).

Despite the demonstrated successes of unions deploying developed strategies around the implementation and debugging of new technologies, many unions remain hesitant towards or ignorant of the apparent opportunities. The hesitancy of some unionists towards advocating strongly on matters of technology change—often favouring 'bread and butter' issues like contract negotiation and enforcement—has some foundation. Several studies have examined the pitfalls of union involvement in decision making usually considered the purview of management. One frequently observed drawback of expanding the scope of union influence into these areas is that it frequently involves submitting to managerial (and capitalistic) logics (Danford et al. 2005). Other studies also point out that managers—even when well intentioned—may struggle to deliver on their side of the bargain due to limitations placed on their decision-making power under contemporary organisational structures (Thompson 2003; 2013). Despite these potential issues, there remain observers highly critical of unions' failure to challenge management's right to manage. Notably, Marglin (1974) argued that unions had not attempted to influence the relationship between workers and the work they perform because this would bring them into conflict with the capitalist system itself, rather than having a marginal say over the division of the capitalist pie. It is argued here that framing union approaches in terms of forcing and fostering is thus a false dichotomy and that examining the presence or absence of developed (timely, considered, and organised) union strategies offers greater explanatory value.

Research Question and Argument

In approaching this study, the fundamental research question guiding the project was:

How do management and union strategies shape the implementation and debugging of new technologies on the shopfloor?

Conflicting views of how actor strategies impact technology change have been brought into sharp focus by the highly variable results of technological implementation in the workplace. Examples of successful technology change which realise efficiency gains alongside worker upskilling (e.g. Wilkinson's (1983) Rubber Moulding Plant) contrast with attempts to implement new technologies that faced significant social and technical difficulties (e.g.: Will-Zocholl 2017). Nonetheless a theoretical framework to grasp patterns of implementation and debugging remains lacking in the literature on workplace technological change. This thesis argues that managerial strategy, understood as a relationship between forcing and fostering, interacts with the absence or presence of a timely, considered, and organised union strategy to shape these changes. Cross-classifying these strategies produces the central theoretical contribution of this study: four patterns of implementation and debugging, each with distinct implications for the speed of the rollout, the efficiency of production, and the autonomy of workers under the new labour processes. The four patterns of implementation are outlined at a high level below:

1. When management deploys a forcing approach and labour has a developed strategy for addressing technological implementation and debugging, a *contested pattern* of implementation results. This pattern is characterised by limited efficiency improvements, frequently by a stymied rollout of the new technologies, and limited but generalised worker upskilling on the new technologies.
2. A *unilateral pattern* arises when management deploys a forcing strategy and labour fails to deploy a developed strategy around technology change on the shopfloor. This pattern involves a rapid implementation process with limited increases to efficiency and minimal worker involvement or upskilling.
3. The *co-ordinated pattern* results from the interaction between a developed union strategy and a managerial fostering strategy. This pattern generates steady, lasting improvements to production efficiency and grants workers significant autonomy over the new labour process through integration and upskilling.
4. Finally, managerial fostering combines with an absence of a developed union strategy to produce a *co-opted pattern* of implementation and debugging. This pattern's significant initial efficiency gains generally prove unsustainable as an absence of organised worker

voice means worker empowerment and upskilling is limited to a small number of favoured employees.

Managerial initiatives and trade union responses around the implementation and debugging of new technology will likely be of high importance in coming years as the 'new new technologies' are increasingly to be operationalised in workplaces. The patterns of implementation framework developed and elaborated in this thesis demonstrates that far from being 'too late' for technologies to be adapted or changed once they arrive on the shopfloor, they can be subject to significant reconstitution in the process of implementation and debugging (Orlikowski 2007; Edwards and Ramirez 2016). This thesis develops our understanding of contemporary technology change through the elaboration of a theoretical framework to grasp patterns of implementation and debugging at the point of production.

Research Context

Testing and developing the argument presented here therefore necessitates getting inside the "hidden abode of production" (Marx 1976, p. 279) to examine the interaction between managers and workers, the role of unions, and the causes for contrasting outcomes in the process of implementing and debugging new technologies. This study develops and elaborates this argument through the study of implementation and debugging of four technologies at the Canadian aerospace firm Laurier Aerospace.[1] The four case studies of technology change are nested in two of Laurier's manufacturing plants: one in Quebec and one in Ontario. The plants are characterised by several consistent contextual factors. Both plants are owned and operated by Laurier Aerospace, and though they maintain different local managements, senior production and human resource managers are part of national teams. The primary production function at each factory is the final assembly of business jets. In other words, both plants produce similar products for the same product market. And finally, both plants used highly comparable production technologies. There were important differences between the cases, however. First, Quebec maintains a "hybrid" model of political economy in which quasi-corporatist institutions are "alloyed onto" a fundamentally liberal market institutional framework (Morissette and Charest 2010, p. 225). Ontario, by contrast, is a more prototypical liberal market economy, with relatively stringent restrictions on unions' right to organise (Haddow 2015). Importantly, workers at the two plants are organised in different unions which maintain observably different approaches to technology change. Thus, this research context

[1] The name of the firm has been changed at the request of the firm's management.

provided a suitable empirical site for the study of how the varying strategies of workplace actors shape patterns of implementing and debugging new technologies.

The first two case study technologies to be discussed are nested in the Quebec plant. First, this study examines the implementation and debugging of composites additive manufacturing robots for fabrication of skins for the aircraft. This case began with management integrating a small group of workers into the process of debugging, while the union at the plant—the International Association of Machinists and Aerospace Workers (IAM or Machinists)—failed to deploy anything resembling a timely and organised shopfloor strategy towards technology change. This co-opted implementation pattern produced a partially successful rollout of the new technologies as integrated workers or 'superusers' helped debug the new robotics, quickly gaining high levels of skills in the process which empowered them to exercise significant control over their new labour process. This situation proved unacceptable to management who switched to a forcing strategy after the initial phase of debugging, refusing other workers requested training and increasing managerial surveillance. For its part, the union remained unwilling or unable to deploy a developed strategy in response. As the robots were implemented in general production, this unilateral pattern produced marginal efficiency gains, as workers involved in the second phase struggled to operate the new equipment with limited training and experienced a degradation of their work process. Similar patterns were observed with the second technology studied at the Quebec plant: drilling and filling robots for the joining of major aircraft components. Again, an initial co-opted pattern of implementation mutated into a unilateral pattern as management opportunistically used workers for the initial debugging phase but faced no organised effort to influence the process from labour. Similarly, the highly efficient co-opted phase granted integrated workers significant autonomy over the new work process and contrasted with lower efficiency gains under the unilateral phase, as workers came to resemble mere machine minders.

The other two case studies are situated on the assembly line at Laurier Ontario. The first case study nested in the Ontario plant examines the implementation and debugging of virtualisation technologies for mapping the join of major components using computer aided design programs. In this process management adopted a fostering strategy, while Unifor—the union organising workers at the plant—deployed a highly developed strategy which included enforcing consultation provisions in their contract, imposing job controls, and campaigning for high levels of worker training on the new equipment. This co-ordinated pattern of implementation produced steady efficiency improvements and workers enjoyed training on the new equipment which granted them significant autonomy over their new labour process. The second case of technology change studied at the Ontario plant was the introduction of drilling and filling robots for the joining of major aircraft

components. Again, Unifor had a developed strategy in their approach to this technology change, demanding a new job code for robot operators, campaigning for higher levels of worker training, and working to re-establish a new technology consultative committee enshrined in their collective contract. Management rejected these claims and instead forced the change on workers with very little consultation or training. This contested pattern slowed the rollout of the machines (Ontario was significantly behind Quebec in deploying the same drilling and fastening robots) and limited efficiency gains. Union advocacy ensured workers received universal training on the new robots though shop stewards and engineers agreed this could have been more thorough.

Studying Patterns of Implementation and Debugging

Methodologically, this thesis uses comparative case studies to examine the process of implementation and debugging of four technologies across the two plants. A frequent criticism of studies of shopfloor politics is that they fail to go 'beyond the shopfloor' to connect the micro processes of capitalism with its macro forces and generate more generalisable theory (Thompson and Smith 2010; Vidal and Hauptmeier 2014). To overcome this potential shortcoming, this study deploys a truncated version of Burawoy's (et. al. 1991; 2009) extended case method. Burawoy advocates placing empirical data in "extralocal and historical context" (2009, p. 14) to help extend empirical findings beyond particular cases and extend existing theoretical understandings. By examining plants in different geographic contexts and conducting "archaeological" and "valedictory" revisits, this study achieves both spatial and temporal extensions advocated by Burawoy (2009, p. 253). This study also deploys extensive participant and non-participant observation as a way of achieving the "extension of [the] observer into the lives of the participants under study" (Burawoy 2009, p. xv). In addition to extensive participant and non-participant observation of the production process, trade union meetings, and management meetings, data sources include 60 semi-structured interviews with workers, trade unionists, managers, and engineers, and document analysis of union pamphlets, union histories, and managerial documents. The study also builds on and extends existing theoretical understandings in the literatures around industrial relations and actor strategies, and labour process analysis to generate a framework that grasps the varying patterns of implementation and debugging new technologies on the shopfloor.

Thesis Outline

In Chapter 2, this thesis reviews the relevant literature for this study. It begins by providing a review of the empirical literature on contemporary technology change and its relationship to work in the manufacturing industry and the aerospace sector. The review then introduces labour process theory as a social science approach to studying the shopfloor processes of technology change, positioning

this study within the post-Marxist materialist tradition of labour process analysis while acknowledging some of its limitations. It then surveys studies of the politics of workplace technological change, drawing heavily on empirical studies from the labour process and the industrial relations literatures. It concludes by discussing conceptual frameworks for understanding actor strategies on the shopfloor and argues that the dominant frameworks require reworking to better explain patterns of implementation and debugging. Chapter 3 elaborates on the theoretical argument outlined above with an extended discussion of how actor strategies are conceptualised in this study, and a detailed discussion of the four patterns of implementation and debugging and their implications for production efficiency and worker autonomy. Methodology and research context are detailed in Chapter 4, including an overview of Laurier as a firm, a discussion of the comparative case study approach, and an elaboration of the truncated version of Burawoy's extended case method deployed by this study.

Chapters 5 through 7 introduce Laurier Quebec and the cases of technology change studied at the plant. The first chapter introduces the research context, including a discussion of Laurier Quebec's political and economic context, and a discussion of the history of the union organising workers at the plant, the Machinists. This research context may more conventionally be found in the methods chapter but is presented here as a separate chapter to maintain the "narrative structure" (Bruner 1997, p. 264) of the case studies. Chapter 6 examines the patterns of implementation and debugging surrounding the composites robots for fabricating aircraft skins. In chapter 7, the introduction of drilling and fastening robots at Laurier Quebec is examined in detail. Chapters 8 through 10 relate to Laurier Ontario. Again, the first provides an in-depth discussion of Laurier Ontario's economic and industrial context including the province's political economy and a brief history of the union Unifor. Chapter 9 examines the implementation and debugging of virtualisation tools. Chapter 10 looks at how the strategies of management and Unifor impacted implementation and debugging of drilling and filling robots at Laurier Ontario. In the discussion section (Chapter 11) the empirical findings are brought back into conversation with the extant literature to develop and extend our understanding of how the strategies of workplace actors shape technological change in the workplace. Finally, this study concludes in Chapter 12 with a discussion of the relevance, value, and implications of my research, as well as its imitations, before providing an outlook on potential future research.

CHAPTER TWO: Literature Review: Contemporary Technological Change and Manufacturing Work.

There is a growing body of evidence to suggest that technological job transformation will be a significant disruptive force in the years and decades to come (Gahan et al. 2017; Lévesque et al. 2021; Pardi et al. 2020). Indeed, the Organisation for Economic Co-operation and Development (OECD 2017) projects that around a quarter of Canadian jobs will undergo dramatic technological transformation in the coming decades, much higher than the percentage of jobs they project to be automated completely. This thesis argues that the strategies of workplaces actors—especially trade unions and managers—in interaction with the technologies themselves, shape patterns of technological implementation and debugging new technologies in the workplace. These varying patterns of implementation have significant implications for the efficacy and speed of roll-out, the performance of the technologies introduced, and levels of worker autonomy and skill under the new labour processes.

In reviewing the literature around this topic, this chapter begins with a discussion of contemporary technology change in the manufacturing sector including an explanation of some indicative technologies like internet enabled devices, virtualisation technologies, and advanced robotics, among others. It examines empirical evidence on their potential, their reality, and their likely impact on the aerospace sector. It then introduces labour process analysis as a sociological approach to examining the shopfloor politics of technological change, discussing different strands of labour process thinking and positioning this study broadly within the post-Marxist materialist tradition. The review then proceeds to analyse the empirical literature around the management, unions, and technology change, drawing on both labour process and industrial relations literature. The labour process literature provides deep insights into the micro political processes of technological change on the shopfloor, while the industrial relations literature is more sensitive to the interaction of actor strategies and how they shape technology change. This review then discusses different conceptualisations of actor strategy and argues for a new framework sensitive to the varying approaches of management and the absence or presence of union activity in this space.

Technology Change in Manufacturing

The available empirical evidence suggests that the degree to which highly advanced manufacturing technologies are actually being deployed in industry is highly uneven and often in their early stages (Lévesque et al. 2021; Pardi et al. 2020). Indeed, some scholars have pointed to examples where the threat of automation exists largely as a discursive tool of managerial power (Benanav 2019a; 2019b; Pitts and Dinnerstein 2021). But the commitment of governments and firms (Pfeiffer 2017),

combined with capitalistic imperative towards technological innovation (discussed at length in following sections of this review) (Briken at al. 2017; Thompson 1990), signals that the instruments of production will continue to develop rapidly in the coming years. A growing body of research makes it clear that governments, industry, and trade unions in major economies around the world see the transition towards more advanced manufacturing technologies as a strategic priority. In addition to Germany's Industry 4.0 (Kagermann et al. 2013), China's 'Made in China 2025' (Lüthje and Butollo 2017), the USA's Inflation Reduction Act (Economist 2022), Australia's advanced manufacturing National Reconstruction Fund (Martin 2021) Canada's NGen Superclusters initiative (Beaudry and Solar-Pelletier 2020) and others (Briken et al. 2017) all indicate that advanced and developing economies alike recognise the economic and strategic importance of developing advanced manufacturing industries.

Observers have pointed out that the global financial crisis spurred renewed governmental interest in growing the 'real' economy and firms capable of creating products of tangible and functional value (Herrigal 2010). This trend has been compounded by the COVID-19 pandemic as lockdowns, disruptions to global supply chains, and resulting shortages of essential goods have demonstrated the strategic importance of domestic manufacturing capacity, though evidence of the degree to which these developments will result in tangible policies towards reindustrialisation remains mixed (Rainnie and Dean 2020; Rainnie 2021). A recent OECD (2021) report argues that the pandemic will likely hasten the adoption of digital technologies and that automation is expected to replace tasks within jobs more than replacing jobs themselves, with the impact being felt across the skill spectrum. Many jurisdictions also see the transition away from fossil fuels as an opportunity to correct for the excesses of deindustrialisation and develop 'green' manufacturing capabilities (for discussion see Meaney 2022). Finally, renewed geopolitical tensions in Europe and the Asia Pacific have spurred several governments to reinvest in defence manufacturing capacities, including advanced manufacturing technologies and aerospace (Snell et al. 2022).

This study is primarily concerned with the *social processes* that surround and shape technology change in the workplace. However, as Hall (2010) has argued, social science studies of workplace technological change should be sensitive to the material realities of the technologies in addition to the social processes that surround them. For this reason, this chapter now reviews several indicative examples of technology change which the literature suggests are likely to have the largest impact on the manufacturing industry and the aerospace sector. These include the technologies being implemented at the plants which form the empirical foundation of this study. It should be noted that this section remains largely at the descriptive level of the relevant technologies. The literature

relating to the social processes surrounding the implementation and debugging of these technologies is introduced in subsequent sections.

Indicative New Manufacturing Technologies

Also known as ubiquitous computing, the internet of things is a term used to describe the interworking of different internet enabled devices through a series of sensors and electronics. These 'smart' devices have three essential components: (1) the physical body of the device; (2) internet connectivity; and (3) smart components such as data collection mechanisms and storage capacity (Porter and Heppelmann 2015). In the manufacturing industry, these cyber-physical systems have the capacity to collect and analyse data on the production process with unprecedented detail. In other words: using advanced cyber-physical systems, an entire factory and value chain can be digitally mapped and enabled using such sensors (Tao et al. 2019). Internet enabled devices are a central enabling technology for Industry 4.0, where they promise to network suppliers, producers and customers through real-time data collection and sharing (Lévesque et al. 2021). Manufacturers can use systems in this vein both to monitor the consistency and delivery of inputs from suppliers and to assess the real-time performance products delivered to customers (Moeuf et al. 2018). Additionally, while much management literature examines how internet enabled devices might be deployed to monitor and improve the efficiency of production systems, firms have also begun to deploy this type of devices for the surveillance and management of employees (Klosowski 2022; Yeginsu 2018).

Internet enabled devices like those described above gather unprecedentedly large amounts of data which, if they are to be made use of, must be stored. Cloud computing allows for the storage of huge amounts of data in a virtual infrastructure of remote servers, freeing organisations from the need for physical infrastructure (Sunyaev 2020). These large amounts of data provide the foundations for the rapidly advancing field of machine learning. A form of artificial intelligence, machine learning refers to the capacity for machines to adapt and change autonomously when exposed to certain data inputs (Lee 2017). In manufacturing this can take the form of predictive maintenance. Here, machine learning uses algorithms to predict the next failure of a component or system, instead of performing maintenance according to a predetermined schedule, or using pre-coded thresholds (Hrnjica and Softic 2020). In a more advanced example, machine learning may manifest as a predictive quality technology. In this form, machine learning uses algorithms that are uniquely trained to understand a specific production process to automatically identify the root causes of process-driven production losses using continuous, multivariate analysis (Wilson et al. 2016).

These technologies are related to recent developments in the informatisation, digitalisation and virtualisation of work processes. Informatisation is not a new phenomenon. It refers to the systematic production and use of information with the aim of creating exchangeable forms of knowledge (Boes and Kampf 2007). Digitisation can then be understood as the transition from analogue processes (e.g.: bookkeeping) of informatisation to digital ones (e.g.: software). Virtualisation takes things a step further. In the context of manufacturing, Will-Zocholl (2017, p. 65) suggests that virtualisation can be understood as the process of creating virtual models of production components and processes that are "very close to something without actually being it". These computer-aided design models have several potential applications. Perhaps most prominently, they can be used to guide robots to create a three-dimensional version of a virtual model by laying down thin layers of material until an object is formed in a process called 3D printing, a form of additive manufacturing. These terms refer to the capacity of a 'printer' or machine to convert a digitised model into a material product through the super-imposition of successive layers of material on top of one another. This is 'additive' rather than 'subtractive' manufacturing in that products are built up rather than cut out of raw materials (Russell et al. 2019).

Advances in virtualisation and digitisation can also be seen as a continuation of previous trends in informatisation technologies (Boes and Kampf 2007). Of course, computer-aided design programmes and similar technologies have existed for some time but there is some suggestion that recent advances may be resulting in qualitative changes in the workplace. Will-Zochol (2017), for example, has pointed to the use of virtualisation by employers to assist in the offshoring and nearshoring of roles that have previously been considered safe from these threats. The same study also points to the considerable technical and social difficulties associated with this attempted use of virtualisation technologies in smoothing vertical disintegration of supply chains. Equally, a related technology, additive manufacturing, cannot be seen as representing a complete paradigm shift due to uncertainty about how generalisable these technologies are. As Pardi and colleagues (2020) note, "[w]here 3D printing is introduced… it is mainly used for the production of individual spare parts, and its deployment in mass production is in a very early stage and it is not clear if it will be possible in the middle term."

Robotics have long been a feature of manufacturing processes, with the first prototype robots introduced to automotive assembly lines in the United States in the late 1950s and into general production in the early 1960s (Freeman 2018; Steigerwald 2010). Recent technological advancements in areas like robotic sensors and metrology nonetheless represent a significant development in the functionality of production robotics. Contemporary sensor technology has moved past the limitations offered by the single laser-line scanners used in many previous robotics,

for example. Some technologies entering factories today are capable of digitally scanning complete components providing full geometrical knowledge to users and analysts instantaneously (He and Chen 2018). These metrological innovations have potential applications for quality control, automated part recognition, marking, and robotic handling (Dzedzickis et al. 2022).

In the heady world of the management consultancy literature, these technologies represent nothing short of a complete revolution in the world of manufacturing. According to a Delliotte report the Industry 4.0 enabled factory:

> *utilises physical-to-digital technologies such as augmented reality, sensors and controls, wearables, and the Internet of Things to track movement and production, monitor quality control, and manage the tooling life cycle, among other capabilities. In this way, Industry 4.0 on the factory floor can enable enhanced capability effectiveness, production asset intelligence, and activity synchronisation and flow (Sniderman et al. 2016)*

The available empirical data, however, renders a picture of incremental development and uneven changes in the technologies of production. Indeed, far short of revolutionary changes in production technologies, business investment in machinery and technology as well as research and development are declining in many OECD countries, including Canada (Stanford 2020). While this data indicates change may not be wide-reaching when measured by capital investment, there is some evidence to indicate qualitatively novel technology change is occurring, however. Few observers, for example, dispute the novelty of the gathering and analysis of unprecedented amounts of data, and this data being made available in real-time to networks of suppliers, producers, and consumers. Yet the application of these incremental changes in production technologies to the manufacturing sector appears to be in its early phases, including in the aerospace sector (see Lévesque et al. 2021).

The aerospace sector is often viewed as being at the cutting edge of technological development in manufacturing (Lévesque et al. 2021). This is not always the case, however. Stringent regulations around safety and associated compliance certification in the sector mean having to wait for technologies to reach a high level of maturity before being implemented, causing aerospace to frequently trail other sectors is some respects (Hartley 2014). In their study of certification and quality control for additive manufacturing in the aerospace sector, Russell et al. (2019) argued that a fractured approach to industry standards and regulation, combined with a lack of technical knowledge of 3D printing techniques and other relevant technologies among senior aerospace engineers, were contributing to slow uptake of new technologies.

Similarly, other research suggests that some aerospace manufacturers are unsure how advanced technologies like the internet of things and 3D printing might be applied to their operations (Hader et al. 2018). The same study found that when firms are adopting more advanced technologies, they are generally being applied to the improvement of existing processes within plants and supply chains, rather than developing dramatically new ones. In their recent report on the development of Industry 4.0 in the Canadian aerospace sector, Lévesque et al. (2021) note that while aerospace may not be at the cutting edge of adoption in terms of advanced manufacturing, aerospace firms in Canada are almost twice as likely to be developing new production technologies than the manufacturing average, trailing only the automotive sector. Statistics Canada (2017) data suggests that the aerospace sector outstrips the rest of the manufacturing sector in the adoption of advanced and emerging technologies across all categories measured. Lévesque et al. (2021: ii) note the dramatic variation within the Canadian aerospace sector between firms in terms of adoption of new technologies:

> *Some firms are fully engaged and are currently operating a virtual factory whereas others have yet to begin the turn towards [Industry 4.0]. In between, some firms sit at different stages, as they build their digital infrastructure to capture and organize the relevant data.*

Significant government investment has been poured into developing ecosystems for encouraging the development and adoption of advanced manufacturing technologies in the Canadian aerospace sector, especially in the Montréal and Toronto 'superclusters' (Lévesque et al. 2021). These will be examined further in the context chapters (5 and 8) where the institutional ecosystems of each plant will be discussed. For now, it is enough to say that Canadian federal and provincial governments appear committed to supporting the development and the adoption of advanced production technologies by firms in the country's aerospace sector.

The Workplace Politics Technology Change

The previous section was concerned with technology change in terms of the physical artefacts and managerial systems being introduced into factories and the drivers of those changes. This section focuses in on the social processes that surround their introduction—with the workplace politics of technological change. Studies in the labour process tradition have long held that the process of technology change in particular workplaces is subject to struggles between labour and capital. As Hall (2010, p. 163) suggests, a large body of labour process scholarship has demonstrated "that the effects of technology [in the workplace] are various and depend on struggle and contestation at different levels." Wilkinson (1983, p. 86) articulates three "stages of innovation" at which such struggle and contestation can occur: (1) design of technology; (2) choice of technology; and (3)

implementation and debugging. This section begins by situating this study in the labour process tradition through a discussion of differing labour process approaches to examining technological change, and of implementation and debugging specifically. After a discussion of the broad theoretical tools offered by labour process analysis to examine these stages of innovation, this section surveys empirical studies from the labour process tradition and the industrial relations literature on the politics of implementing and debugging new technologies in the workplace.

Labour Process Analysis and Technological Change

With the publication of *Labour and Monopoly Capital*, Harry Braverman (1974) introduced a Marxian theoretical framework to the sociological analysis of technological change on the shopfloor. Eldridge et al. (1991, p. 204) argue that this was necessary because labour process analysis' predecessor, industrial sociology, had not developed the necessary theoretical tools for analysing capitalist workplaces and "therefore was not equipped to analyse what was actually happening to industrial societies." So, Eldridge et al. (1991, p. 204) argued, scholars like Braverman, Michael Burawoy and Richard Hyman turned to "a political economy grounded in Marx." To survive, Marx maintains, human beings must transform nature into useful things such as food, clothing, and housing. The process by which human beings turn nature into useful things is called the labour process, or "human action with a view to the production of use values" (1976: 179). The centrality of the labour process to Marx and Engels' (1974: 48) conceptual framework for understanding human history is revealed in the following extract:

> *by stating the first premise of all human existence, and therefore, of all human history, the premise, namely, that men [sic] must be in a position to live in order to "make history." But life involves before everything else eating and drinking, a habitation, clothing and many other things. The first historical act is thus the production of the means to satisfy these needs, the production of material life itself.*

To reproduce themselves, in each period in history and each society, humans develop labour processes. According to Marx, capitalism is set apart from the other economic systems in that the capitalist labour process involves not only the production of use values but also production of self-expanding values: of valorisation. This means that under capitalism, workers perform more labour than the abstract labour time necessary to reproduce their capacity to perform labour, or labour power. The surplus value that labour produces is then taken by the capitalist—the owner of the means of production—and valorised in the form of profits (this is the basis of Edwards 'structured antagonism' (1986) mentioned earlier). The value created by labour and appropriated by capital is surplus value:

> *Capital assembles the means of production and labour power and sets them to work, but it does so in a way that is determined by the objective of valorisation, of maximising surplus value production and as far as possible eliminates all other potentially conflicting objectives (Brighton Labour Process Group 1977: 5)*

Braverman described his book as "an attempt to inquire systematically into the consequences which the particular kinds of technological change characteristic of the monopoly capitalist period have had for the nature of work [and] the composition (and differentiation) of the working class" (1974 p. ix-x). Braverman's intervention represented an attempt to systematically unpack managerial technologies of control under 20th century capitalism. Specifically, Braverman (1974, p. 86) subjected scientific management to extensive criticism, especially the form proposed by Fredrick Taylor whose pronouncements he considered to be "nothing less than the explicit verbalisation of the capitalist mode of production." He argued that it was "not the 'best way' to do work 'in general' that Taylor was seeking… but an answer to the specific problem of how best to *control* alienated labour—that is to say, labour that has been bought and sold" (1974, p. 90, emphasis added).

The fact that employers hire workers' capacity to labour, or labour power, and that extracting value from workers remains a managerial concern after workers are employed, is described in labour process analysis as the indeterminacy of labour (Thompson 1990). Taylor espoused his system of management as a 'scientific' way of overcoming the managerial problem of the indeterminacy of labour and maximise the value extracted from purchased labour power. Braverman was especially critical of three central principles of Taylor's managerial system: (1) that managers should attempt to gather all knowledge previously held by workers and codify this knowledge into a set of rules; (2) all possible mental work should be removed from the shopfloor and centralised with management; and (3) both what work is to be done and how should be planned in minute detail by management. These principles, Braverman (1974, p. 111) argued, undermined the capacity of workers to have any carriage over their labour process, reduced their industrial power in the workplace, and "degraded" their experience of work.

The degree to which Taylorist management principles have ever been realised in actual workplaces is subject to significant debate (see Vidal 2019 for a recent, critical discussion). However, the thrust of Braverman's argument is clear: the imperative for capital to ensure the extraction of surplus value from workers through the labour process, and valorisation (usually the realisation of profits), incentivises managers to exert high levels of control over the work process and workers. Braverman's thesis is sometimes misconstrued as a simple 'deskilling thesis.' It is true that Braverman (1974, p. 424—449) rued the loss of "mastery" among workers over their previous labour processes and the micro specialisation that came with the application of Taylorist principles. But it is

more accurate to describe Braverman's degradation of work thesis in the vein of Burawoy (1979, p. 21); as the strong incentive for managers under capitalism to "separat[e] the conception and execution of work." This idea to some degree mirrors the job polarisation thesis observed by later scholars (e.g.: Milkman 1997) but Braverman (1974, p. 425) emphasised that:

> *The mass of workers gain nothing from the fact that the decline in their command over the labour process is more than compensated for by the increasing command on the part of managers and engineers. On the contrary, not only does their skill fall in an absolute sense (in that they lose craft and traditional abilities without gaining new abilities to compensate the loss), but it falls even more in a relative sense.*

Braverman died only two years after the publication of *Labour and Monopoly Capital* but his work "christened the emerging field of labour process studies" which in turn "reinvigorated intellectual sensibilities and revived the study of the work process in fields such as history, sociology, economics, political science, and human geography" (Palmer 1999, p. 215). The years after its publication saw an explosion of studies in what became known as labour process analysis, a period dubbed "Bravermania" by Littler and Salaman (1982, p. 251). The process of implementing and debugging new technologies has always been a central preoccupation for labour process analysts. As Briken et al. (2017, p. 2) explain, the capitalist imperative to constantly renew production methods under the pressure of competition with other capitalists means that "technology-driven changes in the workplace have been key to labour process analysis." Indeed, several collected volumes have been dedicated entirely to labour process analysis of science and technology (Briken et al. 2017; Knights and Willmott 1988; Levidow and Young 1981; 1983; Willis 1988). Bélanger (2006) goes so far as to suggest that a focus on the role of technology in shaping the organisation of work was one of two central contributions of labour process analysis, alongside its emphasis on control.

Labour process analysis is far from homogenous, and the major strands of labour process analysis hold differing views on the issue of technological change. The views of two major intellectual currents within labour process analysis are examined here. Some scholars, claiming a more orthodox reading of Marx, suggest that technological change is the key motor of historical development (Adler 2007; 2019; Vidal 2019). They argue that competition between capitalist firms drives progressive socialisation of the productive forces (the combination of the technologies of work with human labour power). Marx (1976) defined socialisation as a general phenomenon whereby the labour process comes to embody the collective capabilities of a society. The objective socialisation of the forces of production thus means the ongoing development of productive capacity through the deepening of the social division of labour and increasing complexity of production technologies. Or as Adler (2007, p. 1313) put it "socialisation is the movement away from local isolation towards

'universal interdependence.'" For thinkers in this vein, progressive socialisation increasingly comes into contradiction with the capitalist social relations of production, which are based on the private appropriation of surplus value produced by workers in the labour process. In other words, capitalism drives the constant evolution of technologies for the more efficient production of goods and services through the increasing interdependence of people and systems, but this increasing interdependence comes into contradiction with the antagonistic social relations which underpin capitalism. This, advocates of the position argue, leads capitalist society closer and closer to an ultimate day of reckoning. Mandel (1976, p. 946) summarises this teleology like this:

> *The conflict between, on the one hand, the development of the objectively more and more socialised productive forces and, on the other, the capitalist relations of production based upon private appropriation determines both recurrent economic crises and a potential social crisis, which becomes terrifyingly explosive as soon as bourgeois society has fulfilled its progressive mission and enters a period of historical decline.*

Or in the words of Marx (1976, p. 929):

> *Centralisation of the means of production and socialisation of labour at last reach a point where they become incompatible with their capitalist integument. Thus the integument is burst asunder. The knell of capitalist private property sounds. The expropriators are expropriated.*

This theory of the development of technology, or the means of production and labour power, relates closely to the trajectory of worker autonomy and skill. Adler (2007) argues—contrary to Braverman's thesis—that capitalism tends to increase the complexity of work, while reducing the autonomy of individual workers. Likewise, Vidal (2019, p. 178) argues that workers experience a contradictory dynamic between alienation on the one hand, and productive socialisation through an "increase in its organisational and technical capabilities" on the other. In this interpretation worker autonomy is declining but this is compensated for in the progressive development of society's productive capacity. It is worth noting here that these authors take something of a dim view of the autonomy they concede is declining, claiming that "autonomy is merely the converse of interdependence" (Adler 2007, p. 1319) and that "autonomy is not of much use if it means we cannot work together" (Adler 2019, p. 99). Vidal (2007) makes a similar argument citing empirical evidence from interviews with workers who preferred highly standardised work processes. For these scholars, Braverman's (and other scholars') regret about declining worker autonomy represents either a nostalgia for craft labour, which they consider an outdated and irrational way of organising production, or a manifestation of individualism.

A second current in labour process theory, the materialist post-Marxist perspective, deviates from the orthodox view of technological change in several important ways. First, and perhaps most substantively, the post-Marxists maintain that the distinction between the forces of production—defined as the means of production and collective labour power—and the social relations of production cannot be reasonably sustained. Under the orthodox interpretation the ostensible progressive socialisation of the forces of production can appear as an independent, emancipatory force. But as Thompson (2007, p. 1361) points out in his response to Adler, this position suggests that technology is "neutral and determinate" rather than reflecting and reproducing the social system that created it. Thompson (2007, p. 1362) goes on to argue that this interpretation leads to "uncritical attitudes to Taylorism and lean production and the relatively benign view of skill formation."[2] It is argued here that the post-Marxist analysis presents a more realistic and empirically based analysis of technological change in the workplace. Liberated from grand teleological theories, labour process analysis is open to the theoretical possibility that technology may be degrading work and empowering employers at workers' expense.

Post-Marxist labour process analysis take a considerably different approach to technological determinism. Edwards and Ramirez (2016) argue that there is no tendency for the productive forces to develop autonomously, but that there *is* an autonomous tendency for the forces of production to develop. While the difference is subtle, it is essential to the foundations of post-Marxist labour process analysis of technology change: "The tendency exists within the forces; it does so because of capitalism, which in contrast to other modes of production is driven by a drive for accumulation," they continue, "technology has a tendency to develop, but the ways in which it does so are shaped by many other economic and political forces" (Edwards and Ramirez 2016, p. 100—101). In other words, while the post-Marxist approach accepts that the capitalist drive for accumulation spurs rapid technological change, it does not accept that this change occurs along a predetermined trajectory as others may suggest (e.g.: Adler 2007; 2019; Vidal 2019). Edwards (2018 p. 5) picks up this theme elsewhere arguing that this 'soft' technological determinism is necessarily a break with what can be described as Marxism: "'Determination' is of course a word that can mean 'directly generate' or 'set

[2] Despite claims of 'classical' readings of Marx, Thompson (2007) suggests this 'orthodox' Marxist interpretation of the labour process theory owes more to Karl Kautsky and other Marxian writers from the Second International than Marx in the original. Cruddas and Pitts (2018) note the influence of the writings of Vladimir Lenin on this current of thinking. Indeed, political leaders who advocated Taylorism and scientific management in the early Soviet Union (notably Leon Trotsky) were viewed by many of their fellow revolutionaries as pragmatic revisionists, while those who advocated for what they considered to be a more humanistic work organisation with greater worker autonomy were considered uncompromising idealogues. As Sochor (1981, p. 250) describes, when Trotsky convened a conference in 1921 to consider the question of scientific management "[t]he ideologues accused the pragmatists of a crude, technicist approach… while the pragmatists countered with the charge that the ideologues were… overly bookish."

in motion some tendencies that may or may not be actualised in practice'… most scholars opt for the latter, in which case it is not clear what is left of Marxism."

This relates closely to the post-Marxist view on trajectories of technology change and their impacts on skill development and worker autonomy. As stated above, the orthodox Marxists, in broad terms, argue that while worker autonomy may be declining, the complexity of tasks is increasing. Post-Marxists reject this argument. Thompson (2007: 1364, emphasis in original) argues that the distinction between autonomy and complexity is also unsustainable: "Discretion is the precondition for complexity as it is a key factor that enables the actual *use* of knowledge and skills." The post-Marxist tradition rejects the upskilling thesis of Adler and others but "does not argue that deskilling is an inevitable long-term trend in capitalist societies; it instead emphasises that the interest of management in controlling the work process represents a major constraint on upskilling… because highly skilled workers have reservoirs of knowledge not controlled by management" (Briken et al. 2017).

Despite this study fitting broadly into the post-Marxist approach to labour process analysis, there is one criticism to which it is more sympathetic. This is what Spencer (2000, p. 223), a more orthodox scholar, described as an "unduly pessimistic political agenda on the prospects for transcending capitalist domination." A frequent criticism levelled at Braverman and many of the labour process scholars who followed him was that they underestimated workers' capacity to resist or shape change (Burawoy 1979; Meiksins 1994; Martinez Lucio and Stewart 1997; Spencer 2000; Thompson and Smith 2010). Martinez Lucio et al. (2021) echo this sentiment when they argue that while many contemporary studies have focused on the impact of managerial strategy on technology change, a great number fail to deeply engage with trade union strategies towards technology change, including past struggles.

Indeed, individual and disorganised responses to technological change in the workplace have often been emphasised. Authors have recorded a catalogue of worker 'misbehaviour' in response to managerial initiatives (Ackroyd and Thompson 2016; Thompson and Ackroyd 1995) from sabotage (Friedman 1977), to pilfering (Mars 1973; Ditton 1977), and time indiscipline (Analoui 1999). For Thompson and Ackroyd (1995; 2016) these 'misbehaviours' constitute acts of 'resistance'. Martinez Lucio and Stewart (1997) reject this argument. They suggest that even in the context of a declining labour movement, Thompson and Ackroyd ignore the various ways in which labour necessarily manifests collectively. "Theoretically assuming the demise of […] the organisational capacity of the labour movement, this ideological current has presented a model of such developments that reify the strategic capacity of capital and the control functions of management" (Martinez Lucio and

Stewart 1997, p. 58). Ackroyd and Thompson proceed to misconstrue individual acts of misbehaviour as a form of political resistance to the dominance of management. “That is to say, individualised relations of conflict at work triumph over ‘collective’ relations of conflict *in* work” (Martinez Lucio and Stewart 1997, p. 65, emphasis in original). Martinez Lucio and Stewart do not equate collective labour in the abstract sense with organised labour in the institutional sense, highlighting different levels of collectivised workers such as teams and regions, but nonetheless emphasise the ongoing capacity of workers to engage in collective, organised behaviours such as counter planning (McKinlay and Taylor 1994).

Having justifiably abandoned the grand teleological narrative of their more orthodox counterparts, the post-Marxists present a theory of the labour process that is depoliticised and largely absent of collective worker agency. These theorists maintain that there is no necessary connection between workplace struggle and the ultimate transformation society (Thompson 1983; 1990). While sustainable on its own, this rejection leads to some rather tepid political pronouncements. Revisiting his theory of the structured antagonism, for example, Edwards (2014, p. 17) argues that while exploitation is inherent to the capitalist labour process: “The exploitation that underpins these interests may be a necessary condition. Without some feasible alternative, it makes little sense to suggest that the exploitation is inherently unjust.” This thesis contends that a central task for labour process scholars is to renew research into how workers can act collectively to resist and reshape managerial initiatives and humanise their experience of work. In his more recent discussion of the trajectories of labour process theory and worker participation, Martinez Lucio concluded that (2010, p. 20) “radical and critical debates” risk “remain[ing] encased in the agendas and practices that management set—critiquing in the absence of any alternative debate. In effect, we run the risk of our critiques mirroring the agendas of management.”

It is suggested here that by exploring actor strategy, especially through comparative studies, scholars can explore how managers, workers and their organisations can change the trajectory of technological change. Danford (2005, p. 167) has argued that labour process analysis has not engaged sufficiently with how managerial strategies interact with union strategies to impact technological change due to what he calls “a false dualism between industrial relations and the labour process.” In a similar vein, Thompson and Bannon (1985, p. 3) wrote that “too many studies deal with the *effects* of managerial strategy on workers… [while] the detail of workplace politics remains the province of ‘industrial relations.’”

As a field of study, Hyman (2007, p. 29) describes industrial relations as the examination of “the rules which govern the employment relationship, the institutions involved in this process and the

power dynamics among the main agents of regulation." Researchers have placed a particular focus on the forms of regulation dominated by collective actors and institutions; their "central concern has typically been the collective and institutional regulation… of work and employment." (Hyman 2007: 30). In this way, the industrial relations literature has placed much greater emphasis on how the strategies of employers and their managerial representatives interact with union strategies to shape technology change. However, this has often been to the exclusion of the microprocesses of implementation and debugging on the shopfloor. Elsewhere, Hyman (1975, p. 9), wrote that "everyday interactions" such as "the allocation of tasks by a supervisor to members of his [sic] gang or team… would normally be regarded as too trivial and insignificant to be regarded as industrial relations." As shall be seen below, such "trivial" interactions are of central importance to labour process scholars, as well as to understanding patterns of implementation and debugging technologies in the workplace. In this context, while this study sits within the labour process tradition, it draws on the broader industrial relations literature to consider the collective strategies of workers and employers in shaping the social processes of implementation and debugging in the workplace. The following section of this review provides a non-exhaustive review of empirical studies of the politics of workplace technological change, drawing principally on the labour process literature but also on studies from the industrial relations literature.

Studies of Workplace Technological Change

The shopfloor politics of technology and technological change was a prominent theme in post-war industrial sociology prior to Braveman's intervention. Gouldner's (1954) study of a gypsum mine posited that variations in patterns of struggle between mine workers and their managers and surface workers and their managers could be explained in part by variations in production technologies at the point of production. Touraine's (1955) study of the Renault's automotive factory in Boulogne-Billancourt in Paris examined technological change over several decades at the plant and the impacts on workers and their skills. In an analysis that prefigured Braverman's thesis on technology change and the degradation of work, Touraine argued that successive waves of technology change were being used to concentrate control of the work process with management. He described three phases of technological work reorganisation. In phase one, workers with a broad range of skills used universal machines capable of multiple functions and operated with high levels of worker discretion. In the second phase, Touraine described the deskilling of workers through the transition to specialised machines and the increasing sub-division of labour. And finally, the third phase chronicled the beginnings of industrial automation and increasing concentration of conceptual tasks with management. Blauner (1964) examined technological trends in the printing trades,

automotive assembly, textiles, and chemical manufacturing and argued technology change was contributing to workers' sense of alienation.

Much of the early labour process analysis of technology change emphasised the managerial control imperative. In the immediate wake of *Labour and Monopoly Capital*, Edwards' (1979) study built on Braverman's emphasis on the managerial need for control but suggested that it could not be achieved through Tayloristic scientific management techniques alone. Instead, he posited three essential forms of control: (1) simple control, achieved through straightforward managerial supervision; (2) technical, when control is built into machinery or other workplace technologies; (3) and bureaucratic control, accomplished through organisational rules. Control was also a central preoccupation for Wilkinson (1983), who chronicled the introduction of microelectronics in several factories in the UK—a plating company, an optical company, a rubber moulding company, and a machine tool manufacturer. In addition to economic and technical forces, he argued that the values and interests of managers, workers, engineers, and trade unionists were also critical in deciding how new technologies were chosen and deployed in the workplace. With the exception of the Rubber Moulding plant, Wilkinson noted that unions generally failed to develop adequate strategies towards the implementation and debugging of new technologies, essentially leaving workers a choice between micro acts of resistance or acquiescence to management's control agenda.

The high tide of labour process analysis in the 1970s and 80s receded somewhat in the 1990s but did not disappear entirely. Milkman's (1997) study of auto workers in the United States found that technological change was resulting in skill polarisation and corresponding social struggles within single factories. Studies of technology in the late 1990s and early 2000s increasingly coalesced around pink- and white-collar industries. This partly reflected the shift in the labour market in many developed economies from manufacturing to the service sector but also reflected a correction, as labour process analysis had traditionally focused disproportionately on manufacturing (Thompson and Smith 2010). A rich vein of this research applied labour process analysis to new so-called Enterprise Resource Planning systems, or company-wide information technology systems designed to improve business processes using a shared database and reporting tools. This body of work reflected a non-deterministic view of technological development (Grant et al. 2006), demonstrated how technology was used to extend the parameters of managerial control (Hall 2005) and recognised the role of worker resistance and consent (Grant and Hall 2005).

Most recently, some empirical labour process studies of technology change have been geared towards the so called 'gig-economy' and Industry 4.0. Veen et al (2020) identified three forms of managerial control in the Australian on-demand delivery sector of the gig-economy, citing the

panopticon-like reach of the technological infrastructure, the use of information asymmetries between labour and capital to restrict workers' capacity for resistance and, similarly, the opaque nature of performance management systems. A recent volume dedicated to the labour process analysis of technology change includes chapters examining control and time in online crowd work (Schorpf et al. 2017) and changes in information technology in Swedish banks (Movitz and Allvin 2017) among others. The same book includes several chapters examining technology change in manufacturing. Most notably, Will-Zocholl's (2017) contribution looks at the implementation and debugging of virtualisation technologies in the European automotive sector, demonstrating the significant technical and social barriers around using these technologies to smooth the process of offshoring and nearshoring work. This reflects one of the enduring findings of this labour process analysis: that the technical and social barriers towards the implementation of technology change in the workplace are often underestimated in the managerial literature (Hall 2010).

In what Hall (2010 p.164) describes as "the exemplar of labour process theory analysis of technology", Noble (1984) examined both the design and selection phases of computer numerical control machines in the North American machine tool industry. One of the key merits of Noble's approach is that he chronicled "the road not taken" and attacked the "facile faith" that a "'successful' technology, having become dominant, must have evolved in some 'necessary' way" (1984 pp.144-45). Noble profiles several alternative technologies that were abandoned, ignored, or rejected by decision makers, ultimately concluding that "the concepts of 'economic viability' and 'technical viability' are not really economic or technical categories at all—as our ideological inheritance suggests—but political and cultural categories" (1984, p. 145). Noble argued that the perceived threat posed to United States' interests by the struggle with international communism abroad and an increasingly militant and powerful labour movement domestically drove policy makers and firms to pursue technological innovations that prioritised control of the workforce over efficiency considerations. He suggested capitalists, their engineers and managers adhered to a "worldview of total control", a central part of which was "the dream of the automatic factory" and "the post war preoccupation with controlling labour as an end in itself" (Noble 1984, p. 83).

Writing from an orthodox Marxist perspective, Vidal (2019) is highly critical of Noble's analysis and what he considers to be mainstream labour process scholarship's over-emphasis on control as a managerial motivation. He argued that:

> *The data [Noble] presented can be interpreted more persuasively – requiring fewer assumptions – to show the opposite: automation in machine tools was driven by structural forces leaving little scope for strategic choice; efficiency-driven attempts to develop standard parts and profit-driven attempts to secure*

> *mass consumer markets combined to ensure the dominance of the engineering logic of standardisation/automation (Vidal 2019, p. 184)*

Vidal (2019) goes on to argue that Noble and others have placed too much emphasis on control and not enough emphasis on the managerial drive for efficiency. He argues that the trends examined by Noble can be explained more convincingly by a managerial drive for greater efficiency rather than control:

> *…automation in machine tools was driven by structural forces leaving little scope for strategic choice; efficiency-driven attempts to develop standard parts and profit-driven attempts to secure mass consumer markets combined to ensure the dominance of the engineering logic of standardisation/automation (Vidal 2019, p. 184)*

Vidal's (2019) argument here risks an over correction. As Thompson and Laaser point out, Noble and others "argued that employers and managers made choices over design and deployment of technology that were not based on perceived efficiency criteria alone, but also by increasing options to organise work in the interest of capital" (2021, p. 146). This has long been the view of post-Marxist labour process analysis (see Thompson's (1990) 'core theory'). Nonetheless Vidal's (2019) central argument, that labour process analysis has placed too much emphasis on control at the expense of efficiency considerations, remains valid. Scholars in the post-Marxist materialist tradition have also acknowledged such tensions and even contradictions have too often been ignored, including in the process of technology change (Hall 2010; Thompson and Laaser 2021).

Another criticism levelled at both Braverman and the labour process scholars who followed him was that they underestimated workers' capacity to resist or shape change (Burawoy 1979; Thompson and Bannon 1985; Meiksins 1994; Martinez Lucio and Stewart 1997; Spencer 2000; Thompson and Smith 2010). In a classic text from the industrial relations literature, Turner's (1991) *Democracy at Work* examined the impact of intensified international competition and rapid technological change on labour and management in comparative context. After outlining the complexities of work reorganisation in the 1980s and 1990s and their impact on industrial relations, Turner examines at length the shopfloor politics of technology change in the automobile industries in Germany and the United States and the role of unions in those politics. In the processes of technology change, Turner (1991, p. 223) distinguishes between "integrated" unions on the one hand and "adversarial" unions on the other. Additionally, he contrasts institutional environments like West Germany, which support union participation and worker voice in processes of work reorganisation and technological change with those like the USA, where unions are institutionally excluded from such processes. Supported by extensive empirical data from shopfloor level, one of Turner's central arguments is that union involvement in firm strategy and decision making is quite compatible with union

independence and strong union influence, and 'co-operation' at the workplace is more stable where it is built on solid institutional foundations.

Turner appears to sometimes soften or qualify the strength of his argument with passages like the following: "somewhat paradoxically... I am arguing at once for stronger unions and for more collaborationist unions; this is what contemporary world markets appear to demand if unions are to continue playing an important economic, social and political role" (p. 241). As Streeck (1993, p. 194) points out, "Turner's findings themselves suggest strongly that there is no paradox here at all, and that institutionally based union influence on management needs to be clearly conceptually distinguished from mere union collaboration with management." Streeck accepts that when unions take an active interest in efficiency and successful production, they will sometimes share interests with management. He emphasises, however, that when such interests are pursued from an anonymous power base, 'collaboration' is not a necessary precondition of such initiatives.

Other studies have examined highly developed union strategies surrounding technological change. Frenkel (1988, p. 233) studied the Australian Amalgamated Metalworkers' Union's (AMWU) "offensive" in response to economic recession and significant technological change in the 1980s. The AMWU developed a comprehensive strategy spanning formal partnership with the country's Labor government on industry policy, industry-wide bargaining on skills and job controls, and worker participation in developing measures to improve efficiency at the point of production, including through the adoption of new technologies. More recent studies of this period in the AMWU's history—notably Humphrys' (2018) examination of the union's role in policy making in the 1980s and 90s—have argued that the integrative elements of the union's strategy contributed to its long term, significant decline. Indeed, Ross (2020) recorded extensive rank-and-file resistance to many of the union's more integrative strategies. It can be said generally, however, that the union generated highly developed strategy towards technology change in the manufacturing industry. Indeed, Scott (2013) argues that the AMWU developed a uniquely comprehensive strategy in response to technology change during this period.

Around the same period, North American unions were confronted with similar technological changes. Katz (1988) chronicled policy debates among North American unions around technological change in the 1980s. He argued that two basic policy orientations dominated these discussions: a co-operativist approach, which favoured integration with management and concession bargaining; and a militant strategy, which favoured a much more oppositional approach to technology change. He notes, however, that "militants sometimes agree to co-operative-like reforms, while the co-operativists have at times militantly opposed certain management demands" (Katz 1988, p. 220).

Steigerwald's (2010) history of the United Auto Workers' (UAW) approach to automation in the decades following World War II reflect this tension within one union, as shop stewards pursued more militant strategies on the shopfloor, while union leaders were more open to integrative strategies at a policy making level. This pragmatic approach is reflected in the literature on other north American unions from the period (e.g.: Rutherford and Frangi 2020). Gindin (1985) argues that while the UAW and Canadian Auto Workers' (CAW) frequently expressed high levels of interest in influencing technology change, they rarely developed comprehensive strategies towards doing so on the shopfloor.

Several studies have examined the role of job controls as a mechanism used by unions to influence technology change in the workplace. Job controls in the form of job classifications are the negotiated rules governing the particular duties and tasks of employees. Through their negotiation and enforcement, unions can exercise influence over how tasks are bundled together into jobs, the selection of workers for those jobs, and the training requirements of the roles (Oliver and Walpole 2018). Scullion and Edwards (1988), for example, examined the relationships between craft unionism, job controls, and management strategy, concluding that job controls were the central source of union influence in the plants they studied. In the same volume Bélanger and Evans (1988) looked at shop steward strategies towards job controls among semi-skilled engineers in England. Beynon's (1974) study of the struggle for control on the floor of a Ford factory in England is representative of an early wave of labour process analysis that was concerned with trade unions' role in shaping work organisation through job controls. It concluded that:

> *The extent and durability of job controls are subject to the market. Fluctuations in the sales of cars, in the rate of capital of investment, soon reveal themselves in the social relations of the shop floor. It is in this sense that unionism and workplace organisation can be seen as the direct consequence of economic forces… It's nothing to do with fairness. What it has to do with is economics and power (Beynon 1974, p. 132—133)*

Oliver and Walpole (2018) note that the capacity of unions to bargain for and impose job controls has been weakened in many liberal market economies in recent years because of declining union strength and changing regulatory environments. Nonetheless, the authors conclude, job controls remain one of the most proven tactics for unions when attempting to influence the process of technological change.

Another prominent strand of analysis analysed the introduction of Japanese management technologies to factories (and other workplaces) around the world. These include the introduction (or attempted introduction) of lean production, teamworking, kaizen ('continuous improvement'),

and total quality management (Womack et al. 1990). Danford (1999) examined trade union responses to the introduction of Japanese style managerial innovations in the UK in the 1990s. The study found significant shopfloor scepticism and resistance towards the reorganisation of production, despite varied responses from trade unions at the fifteen plants studied. Delbridge et al. (2007) found workers experienced significant work intensification with the introduction of 'just in time' management to non-Japanese factories. Vidal (2007) argued that the orientation of management—either maximising or satisficing—and the disposition of workers towards any change were key factors in explaining uneven patterns of implementation in the application of lean management techniques in North American factories. In a later study, Vidal (2017) examined the institutional logics of the application of lean management techniques based on interviews with shopfloor actors from more than 30 firms. This study argued that management was often not motivated by an overarching strategy so much as a need to "satisfice" production targets, or "settling for good enough based on a given aspiration level" (Vidal 2017, p. 4).

In a rare example of an in-depth discussion of trade union strategy from a labour process perspective, Vidal (2022a) argues for unions to engage with and shape the application of lean production techniques with a view to building more democratic workplaces. He argues that many of the technologies developed under capitalism have the potential to be applied in more humanistic ways. He suggests that organising workers around matters of work organisation and technological change are a potential pathway to rejuvenated union workplace structures. "The path to union renewal and worker control entails fighting for co-management of lean production as part of a broader campaign for workplace democracy" (Vidal 2022a, p. 135). In response, Rosenfeld (2022) argues that Vidal is too optimistic about the liberatory potential of technologies developed under capitalism, arguing that lean production techniques intensify work and undermine solidarity between workers by placing them in competition with each other. Rosenfeld argues that while unions must play a role in shaping technology change in the workplace, Vidal concedes too much to management around objectives such as cost reduction and improving competitive advantage, ultimately undermining worker solidarity across sectors and workplaces. While the conceptual disagreement stems from Vidal's previously discussed view of capitalist technologies as "neutral and determinate" (Thompson 2007, p. 1361), the strategic argument divides along the degree to which unions can feasibly concede to capitalistic logics while maintaining a strong, independent position. In a third paper from this exchange, Vidal (2022b, p. 136) makes the case for what he calls "conditional co-operative radicalism," arguing that "that capital, management, and labour have some overlapping interests, which provide a basis for conditional cooperation without undermining union independence."

Another strand of analysis has focused on formal partnerships between union and management in the workplace in the process of technological change. Harley et al.'s (2005) review points out that labour process scholars have generally been sceptical of the benefits to labour of pursuing a formal strategy of integration with management. Many early studies in this vein were built around Ramsay's (1977) 'cycles of control' paper which surveyed different formal partnerships pursued by unions and management in the UK over several decades. It argued that the state and capital integrated unions in various ways at peaks of labour militancy and strength to incorporate them with the logics of capitalism and blunt their power. While scholars are in broad agreement that the cycles of control presented a simplistic picture of integrative practices (Marchington 2005), most remain sceptical about the potential benefits of partnership to trade unions and workers. A series of studies examined the wave of formal union-management partnerships in the UK in the 2000s. While some positive outcomes for labour were identified around shaping technology change (Geary and Trif 2011), authors have generally observed that partnership carries significant distributive and political risks for unions (Martinez Lucio and Stuart 2005) and that management was often either unwilling or unable to keep its side of the bargain (Jenkins 2007; 2008; Thompson 2003; 2013).

Some studies have examined attempts by unions to bargain over and organise around the introduction of new technologies on the shopfloor. Taylor and Bain's (2001) highly cited paper examined differentiated trade union strategies towards new managerial technologies resulted in different outcomes for workers in the British banking sector. The paper noted that some unions organising workers in finance sector call centres developed strategies that went "beyond 'traditional' bargaining items" (Taylor and Bain 2001, p. 62) in response to managerial strategies of intensified control. They concluded that "newly established managerial 'frontiers of control'" needed to be "combated by new union bargaining agendas which seek to address employees' concerns at the point of production" (Taylor and Bain 2001, p. 39). More recently, Murphy and Cullinane (2021, p. 288) examined changes to the labour process for British bank workers under new managerial processes. The authors argued that while "unions can acquiesce to new management [technologies] by securing compensation in other areas" they can also "try to prise open bargaining agendas that extend their influence on these innovations" (Murphy and Cullinane 2021, p. 288). Edwards and Ramirez (2016) asked when workers should resist and when they should embrace technology change. They suggested that technologies can be assessed on six dimensions: intended or unintended effects; direct and indirect effects; degree of reconstitution in use; immanence; degree of success; and degree of discontinuity with the past. These dimensions are then used to articulate several questions for the labour movement when faced with technological work reorganisation and

prefigure the kind of study that a deeper engagement between the labour process literature and the literature on union strategy may produce.

Bosch and Schmitz-Kiebler (2020) examined German trade unions' engagement with management around Industry 4.0 technological change through the 'Arbeit 2020' project. Using publicly funded consultants and drawing on the knowledge of shopfloor workers, the change processes in selected plants were investigated. In some of the plants studied, social partners implemented agreements between management and unions on the future shaping of digital change. One of the unions involved, IG Metall, then aimed to build off this project and train 1,000 'promoters of change' in the workplace to influence the implementation and debugging of Industry 4.0 technologies. The article states that some German unionists view an increased role for organised labour in technology change of work as a pathway towards union renewal. They suggest that this project was premised on the notion that upskilling workers for the new technologies was mutually beneficial for capital and labour:

> *Further intensification of a Taylorist mode of work organisation based on short-cycle, highly standardised, monotonous work tasks is regarded as a cul-de-sac, contradicting the new technologies' potential for increasing efficiency. Instead, the greater complexity of future work will require highly qualified workers able to operate independently (Bosch and Schmitz-Kiebler 2020, p. 191)*

The authors provide limited workplace level evidence of social partners acting on the idea that degraded manufacturing jobs are a cul-de-sac; nor do they provide any evidence to suggest that factory jobs are actually becoming more skilled and diverse thanks to recent technology changes. They nonetheless argue that German unions and employers are coming to the realisation that new technologies will drive towards more highly skilled and less standardised manufacturing work. Limited evidence on the reality of these technologies in actually existing manufacturing make assertions such as this difficult to sustain.

Rutherford and Frangi (2020) examined the role of the Canadian trade union Unifor (examined in depth in later chapters) in shaping the interaction between Industry 4.0 and High-Performance Work Systems in the automotive sector in southern Ontario. Unifor and its predecessor unions (the UAW and CAW) have long maintained that it can best serve its members by maintaining a rigid line of demarcation between the union and management and thus has been resistant to anything approaching co-management arrangements (Gindin 1995; Rinehart et al. 1997). This chimes with a broader argument within the literature around trade unions and technological change in which unions are seen to best serve their members if they maintain a clear line of demarcation with management (see Clegg 1951; Martinez Lucio 2010). Rutherford and Frangi (2020) found, however,

that union strategy is an important variable in explaining variations in technological change, noting that despite rhetorical commitments otherwise, integrative strategies were deployed pragmatically by Unifor shop stewards on the shopfloor. Elsewhere, Rutherford (2021) explores some of these tactics in further depth, including the use of management-union plant level new technology committees, illustrating some of the difficulties faced by unionists to make these semi-voluntary committees impactful.

An important theme developed here is that while labour unions maintain the ability to influence the processes of technological change in the workplace, including through shopfloor interventions, they are often strategically absent from these discussions. Many labour process studies have noted unions' failure to develop coherent strategies around influencing processes of technological implementation and debugging (Wilkinson 1983; Thompson and Bannon 1985; Delbridge 2000; Bilsland and Cumbers 2018). While others have observed labour's ability to prise open new bargaining agendas in this area when they deploy a developed strategy (Taylor and Bain 2001; Danford 2005; Murphy and Cullinane 2021). This reflects a similar idea developed in the industrial relations literature on technology change where it has been argued that unions with comparable power resources may achieve significantly varying outcomes based on different union capacities and strategies. As Lévesque and Murray (2010, p. 341) observed, "unions can have power resources… but are not particularly skilled at using them." For example, Frost (2000) demonstrated the varying capabilities of different union locals explained the differing outcomes for North American unions faced with technological work restructuring in the 1990s.

Conceptualising Actor Strategies

As Hyman (1987, p. 48) argued, the strategies of managers and unions are often incoherent, variable between individual workplace actors, and subject to significant "obstacles to integration." Similarly, Vidal and Hauptmeier (2014) point out that managerial strategies can be multiple and often incoherent. Indeed, frequently what passes for strategy is merely the efforts of frontline managers to satisfice the needs of the production line (Edwards and Collinson 2002; Vidal 2007; 2017). Despite these qualifications, however, Hyman (1987) acknowledges that strategy—as shaped by structural variables—remains a legitimate object of study. This thesis demonstrates that labour and management strategies can be shown to have significant explanatory power around the patterns implementation and debugging of new technologies. This study suggests that efforts at a coherent strategy are more likely to be present at a moment of workplace reorganisation—such as technology change—as workplace actors are compelled to consider the opportunities and threats that the introduction of a new technology may represent. This section of the literature review provides an

overview of conceptual approaches to studying the strategies of unions and employers. It then argues that, to now, a theoretical framework for understanding these patterns has been lacking, and outlines the need for the development and elaboration of such a framework in this study.

Coercion, Consent, Influence, and Acquiescence

Generally, the strategies of workplace actors towards technology change are conceptualised as a relationship between more militant or coercive approaches on the one hand, and more consent-based or integrative approaches on the other. Armstrong (1983), for example, held that managerial activities could be categorised in two groups. First, the "productive" or co-ordination function of capital, which involved tasks that directly contributed to the productive process (Armstrong 1983, p. 345). For example, helping to solve sequencing problems in the production process can be considered a co-ordinating function of management. And second, the "non-productive" or control function of capital (Armstrong 1983, p. 345). An example here might be discipline of workers through direct surveillance. As discussed above, Turner (1991) conceptualised labour approaches to technological change as a relationship between integrative strategies on the one hand, whereby labour is incorporated in managerial processes, and an adversarial approach on the other, whereby a workplace actor takes a combative approach to dealing with another. This is reflective of much of the literature on actor strategy. In his discussion of trade union policy responses to technological change, Katz (1988 p. 221) placed unions into two categories: "co-operatists" who were willing to engage in concession bargaining, and "militants" who were not. All these authors acknowledge that most workplace actors will employ some combination of these approaches in a given circumstance but contend that one can generally be seen as the animating force behind a particular strategy or tactic.

Walton and McKersie (1965, p. 179) argued that both workers and employers could pursue either: (1) competitive behaviours which aim to win an absolute gain over the opponent, described as "distributive bargaining;" or (2) problem-solving behaviours which aim to develop the productive capacity of the firm through "integrative bargaining." Additionally, they describe two other activities observed in the context of bargaining: (3) activities affecting attitudes of the parties to one another—"attitudinal structuring," and (4) behaviours of a negotiator for achieving consensus within his own organisation—"intraorganisational bargaining" (Walton and McKersie 179—180). More recently, Walton et al. (2000) conceptualised the approaches of labour and capital as a relationship between forcing and fostering. Managerial forcing is the coercive exercise of the managerial prerogative to drive a workplace change. Walton and colleagues (2000, p. 25) describe managerial forcing strategy like this: "The most immediate and direct response to the need for change has been

for management to attempt to force economic concessions and changes in work rules and worker behaviour." Alternatively, employers and managers can *foster* change to achieve their respective goals. A managerial fostering strategy will likely involve attempts to gain the consent of labour through involving or consulting the workforce in technology change in the workplace.

Walton et al. (2000) also conceptualise labour strategies as a relationship between forcing and fostering. For labour, forcing describes a zero-sum strategy towards influencing how technology change is implemented. Forcing "is the most symmetrical influence option, in that it is similarly employed by management and labour, but the enforcement power of either party may wax or wane with changes in contextual factors" (Walton et al. 2000, p. 27). Fostering is a labour strategy towards technological change that is plus-sum and open to integration with management in the process of implementation and debugging. Walton and colleagues (2000, p. 28) point out that "it is usually management that directs the fostering at both the workers and their representatives, but unions also utilise fostering in response and as part of independent initiatives."

This study argues that the approaches of management towards implementation and debugging—as the prime movers in technology change in the capitalist enterprise—are adequately captured by the relationship forcing and fostering outlined by Walton et al. (2000). These categories capture the tensions discussed by Vidal (2019). Broadly speaking, he argues that management faces a tension between empowering workers through fostering strategies for greater efficiency, on the one hand, and deploying forcing strategies to maintain control of the labour process on the other. However, a key theme emerging from the labour process literature is that unions often refuse or are unable to seriously engage on matters of technology change in the workplace. Multiple studies have found that while unions may have some capacity to shape technological change on the shopfloor, they are often either unwilling or unable to access this latent power. Union responses around technology change have been found to be inadequate due to union weakness (Bilsland and Cumbers 2018), lack of organised campaigns (Thompson and Bannon 1985), lateness in the development of strategies (Wilkinson 1985), or failing to grasp the changes occurring.

The quotes below from studies of workplace technological change are broadly representative of a range of studies that have observed a similar phenomenon:

> *During this research, workers did report their discontent… However, because of a lack of organised support, this antipathy was not channelled into a constructive challenge to management. Where workers did resist, it was in an ad-hoc and reactive way (Delbridge 2000, p. 199)*

> *[U]nions appear to have barely shaken from their traditional defensive, reactive and economistic perspectives… As they fight a series of rear-guard actions most*

> *workers simply assume the national union structures will not come up with a strategy that can be applied to their own circumstances (Thompson and Bannon 1985, p. 122)*

There are several legitimate, and some less legitimate, reasons trade unionists may hesitate to engage in these areas. Trade union reluctance—or flat-out refusal—towards developing a comprehensive strategy towards technological work reorganisation has some basis in empirical evidence. Many studies have demonstrated that high levels of union involvement in what otherwise might be considered managerial decisions requires unions to submit to managerial (and capitalistic) logics (Bar-Haim 1984; Danford et al. 2005). Similar patterns have been observed when trade unions in liberal market economies have been heavily integrated into managerial processes. This was the empirical finding of studies that examined partnership arrangements in the early 2000s in the UK (see for examples Jenkins 2007; 2008) with authors observing they carried significant distributive and political risks for unions (Martinez Lucio and Stuart 2005). A further contribution emerging from the rich vein of studies into these partnerships was the observation that under financialised capitalism, well-intentioned local managements are unable to deliver on their side of partnership arrangements as decisions made by distant shareholders undermined local agreements, often through the withdrawal of capital and plant closure (Thompson 2003; 2013). Concerns around co-optation are closely related to many unions' preference for 'bread-and-butter' unionism. This style of unionism favours the negotiation of pay and benefits and contract enforcement, while largely respecting the managerial prerogative and declining to campaign on broader social issues (Porter and Hertel-Fernandez 2018). Bread-and-butter unionism has a long history in North America, including unions actively opposing proposed institutional changes that would expand the scope of formal bargaining in ways that include unions in managerial decision making (Morgan and Hauptmeier 2020).

Some scholars have demonstrated that strong strategies around control of the labour process can empower shop stewards at the expense of union leadership (Hinton 1973; Holgate 2021). Beynon (1974) demonstrated how struggles over the control of the labour process including technology change at the Ford Plant in Liverpool were crucial for the development of the power of shop stewards' committees. This power was twofold. First, it gave the committees power over the shopfloor and thus in their wider struggles with management. But secondly, and most relevant here, they helped the shop stewards bypass cumbersome trade union structures and conservative union leaderships with unofficial industrial action (see also Holgate 2021; Allinson 2022). Indeed, Steigerwald (2010, p. 437) argues that concern about giving rank-and-file unionists too much power was partly responsible for the unions in North America largely leaving "questions of management"

alone in its post war era of high membership and industrial strength. This brings us to an argument made most forcefully by Marglin (1974, p. 78), who claimed that unions did not want to confront the relationship between "men [sic] and their work" because they would: "find themselves in conflict with the very principles of capitalist organisation, not merely in conflict over the division, at the margin, of the capitalist pie. No longer could labour's spokesmen be pillars of the established order." In short, for union leaders there can be security both internally and externally in respecting the frontier of managerial control and focusing the union's resources on 'bread-and-butter' issues like pay and benefits.

These issues provide some perspective on why several studies have noted that unions often fail to develop comprehensive strategies around technological change in the workplace (Wilkinson 1983; Thompson and Bannon 1985; Delbridge 2000; Bilsland and Cumber 2018). Though it can be gleaned from many of these studies that some unionists are merely ignorant of the possibilities and threats technological change represents for labour, this does not change the fact that unions can and do develop coherent strategies to try and influence technology change, which are often effective (Frenkel 1988; Taylor and Bain 2001; Danford 2005; Murphy and Cullinane 2021). In this context the framing of union strategies as a relationship between forcing and fostering appears inadequate. Instead, this thesis argues that the presence or absence of a timely, considered, and organised union strategy has greater explanatory power in understanding what shapes patterns of implementation and debugging in the workplace. In the following chapter, a framework for understanding patterns of implementation and debugging new technologies in the workplace is elaborated that considers the presence or absence of such a strategy.

Patterns of Implementation and Debugging

As outlined above, studies of technological change in the workplace are plentiful, both at the level of formal bargaining and at the level of shopfloor implementation and debugging. Conflicting views of how actor strategies impact technology change have been brought into sharp focus by the highly variable results of different union and managerial approaches. Nonetheless a theoretical framework to grasp how these differing strategies shape workplace patterns of implementation and debugging is lacking. Analogous frameworks exist examining other issues. For example, Edwards et al. (2006) developed a framework for understanding worker participation schemes on the basis of a review of a wide range of empirical studies. These authors conceptualised capital and labour's concerns along the lines of 'control' of the workplace and the longer term 'development' of the productive forces. Cross-classifying these concerns produced a matrix of patterns of worker participation in the workplace. In a similar vein, this study conceptualises the strategies of management as a relationship

of forcing and fostering and labour's strategies as the presence or absence of a developed strategy. Cross-classifying these strategies produces four patterns of implementation each with outcomes for the speed and efficacy of the rollout, efficiency gains under the new production process, and the autonomy of workers. Such a framework is needed to deepen our understanding of how technological change occurs in the workplace, and is necessary in the context of significant projected technological work reorganisation in the coming decades (OECD 2017; 2020). The next chapter elaborates this framework, outlining the argument of this thesis in details.

CHAPTER THREE: Argument and Theoretical Contribution

The purpose of this chapter is to present the argument and theoretical contribution of this thesis, which aims to further develop our understanding of the social processes of technological implementation and debugging in the workplace. Broadly speaking, I contend that different managerial approaches, conceptualised as a relationship between forcing and fostering, interact with union strategies, conceptualised as the presence or absence of a timely, considered, and organised strategy, to produce observably distinct patterns of implementation and debugging. These patterns of implementation— (1) contested implementation; (2) unilateral implementation; (3) co-ordinated implementation; and (4) co-opted implementation— elaborated at length below, have implications for the efficacy and speed of the change, the efficiency improvements associated with technology change, and the skills and autonomy of workers. As discussed in the previous chapter, despite a rich body of empirical studies examining technological implementation and debugging, a conceptual framework explaining different patterns of implementation remains lacking. The central contribution of this study is the development of such a framework as outlined in this chapter.

Managerial Strategy

Patterns of implementing and debugging new technologies are shaped by the varying strategies of workplace actors. Under capitalism, managerial strategies remain the prime mover in shaping technological change in the workplace. This is particularly the case in liberal market economies like Canada where workers and their unions have access to minimal institutional mechanisms for influencing the deployment of new technologies when compared to unions in co-ordinated market economies, where participation rights are institutionally enshrined. Managerial approach towards the deployment of new production technologies is thus of central importance to understanding patterns of implementation and debugging. This does not mean that managerial approach is definitive, coherent, or even always deliberate, however (Hyman 1987; Vidal and Hauptmeier 2014). As several scholars have noted, often what is discussed as managerial strategy is merely the efforts of frontline managers to satisfice the needs of the production line (Edwards and Collinson 2002; Vidal 2017), though this study contends that efforts at a coherent approach are more likely to be present at a moment of workplace reorganisation, as management is forced to consider the opportunities and threats that the introduction of a new technology represent.

Studies of the implementation and debugging of new technologies have regularly examined managerial approaches towards technological change. Some studies have explicitly deployed managerial strategy as an explanatory variable. Vidal (2007, p. 199), for example, examined the "strategic orientation of management" in the deployment of lean production technologies, arguing

that management is often primarily concerned with satisficing production targets instead of striving for optimal performance. Similarly, Liang (2021, p. 98) looked at the "multilayered management strategy" of control in the introduction of internet based virtual teams. Perhaps the classic question for labour process scholars around managerial approaches towards technological work reorganisation is how managers deploy new technologies for the purposes of controlling the workforce (Edwards 1979; Bélanger 2006; Hall 2010; Briken et al. 2017). Many studies emphasise the managerial control imperative over other considerations (for examples see Noble 1984; Schopf et al. 2017). However, as discussed in previous chapters, this study follows Vidal (2019) to examine the managerial tension between empowering workers for greater efficiency and disempowering workers through tactics like deskilling to maintain control of the labour process.

Managerial strategy towards technology change is thus conceptualised here as a relationship between *forcing* and *fostering* (Walton et al. 2000). *Forcing* is the coercive exercise of the managerial prerogative in order to drive a workplace change. Walton and colleagues (2000, p. 25) describe managerial forcing strategy as the "most immediate and direct response to the need for change" and entails management forcing economic concessions and changes to work rules on a group of workers. Managerial forcing strategies around technological change in the workplace may involve bypassing obligations to consult, refusing incumbent workers training on the new equipment, and using technology changes to make workers redundant, among others. Walton et al. (2000, p. 25) suggest this kind of approach is usually used when management's long-term goal is to "tighten the terms of traditional compliance relationship with workers and/or weaken the union." In other words, forcing is generally deployed as a strategy when management's primary concern is control. The authors acknowledge that forcing managerial approaches may also be deployed more occasionally and for limited purposes when the long-term goal is "high commitment and union-management cooperation" (Walton et al. 2000).

The principal alternative managerial strategy articulated by Walton et al. (2000) is *fostering.* "A highly contrasting strategy, the parties can foster change so as to achieve their respective goals" (Walton et al. 2000, p. 28). A managerial fostering strategy involves managerial attempts to gain the consent of labour through involving or consulting the workforce in technology change. "Management has traditionally used fostering activities in a limited and temporary way to soften labour's resistance to a planned change, *such as the introduction of a new technology,* or to solicit labour's involvement in carefully delineated areas, such as a safety program" (Walton et al. 2000, p. 28 emphasis added). As shall be seen below, managerial fostering strategies were often used in the process of implementing and debugging new technologies, but generally only occurred under conditions where a satisfactory efficiency outcome could not otherwise be achieved. In short,

fostering is a managerial strategy that is more likely to empower workers to achieve greater efficiency. Both forcing and fostering are present in any managerial strategy, but one will be generally emphasised over the other.

Trade Union Strategy

This study argues that varying union approaches are a key explanatory factor when attempting to understand patterns of implementation and debugging new technologies in the workplace. Several major studies of technological change in the workplace have considered the role of trade unions at the level of formal bargaining (e.g.: Rutherford and Frangi 2020) and policy advocacy (e.g.: Katz 1988). Others have considered the role of unions on the shopfloor (e.g.: Turner 1991). In these studies, union strategies towards technology change are generally conceptualised as a relationship between some variation of a forcing or distributive approach on the one hand and integrative or fostering on the other. As was argued in the literature review, these categories insufficiently grasp the options available to trade unions when faced with technological change in the workplace. Instead, this study conceptualises union strategies towards processes of implementation and debugging as either a developed strategy, which is timely, considered, and organised, or the absence of such a strategy.

Multiple scholars have noted that trade unions are often absent from the social and political processes surrounding implementation and debugging. Delbridge (2000), for example, found despite widespread discontent around work intensification and other issues associated with technological change in British factories, workers' discontent did not find a coherent voice as trade unions failed to organise around these issues. Other studies have come to similar conclusions (e.g.: Thompson and Bannon 1985). Reasons for unions' inability or unwillingness to develop timely and organised strategies around technological change are varied. Unions may have the capacity to influence technological work reorganisation but choose not to in favour of 'bread-and-butter' unionism, either for fear of co-optation or disinterest in matters considered the purview of management (Steigerwald 2010; Morgan and Hauptmeier 2020). Trade union leaders may also prefer centralised bargaining on matters of pay and conditions as shopfloor activism around technology change and work organisation has the potential to empower workplace delegates at their expense (Hinton 1973; Beynon 1974; Holgate 2021; Allinson 2022). Finally, unions in liberal market economies have limited institutional levers at their disposal when it comes to technological change in the workplace (McCann et al. 2010).

However, several studies have also demonstrated that "unions can have power resources" to influence the process of technological change, "but are not particularly skilled at using them"

(Lévesque and Murray 2010, p. 341). Rutherford and Frangi (2020) examined the impact of union bargaining on the implementation of Industry 4.0 technologies in the Ontario automotive sector. They argue that union strategy towards technology change is a key variable in shaping the application of new technologies, though their study examines a single union and its strategies and lacks the generalisability of a comparative study. Martinez Lucio et al. (2021) briefly survey union responses to technological change and argue that contemporary scholarship is unduly pessimistic in relation to union's ability to shape the trajectories of technology change. Vidal (2007 p. 199) examines the role of "organised worker power" and "workforce disposition" alongside the "strategic orientation of management" and how these variables shaped the deployment of lean management techniques. Murphy and Cullinane (2021 p. 288) examined the introduction of new managerial technologies in the British banking sector and concluded that while "unions can acquiesce to new management [technologies] by securing compensation in other areas, they can dissent and try to prise open bargaining agendas that extend their influence on these innovations."

Reflective of the literature outlined above, trade union approaches to technological implementation and debugging are conceptualised as involving either a developed strategy or the absence of a developed strategy. *A developed* union strategy to implementation and debugging could involve a range of tactics deployed with the intention of influencing the process of implementation and debugging. This may involve highly conventional union tactics towards the implementation and application of job controls (Danford 2005), contract enforcement on issues like retraining and redeployment (Rutherford and Frangi 2020) or bargaining for assurances around the maintenance of employment numbers (Stanford and Bennett 2021). It may also involve approaches aimed at creating new spaces for bargaining technology change such as new technology committees or otherwise institutionalised worker involvement in technological change (Rutherford 2021). This study demonstrates that effective union strategies towards influencing the processes of implementation and debugging will likely draw on a range of formal and informal, forcing and fostering, approaches to change. Importantly, a developed union strategy must be: (1) timely, in that it is not operationalised 'too late' in the process of implementation; (2) considered, in that it has been discussed and developed among a range of union stakeholders; and (3) organised, meaning the union works more or less coherently to shape the change.

By contrast, *the absence of a developed union strategy* is characterised by the union and its representatives playing little or no part in the process of implementation and debugging. As discussed above, this may occur for several reasons including union fear of co-optation (Rinehart et al. 1997) or an impulse to centralise control power with the union's leadership (Hinton 1973; Holgate 2021). And while there may be institutional limitations on unions influencing the process of

implementation and debugging, this study supports the argument that unions can prise open new space for bargaining if they are committed to doing so (Taylor and Bain 2001; Murphy and Cullinane 2021). Instead, the absence of a developed union strategy is considered one in which the union is unwilling or unable to influence the process of implementation and may essentially accept managerial prerogative in this space; any effort that is observable would be untimely, unconsidered, and/or disorganised.

Patterns of Implementation

The cross-classification of these explanatory factors give rise to four potential *patterns of implementation* (see **Table 1**). They are titled: (1) contested implementation; (2) unilateral implementation; (3) co-ordinated implementation; and (4) co-opted implementation. Each pattern of implementation is characterised by variations in the efficacy and speed of rollout, the efficiency gains realised from the change, and the skills and autonomy of the workers on the line under the resulting labour processes. Efficiency here means producing more with a given set of resources by optimising work processes (Chang 2014). In the context of technological implementation and debugging this can mean the speed of the rollout of new technologies, or increased outputs from given inputs resulting from the technology change relative to the original work process (Wilkinson 1983). The other outcome examined in these patterns is worker autonomy in the new labour process, or put simply, the level of discretion workers have to do their job after the technology change. While some have argued that worker skill and worker autonomy can be separated (Adler 2007; 2019; Vidal 2019) this study follows Thompson (2007) to argue that the two are inherently linked. As he concluded, autonomy "is the precondition for complexity as it is a key factor that enables the actual use of knowledge and skills" (Thompson 2007 p. 1364). The four patterns of implementation are described in turn below.

Figure 1: Patterns of Implementation

		UNION STRATEGY	
		DEVELOPED	UNDEVELOPED
MANAGERIAL STRATEGY	FORCING	*(1) Contested Implementation*	*(2) Unilateral Implementation*
	FOSTERING	*(3) Co-ordinated Implementation*	*(4) Co-opted Implementation*

A *contested implementation pattern* results from management adopting a forcing approach and the trade union pursuing a developed strategy towards technological change in the workplace.

Contested implementation patterns generally see the rollout of new technologies occurring in a gradual and somewhat restricted way as management and unions bargain over different aspects of the change such as job controls and the redeployment of workers. It can result in tangible improvements to production processes in terms of efficiency and accuracy, but these gains are likely limited by the contested nature of the change. For example, if management provides limited training for employees in the operation of the new equipment, acceptable efficiency gains can be made without realising the full potential of the new technology. In this study, contested implementation patterns resulted in generalised but limited upskilling as unions demanded all relevant workers be trained in the use of new technologies but workers were not deeply involved in debugging process.

Managerial forcing in the absence of a developed union strategy results in *unilateral implementation pattern*. As management is allowed to rollout the new technologies without meeting any organised effort to influence or resist change, the process of implementation and debugging is generally relatively quick. It is limited, however, in the efficiency gains that can be realised as the change is forced on a disenfranchised workforce who have limited investment in or input to the process of technology change. Under the unilateral implementation, pattern workers are not substantively involved in the process of implementation and debugging new technologies and generally receive minimal training, resulting in them having limited capacity to operate the new equipment. In other words, this implementation is likely to result in a degraded labour process for workers.

The third implementation pattern—*co-ordinated implementation*—arises from the interaction between a fostering managerial approach and a developed union strategy. High union and worker involvement in the co-ordinated implementation translates to a high level of problem-solving capacity among workers and aids in the efficient rollout of new technologies. Workers and management are generally able to achieve measurable productivity improvements under this pattern as the process of implementation benefits from broad 'buy-in'. As workers are involved in the process of implementation and debugging, they are likely to gain significant knowledge of the new production technologies, meaning—all other things being equal—they will have a level of autonomy in the operation of the new equipment.

Co-opted implementation, the fourth and final pattern of implementation, arises from a fostering managerial strategy in the absence of a developed union strategy. Of all the patterns described here, co-opted had the fastest initial rollout of new technologies as management can selectively involve workers in the process of implementation and debugging, facilitating rapid initial adoption. The implementation process benefits from the involvement of production workers and significant gains in efficiency and accuracy are possible. Workers integrated into the implementation and debugging

process are also likely to gain a deep understanding of the new technologies. However, in the absence of any organised worker efforts to influence the change, any worker upskilling or empowerment is unlikely to be generalised. In fact, co-opted implementation can result in a fractured workforce and is likely to be difficult for management to sustain.

Of course, this framework has limitations. One is that it does not explore the more conventional question of labour's forcing or fostering strategies. In this study, trade union approaches to technological implementation and debugging were best characterised by either 'highly developed' or 'effectively absent.' When a trade union took a developed strategy, both forcing and fostering approaches were evident. Clearly, when a union failed to develop a response to technology change on the shopfloor neither forcing nor fostering approaches were evident in any significant way. Nonetheless, it seems obvious highly developed strategies will sometimes emphasise either forcing or fostering strategies and these are only captured descriptively in this study. In the discussion chapter, this thesis will place previous studies of implementation and debugging into the conceptual framework represented in **Table 1** and elaborated here. It will demonstrate that a broad range of shopfloor studies of technological change can be accommodated in the conceptual framework developed in this thesis.

Despite these limitations, using this framework, this study will demonstrate that managerial strategies (a relationship between forcing and fostering), and union strategies (the presence or absence of a timely, considered, and organised approach), interact with the technologies themselves to generate distinct patterns of implementation each with different implications for the efficacy of rollout, efficiency gains, and workers' new work processes. By demonstrating the explanatory value of managerial and trade union strategies in shaping patterns of debugging new technologies, this study deepens our understanding of how contemporary technological change occurs, and how managers, workers, and their organisations can act to shape it. This framework was developed out of the examination of four case studies nested inside two plants in the Canadian aerospace sector. The following chapter details some of this research context, and the methodology deployed by this study, including the selection of case studies, as well as data collection and analysis.

CHAPTER FOUR: Methodology and Research Setting:

This chapter outlines the research methodology of this study and gives an overview of the research setting, Laurier Aerospace. First, it discusses the merits and limitations of the comparative case study research design, placing this approach in the context of other studies of implementation and debugging, and explaining how a truncated version of Burawoy's (1998; 2009; Burawoy et al. 1991) extended case method is used to go 'beyond the shopfloor' and build more generalisable theory. It then considers Laurier Aerospace as a research setting: why and how the firm was selected; how access was arranged and managed; and gives a brief history of the firm and discusses its current structure and operations. Next, it provides a detailed account of the process of data collection and analysis, as well as discussing the limitations of the three broad categories of data this study draws on in order of their empirical importance to the project: (1) semi-structured interviews; (2) participant and non-participant observation; and (3) document analysis. Finally, it outlines the methodological principles that underpin this study. This includes a brief discussion of the approach to logic, reasoning and inference taken by this study, and how data was triangulated using mixed methods of data collection.

In summary, this chapter presents a thorough account of how empirical data was gathered, analysed, and triangulated with the aim of answering the central research question:

How do management and union strategies shape the implementation and debugging of new technologies on the shopfloor?

Study Design

Case Study Research

As a research design, case studies are one of the most widely used approaches in business research generally (Eisenhardt and Graebner 2007) and have historically been the dominant approach taken by scholars of shopfloor politics (Thompson and Smith 2010). Case study research involves the detailed and intensive analysis of a single person, event, relationship, or organisation (Yin 2009). As a research design, case studies "allow investigators to retain the holistic and meaningful characteristic of real-life-events such as… organisational and managerial processes" (Yin 2009, p. 41). Through the in-depth and holistic study of a workplace or team, a case study approach allows the researcher to examine multiple explanatory factors that might impact the dependent variable or phenomenon being examined (Flyvbjerg 2006). Case study research has perhaps been the dominant methodological approach to studying the social processes of implementation and debugging, especially in the labour process tradition. Labour process analysis has its origins in the Manchester and Liverpool schools of industrial sociology (Thompson and Smith 2010), which developed in the

first half of the 20th century and with the task of studying the "social relations in work situations and to develop an understanding the links between industrial systems and the wider society" (Eldridge et al 1991, p. 202). Methodologically, post war industrial sociology relied heavily on covert auto-ethnographies, with researchers taking jobs in a workplace (often factories) and documenting working conditions and how workers and managers interacted. There are several prominent examples of this kind of workplace auto-ethnography, especially from the 1950s and 60s. In one of the most referenced studies, for example, Roy (1952, p. 427) worked as a machine operator for a year in a Chicago factory to study what he described as the workers' "ceaseless war with management."

In the decades following Braverman's (1974) *Labor and Monopoly Capital* labour process analysis built on the foundations of industrial sociology and largely continued with its methodological inheritance, relying heavily on single site case studies. Case studies offer "a means of investigating complex social units consisting of multiple variables of potential importance" (Flyvbjerg 2006, p. 214). Early labour process studies provided empirically rich, often incredibly detailed accounts of the social dynamics of the workplaces studied. Indeed, many of the classic early labour process studies were book length accounts of a single workplace (e.g.: Burawoy 1979; Nichols and Beynon 1977). However, these single site case studies were also limited in their capacity to develop more generalisable knowledge—"to develop an understanding the links between industrial systems and the wider society" (Eldridge et al. 1991, p. 202) —a common criticism of case study research (Bulmer 1978). As Flyvbjerg (2006, p. 215) argues "because a case study focuses on a single unit, a single instance, the issue of generalisability looms larger here than with other types of qualitative research."

Indeed, a concern with 'going beyond the shop floor' has been a preoccupation of labour process scholars for several decades (Edwards 2010; Thompson and Smith 2010; Vidal and Hauptmeier 2014). Edwards (2010, p. 31) notes that what "concerned writers […] was that the analysis remained at the level of particular cases […] and there was no effort to relate it to the underlying features of the organisation of work in capitalism." As noted in the literature review, scholars have proposed several theoretical (e.g.: Haidinger et al. 2014; Newsome 2015; Vidal 2014) and methodological (e.g.: Burawoy 1998; 2009; Coe 2015) approaches to overcoming this limitation of some labour process analysis. This study adheres to Thompson and Smith's (2010) analysis and deploys a comparative case study approach which was complimented by a truncated version of Burawoy's extended case method to go beyond the shopfloor and extend existing theory.

Comparative case studies involve the examination of the patterns, similarities, and differences across two or more cases to address the same research question. By conducting multiple case studies that share a common focus or goal, researchers can triangulate their own findings and generate more generalisable knowledge (Gobo 2008; Goodrick 2014). A comparative case study approach is not without its potential pitfalls, however. Dyer and Wilkins (1991) point out two: first, researchers can sometimes not pay enough attention to the dynamics within a single case study; and second, there is a tendency to search for the differences between case studies, sometimes to the exclusion of edifying similarities or commonalities. To ameliorate the first potential shortcoming, the findings of this study are presented in a way that attempts to maintain the "narrative structure" (Bruner 1997, p. 264) of each plant and the studies nested within it by telling the story of the struggle over the implementation and debugging of technologies in each workplace. This involves presenting a context chapter for the relevant plant followed by the two case study chapters of technology change within that plant. The second possible drawback relates to a broader concern in economic sociology identified by Streeck (2009; 2012)—the need to study the commonalities as well as the differences in how capitalism manifests. The theoretical framework developed by this study for understanding patterns of implementation and debugging on the shopfloor accounts for both similarities and differences between the cases studied.

The Extended Case Method

To take this study "beyond the shopfloor" this study uses a truncated version of Burawoy's (2009, p. 12) extended case method. Burawoy suggests that researchers can extend their findings from the examination of micro processes of capitalism by placing empirical data—gathered through participant observation and interviews— in its "extralocal and historical context" (2009, p. 14). The extended case method involves four extensions, though only three are deployed here and it is beyond the scope of this study to deploy each of them in full. The first two extensions relate to fieldwork and will be discussed below:

1. The extension of the researcher into the lives of social actors through participant observation; and
2. The extension of fieldwork over time and space.

The other extension deployed by this study relates to data analysis and theory building and while it is discussed briefly below, a more extensive elaboration of the theoretical contributions of this study can be found in the preceding argument chapter:

3. The extension of theory based on new empirical findings.

While this study draws heavily on these three extensions, it deploys a *truncated* version of the extended case method in that some of these extensions are only completed in partial form and

others are achieved through a workaround. The first extension was achieved in this study through participant and non-participant observation, discussed at length later in this chapter, though semi-structured interviews remained the principal data source for this study.

The second extension involves two components: a spatial extension and a temporal extension. The spatial extension was achieved in this study through the study of four cases across two geographically distinct locations: Ontario and Quebec. This is most clearly represented in the context chapters preceding the case study chapters which include a discussion of the political, economic and industrial institutions of each jurisdiction. This analysis draws on interview data as well as a review of the literature relating to the history, political economy and industrial environment of each province. The temporal extension was achieved using strategies comparable to what Burawoy (2009, p. 253) terms an "archaeological revisit" and a "valedictory revisit". An archaeological revisit "moves back in time to excavate the historical terrain that gives rise to the ethnographic present" (Burawoy 2009, p. 131). As Martinez Lucio and Weston (1992) argue, understanding trade union responses to new managerial initiatives requires an understanding of the unions' histories and traditions. In the context chapters (chapters 5 and 8) preceding the cases study chapters (chapters 6-7 and 9-10), examine the ideological and organisational inheritance of both the trade unions and to a lesser extent the company were examined through a "traditional history of ideas methodology" (Fry and Mees 2017, p. 485) using a review of documentary evidence including union pamphlets, management documents, trade magazines, and histories of both the firm and the unions. This methodology is discussed later in the chapter. A valedictory revisit is when the researcher "returns to the subjects, armed with the results of the study, whether in draft or published form" (Burawoy 2009, p. 134). As Burawoy goes on to point out, the point here is not to undertake another in depth study, but to ascertain participants' responses to the findings and to see what has changed since the last visit. Inspired by the concept of a valedictory revisit, I conducted a series of follow-up interviews one year after the initial field visit. On this revisit, an initial analysis of data was presented to a small group of study participants and feedback obtained.[3]

The argument developed here builds on two sets of theoretical literature and thus achieves Burawoy's third extension: the extension of theory based on new empirical findings. First, it extends the literature on the implementation and debugging of new technologies—especially in the labour

[3] It can also be noted here that this ongoing engagement with study participants—notably a Unifor shop steward from Ontario and a Machinists shop steward from Quebec—helped shape the structure of this thesis in other ways. After reading some draft chapters, both expressed a preference for more, shorter chapters, rather than fewer, longer ones. One also suggested placing the context chapters ahead of the findings chapters rather than in the methodology chapter to maintain the narrative structure of the case studies.

process tradition—by codifying a series of patterns of implementation. As will be shown in the discussion chapter, many previous case studies can be accommodated in the theoretical framework developed in this study. Thus, this framework extends our theoretical understanding of the social processes of technological change in the workplace through a deep engagement with the previous literature. Second, it extends our theoretical understanding of actor strategy. This study achieves this extension by demonstrating the explanatory value of analysing the presence or absence of a developed union strategy, rather than the more conventional relationship between some variation of forcing or distributive strategies on the one hand and fostering or integrative strategies on the other.

Case Selection and Access

Case selection was geared towards studying a manufacturing firm where new technologies such as advanced robotics, the Internet of Things, virtualisation tools and additive manufacturing were being used or were being introduced. It was also preferred that the firm had plants in different geographical locations for the purposes of the comparative case study approach and to apply a truncated version of Burawoy's (1998; 2009) spatial extension. Most importantly, the cases to be studied needed to have likely variations in terms of trade union and management strategy towards technology change on the shopfloor. In other words, the aim was to find a location for fieldwork that would help address the main research question of this study which relates to the strategies of workplace actors and their impact on patterns of implementation and debugging. Through an academic contact, I was put in touch with a senior official at Quebec Machinists' union who, based on the requirements discussed above, suggested three potential case studies, all in the aerospace sector. From this point forward, pragmatic decision making was used to select the firm which was ultimately studied (Reeves 2010).

One of the three potential case studies was immediately eliminated as the firm's plants were too geographically dispersed and linguistically diverse to make studying them practical. In addition to plants in Quebec, the remaining two options had plants in the UK and elsewhere in North America, making them more suitable. These two potential case studies were then discussed with a broader group of IAM representatives who unanimously agreed that Laurier was the better choice. First, they were concerned that they were about to begin bargaining for a new contract with the other firm and did not want to be approaching management for a favour at that time. Secondly, they felt the new technologies being used were more advanced—particularly drilling and filling robots and additive manufacturing—at Laurier than at the other firm.

The most important consideration was the likely variation in managerial and trade union strategies around technology change. IAM organisers and officials agreed that they took a different approach to trade unionism at the Laurier Quebec plants than Unifor at the Laurier plant in Ontario. As will be discussed in the findings chapters, the IAM described their own organising approach as "business unionism," with one organiser saying "we represent our members, but we're smart about it" (Interview 4, IAM Organiser, 19-05-19). By contrast, Unifor representatives described their approach as "militant, democratic unionism" (Field Notes, National President, 29-07-19). The IAM officials also speculated that management may take different approaches in Ontario than in Quebec as the provinces maintain distinct industrial relations traditions. One organiser summarised it like this: "They do things differently down there" (Field Notes, IAM Organiser, 18-05-19). Thus, Laurier was seen to be a suitable research context to examine how the strategies of trade unions and management shape patterns of implementation and debugging.

A meeting was then arranged with the senior human resources manager who agreed to grant the researcher access for interviews and limited participant observation at four plants: the principal Quebec plant, and plants in Ontario, Ireland and Mexico. Unfortunately, plans for visiting the Irish and Mexican plants had to be abandoned due to travel restrictions and other disruptions associated with COVID-19 pandemic. As part of the access agreement (see **Appendix 1**) the senior resource manager requested that I use a pseudonym for the firm and take reasonable steps to protect the anonymity of individual research participants from within the firm. For this reason, the firm is referred to here as the fictional 'Laurier Aerospace' and the positions of Laurier workers are made more generic. For example, a Director of Continuous Improvement might be described as a 'Senior Engineer'.

While this access 'opened the door' for the research, the firm only agreed to arrange 10 interviews in each plant. To supplement this empirical foundation, interviews were arranged through the relevant trade unions. A gatekeeper was already established with IAM but due to significant tension between the two unions (discussed briefly in the case study chapters) a separate approach was made to Unifor through a contact in the Australian (the researcher's home country) trade union movement who had previously worked at the union. In addition to organising around half of the interviews that form the empirical spine of this study, both trade unions assisted in arranging other significant data collection opportunities including documentary evidence, participant observation in union conferences and non-participant observation on the shopfloor. This allowed for a more representative sample of interviewees and for the triangulation of data through multiple sources and methods of collection.

This study examines the process of implementing and debugging two technologies at each of the two plants studied. These four technologies constitute four nested case studies within the two broader sites of empirical fieldwork. The two technology changes which constitute the Quebec nested case studies are:

1. Composites additive manufacturing robots for fabricating aircraft skins; and
2. Robots for drilling holes and inserting fasteners to join major components of the aircraft;

In Ontario, the two nested case studies involve the study of the following technological changes:

3. Virtualisation technologies deployed with the aim of modelling components and planning their join; and
4. Robots for drilling holes and inserting fasteners to join major components of the aircraft.

Laurier Aerospace

The two factories examined in this study, located in Ontario and Quebec respectively, are two of the principal manufacturing facilities of Canadian manufacturer Laurier Aerospace. As mentioned above, a condition of access was that the researcher would not identify Laurier's actual name and take reasonable steps to obscure the identity of the individual research participants in this thesis and in any resulting publications. Thus, while this brief historical context draws heavily on a written history of the firm and on the firm's website, these are not referenced. This history is also written with a level of abstraction, obscuring the most specific details, to obscure the identity of the firm. Laurier is a Canadian firm founded in the 1940s to manufacture vehicles and machinery for recreational, transportation, and agricultural purposes. In the 1980s the firm expanded into aerospace, acquiring several existing manufacturing facilities in Europe and North America between 1986 and 1995. In the 2000s, Laurier established component fabrication and sub assembly plants in Mexico and North Africa. Most recently, Laurier had responded to new trade barriers implemented by the USA government by outsourcing some production to a factory in Alabama, which it later acquired.

For most of its time in the aerospace sector Laurier has specialised in the business aircraft, with a smaller component of the business building propellor planes for regional transportation and military applications. The propellor plane assembly plant is located on site at the Ontario factory but was sold to a new owner in 2018 and workers were transferred to their new employer while I was conducting fieldwork in 2019. Since this transfer, Laurier is engaged exclusively in the manufacture of business aircraft and it commands a major market share in this area. In addition to some fabrication occurring in Quebec and Ontario, components for these jets came to Ontario and Quebec from their own plants in Ireland, Mexico, USA, and Morocco, and from major suppliers in China.

Most structural assembly was performed at the two plants examined here and one other plant in Quebec, also visited during field research. Interiors were fitted and the aircraft were painted in Quebec before being delivered to customers in the onsite delivery centre.

The teams examined in detail for this study were engaged in the fabrication of parts for, and the assembly of, business jets. Both plants performed some fabrication tasks—especially Quebec—and the process introducing additive manufacturing robots for aircraft skins is examined at length in the Quebec chapter. Besides this, the bulk of the empirical evidence examined in this research was gathered in and around the final assembly lines. Here, the two plants shared two major attributes: (1) they produced for the same product market; (2) and they used comparable production technologies. These two contextual variables are borrowed from Bélanger and Edwards (2007) who deployed these as explanatory variables for conditions shaping patterns of workplace compromise. As we shall see, however, they offer little explanatory power in this case as both plants operated in identical product markets and with highly comparable technologies. Thus, product market and production technologies are presented here as a set of common constraints within which patterns of implementation and debugging occurred.

In addition to the additive manufacturing of aircraft skins mentioned above, the final assembly lines which form the empirical spine of this study were involved in the joining of major parts of business jets—fuselage, wings, cockpit, and tail—each seating between 18 and 35 passengers. The central task of assembly workers on these assembly lines was ‘drilling and filling’ or the drilling of holes and inserting fasteners to join the major components of the aircraft. In both plants, drilling and filling robots had been introduced around four years prior to the fieldwork. These robots promised to automate, to a significant extent, what had previously been done manually but were still in the process of being rolled out in both plants. The jets manufactured in both plants were ultimately destined for sale to private customers at the delivery centre, which was on site at a Quebec plant. Here, several completed jets were displayed alongside coffee tables covered in glossy magazines advertising jets to prospective customers. These publications include advertisements for luxury goods like Rolex watches and interviews with previous customers, including one Chief Executive Officer in the finance sector who reported using his jet to commute between his homes in London, Texas, Hong Kong, and a vineyard he owns in Tuscany. The jets retailed for an entry level price of about $80,000,000 Canadian in 2020.

Data Collection and Analysis

This section outlines the data sources in the order of their centrality to the study: semi-structured interviews; participant and non-participant observation; and document analysis. For each data source, the sample, methods of analysis and limitations of the approach are discussed.

Semi-Structured Interviews

Semi-structured interviews are the most central data source for this study. The principal virtue of semi-structured interviews is their flexibility. For each interview in this study, I prepared an interview guide (see *Appendix 2* for an example) which included questions and topics that needed to be covered in the interview; these were designed to elicit information on the interviewee's role, affiliations, their understanding of the forces shaping technological change in the aerospace sector, and how different workplace actors approached these questions. However, despite this guide, the semi-structured approach to interviewing allowed me to deviate from prepared questions and follow the natural flow of the conversation when I deemed it useful or appropriate. This also allowed for an abductive approach to data collection and analysis, discussed later in the chapter.

> *Characteristic of its unique flexibility, the semi-structured interview is sufficiently structured to address your specific question while also leaving space for study participants to offer new meanings to the topic of study (Galletta 2012, p. 2)*

This study involved two tranches of interviews averaging around 45 minutes in length with the shortest interview lasting just over half an hour. Interviews were conducted with shopfloor workers, union shop stewards, trade union officers and officials, engineers, production managers, and participants from the broader industrial ecosystem like training academies and employer organisations. **Table 1** provides the details of the 54 interviews which constitute *Tranche 1*, conducted between May and September 2019, and *Tranche 2*, conducted between October 2020 and February 2021. Each line of the table includes an interview code, which will be used for referencing these interviews throughout the thesis. The primary affiliation describes the interviewee's main organisational connection to the subject matter, often their employer but also voluntary or elected affiliations such as employers' bodies and the relevant trade union for shop stewards, officers and officials. Finally, it includes the date the interview was conducted and the case study to which the data gathered related most closely. It should be noted here that the case study assigned to each study participant and interview is indicative of their primary use only. Several study participants had roles that spanned both cases (e.g.: national union leaders with Unifor) and many commented on the other case study by way of comparison.

A key strength of this sample is that, in both plants, participants were recruited through different gatekeepers; at both factories, management and the relevant trade unions arranged access and interviews separately. Gatekeepers are generally identified as individuals or institutions that have the capacity to grant or withhold access to a research population (De Laine 2000). But as Crowhurst and Kennedy-Macfoy (2013) note, gatekeepers are more than a neutral, practical consideration; they have the capacity to shape research both empirically and theoretically. By arranging access through different individuals and institutions (the firm, trade unions and academic contacts) this study was able to gain a more representative sample of roles, perspectives, and affiliations among study participants (Crowhurst and Kennedy-Macfoy 2013).

Included in **Table 1** is the second tranche of interviews. *Tranche 2* were follow-up interviews with participants from *Tranche 1,* conducted in late 2020 and early 2021 and constituting part of the temporal extension of this study (Burawoy 2009). These interviews include a bracketed code indicating the previous interview number. These interviews were necessarily skewed towards participants who had taken an interest in the project as access was arranged directly between the researcher and the interviewee. Follow up interviews aimed to fill gaps in this study's understanding of workplace dynamics which remained after analysis of the first tranche of data was completed (for example: they were targeted at understanding the tensions between trade unionists in the Ontario plant around re-convening a new technology committee there). Participants were also presented with tentative analysis of the first tranche of data and asked to provide their feedback. This longitudinal approach to data collection and analysis also constitutes part of the temporal extension designed to expand the explanatory power of this study.

Table 1: Semi-Structured Interviews

Tranche 1: May to September 2019.				
Interview Code	**Primary Affiliation**	**Interviewee Role(s)**	**Date**	**Case Study**
Interview 1	Laurier Aerospace	Assembly Worker	19/05/2019	Quebec
Interview 2	Laurier Aerospace	Assembly Worker	19/05/2019	Quebec
Interview 3	Fraternité Internationale de la Mécanique	Local Organiser	19/05/2019	Quebec
Interview 4	IAM	Regional Organiser	19/05/2019	Quebec
Interview 5	Laurier Aerospace; IAM	Maintenance; Alternative Shop Steward	19/05/2019	Quebec
Interview 6	Laurier Aerospace; IAM	Assembly Worker; Alternative Shop Steward	19/05/2019	Quebec

Interview 7	IAM	Quebec President, IAM	19/06/2019	Quebec
Interview 8	Ontario Aerospace Council	Shop Steward	07/07/2019	Ontario
Interview 9	Ontario Aerospace Council	Executive Director	08/07/2019	Ontario
Interview 10	Ontario Aerospace Research and Training	Director of Operations	09/07/2019	Ontario
Interview 11	Unifor	National Representative, Research Department	10/07/2019	Ontario
Interview 12	Unifor	National Representative, Research Department	10/07/2019	Ontario
Interview 13	Unifor 112	President Local 112; Ontario President	11/07/2019	Ontario
Interview 14	Laurier Aerospace; Unifor 112	Assembly Worker; Technical Skills Instructor	11/07/2019	Ontario
Interview 15	Laurier Aerospace	Quality Inspector; Alternative Shop Steward	11/07/2019	Ontario
Interview 16	Laurier Aerospace	Production Manager	11/07/2019	Ontario
Interview 17	Laurier Aerospace; Unifor 673	Quality Assurance Technician; Alternative Union Rep	11/07/2019	Ontario
Interview 18	Unifor	Aerospace Director	17/08/2019	Ontario
Interview 19	Unifor 673	President Local 673	17/08/2019	Ontario
Interview 20	Laurier Aerospace; Unifor 673	Shop Steward	17/08/2019	Quebec
Interview 21	Laurier Aerospace; Unifor 673	Shop Steward	17/08/2019	Ontario
Interview 22	Unifor 62	President Unifor Local 62	18/08/2020	Quebec
Interview 23	Laurier Aerospace	Assembly Worker	21/08/2019	Ontario
Interview 24	Laurier Aerospace	Assembly worker	21/08/2019	Ontario
Interview 25	Laurier Aerospace	Lead Hand	21/08/2019	Ontario
Interview 26	Laurier Aerospace	Director of Operations	21/08/2019	Ontario
Interview 27	Laurier Aerospace	Director of Engineering	21/08/2019	Ontario
Interview 28	Laurier Aerospace	Director of Robotics	21/08/2019	Ontario
Interview 29	Laurier Aerospace	Lead Hand	22/08/2019	Ontario
Interview 30	Laurier Aerospace	Logistics and Inventory	22/08/2019	Ontario
Interview 31	Laurier Aerospace; Unifor 673	Shop Steward	22/08/2019	Ontario
Interview 32	Laurier Aerospace; Unifor 673	Shop Steward	22/08/2019	Ontario
Interview 33	Laurier Aerospace; Unifor 673	Methods Worker; Alternative Shop Steward	22/08/2019	Ontario

Interview 34	Laurier Aerospace	Operations Supervisor – Composites	29/08/2019	Quebec
Interview 35	Laurier Aerospace	Operations Supervisor – Automated Production	29/08/2019	Quebec
Interview 36	Unifor	Unifor Aerospace Council Chair	30/08/2019	Quebec
Interview 37	Laurier Aerospace	Senior Engineer	03/09/2019	Quebec
Interview 38	Unifor	Retired Senior Union Officer	5/09/2019	Ontario
Interview 39	Laurier Aerospace	Automation and Robotics Supervisor	10/09/2019	Ontario
Interview 40	Laurier Aerospace	Assembly Worker	12/09/2019	Quebec
Interview 41	Unifor	Senior Union Official	16/09/2019	Ontario
Interview 42	Laurier Aerospace	Assembly Worker	17/09/2019	Quebec
Interview 43	Laurier Aerospace	Assembly Worker	17/09/2019	Quebec
Interview 44	Laurier Aerospace	Assembly Worker	17/09/2019	Quebec
Interview 45	Laurier Aerospace	Assembly Worker	18/09/2019	Quebec
Interview 46	Laurier Aerospace	Assembly Worker	18/09/2019	Quebec
Interview 47	Laurier Aerospace; IAM	Shop Steward	20/09/2019	Quebec
Interview 48	Laurier Aerospace; IAM	Shop Steward	20/09/2019	Quebec
Interview 49	Laurier Aerospace; IAM	Shop Steward	20/09/2019	Quebec
Interview 50	Laurier Aerospace; IAM	Shop Steward	21/09/2019	Quebec
Interview 51	Laurier Aerospace	Assembly Worker	25/09/2019	Quebec
Interview 52	Laurier Aerospace; Unifor 112	Shop Steward	29/10/2019	Ontario
Interview 53	IAM	Local Organiser	30/10/2019	Quebec
Interview 54	Laurier Aerospace	Human Resources Manager	30/10/2019	Quebec
Tranche 2: October 2020 to February 2021				
Interview 55 (32)	Laurier Aerospace; Unifor	Shop Steward	10/10/2020	Ontario
Interview 56 (26)	Laurier Aerospace	Director of Operations	14/10/2020	Ontario
Interview 57 (35)	Laurier Aerospace	Operations Supervisor – Automated Production	21/01/2021	Ontario
Interview 58 (37)	Laurier Aerospace	Senior Engineer	27/01/2021	Quebec
Interview 59 (49)	Laurier Aerospace; IAM	Shop Steward	27/01/2021	Quebec
Interview 60 (35)	Laurier Aerospace	Operations Supervisor— Automated Production	06/02/2021	Quebec

Wherever possible, interviews were conducted in-person rather than by telephone or using a digital platform. In the first tranche of data collection, interviews were conducted in a range of locations including at people's workstations, in plant cafeterias, coffee shops, meeting rooms, bars, once in an

interviewee's car and twice over the telephone. Oltmann (2016, p. 18) identifies several advantages of face-to-face interviews; key among these is the ability of the interviewer to observe "nonverbal language and cues [which] can be very rich, including dress, body language, mannerisms, and so on." Oltmann (2016) also argues that people are generally more willing and able to express themselves in-person, with the interviewer having more tools at their disposal to put the study participant at ease and clarify ambiguities or confusions that may arise. Due to the COVID-19 pandemic, Tranche 2 of interviews took place over the cloud-based video conferencing service Zoom. Obviously, these interviews were more restricted than the face-to-face interviews from Tranche 1. However, since the researcher had an existing relationship with all the participants in Tranche 2, the rapport previously built with the interviewees helped overcome some of these limitations (Oltmann 2016). With three exceptions, where interviewees declined, interviews were recorded using a Dictaphone before being simultaneously transcribed and edited into clean read transcriptions (Kvale 1996). Each interview was then thematically coded using open, axial, and selective coding (Böhm 2006).

Interviews began with general questions about the individual, their organisational affiliations, and their role. For example: "Can you start by telling me your role and what a normal day at work looks like for you?" Questioning narrowed gradually to more specific questions about technological change, the strategies of workplace actors and resulting patterns of technological implementation and debugging. Consistent with the semi-structured approach, these interviews followed a preprepared interview protocol but were conducted in an informal, often conversational, style to encourage the participants to feel generally at ease (Oltman 2016). On occasions, the interviewer deviated from the interview protocol deliberately to provoke participants with mildly inflammatory questions to elicit more interesting and useful responses. This technique, advocated by Burawoy (1979; 2009), could for example involve asking question of a worker like "Why do you put up with how they treat you?" in a deliberate effort to prompt a more visceral response.

A central limitation of the semi-structured interviews relates to how access was organised. In both case studies, around half of the interviewees came from an introduction (or 'snowballed' (Handcock and Gile 2011) from an introduction) by a managerial gatekeeper and around half came from an introduction (or 'snowballed' from an introduction) by a trade union gatekeeper. While two gatekeepers, each representing different interests and concerns within the workplace, can allow the researcher to gain a *more* representative sample, this sample may still not be representative of the workplace (Crowhurst and Kennedy-MacFoy 2013). The trade unions, for example, tended to introduce the researcher to shopfloor workers who were heavily involved in the union, suggesting that the sample was more cognisant of, or involved in, workplace politics than the average worker. A similar but inverse limitation exists on the managerial side. Interviewees are necessarily 'reactive

respondents' and are thus likely to reflect or defend the organisations they feel an affiliation towards (Given 2008). This suggests that the sample is likely to reflect the management 'line' and the trade union 'line' more than the interests and concerns of less overtly politicised workers. However, as Given (2008) suggests, a researcher can lessen the potential bias through careful analysis and interpretation of the data collected, and by viewing it in its broader organisational context.

Participant and Non-Participant Observation

The first 'extension' of the extended case method is the "extension of [the] observer into the lives of the participants under study" (Burawoy 2009, p. xv) through participant observation. For social scientists participant and non-participant observation are methods in which a researcher takes part in the "daily activities, rituals, interactions, and events of a group of people as one of the means of learning the explicit and tacit aspects of their life routines and culture" (Musante and DeWalt 2011, p. 1). In participant observation the researcher takes part in these events and interactions while in non-participant observation the participant observation the researcher 'stands back' and is solely an onlooker. This study involved both types of observation. Participant and non-observation have long been a central methodology for scholars examining the social processes of technology in the workplace from Gouldner (1954), to Wilkinson (1983), to Delbridge (2000), to (Veen et al. 2020). Participant observation allows the researcher to gather rich empirical data and gain deep insights into the routines and cultures of the organisations—in this case factories and trade unions—that are observed (Musante and DeWalt 2011).

> *As a technique of research, participant observation distinguishes itself by breaking down the barriers between observer and participant, between those who study and those who are studied. It shatters the glass box from which [sociologists] observe the world and puts them temporarily at the mercy of their subjects (Burawoy 1991a, p. 291)*

Participant observation took place as part of the first tranche of data collection between May and September 2019. **Table 2** provides a non-exhaustive overview of the participant and non-participant observation performed during this study. It details the dates of the data collection, the case study the fieldwork was most relevant to, a title and a description of the event or phenomenon observed. It is non-exhaustive in that it is largely limited to formal or discrete events or occurrences such as trade union conferences and factory tours. Many hours of what might be called informal participant observation such as chatting to waiting union members and managers in informal environments such as on the side of conferences, or drinking with shop stewards in bars, are not documented in this table but are drawn on throughout the findings chapters of this study.

Table 2: Participant and Non-Participant Observation

Date	Case Study	Event	Description
19-20-21/05/2019	Quebec	IAM Quebec Conference	The annual conference of the Quebec division of the IAM was held over three days at a hotel in a small town in regional Quebec. This conference involved speeches from the International President, the Canadian President, and the Quebec President. Technological change and its implications for the union was the key theme of the Canadian President's address and the theme of an address from a group of researchers including this researcher.
20/05/2019	Quebec	IAM Conference Dinner	The annual conference dinner was held at a pizza restaurant and brewery in the town where the conference was held. It was an informal event and the researcher was able to mingle freely with delegates, organisers, and union officials. After the bar was closed, drinks continued in the hotel of the carpark until the early hours of the morning. Union delegates played guitar and sang union songs together.
11/07/2019	Ontario	Guided tour of the Ontario plant with President of Unifor Local	The President of Local 612 took the researcher for a tour of the Ontario plant, including a walkthrough of the assembly lines and the union's offices within the plant. The researcher was left in the waiting room of the union's offices for around an hour and was able to talk to several union members waiting to meet with union officers and officials.
16-17-18/08/2019	Ontario	Unifor Aerospace National Council	Unifor's annual conference of delegates from the aerospace division of the union took place at a hotel in Quebec City. This included speeches from the national president, the divisional director, and reports from union locals. It also included two presentations on the impacts of technology on the aerospace sector: one from researchers from the union's national office and the other from this researcher.
17/08/2019	Ontario	Unifor Aerospace Delegate's Conference Dinner	The annual conference dinner was held at a restaurant in Old Quebec, Quebec City. This included speeches from the Ontario President of Unifor and a speech and toast from the aerospace director. I sat with delegates from Laurier Ontario and two researchers from the union's head office.

19/08/2019	Ontario	Unifor Annual Conference General Assembly	Following the annual aerospace delegates' council, Unifor's general annual conference took place at the same venue with delegates from all divisions of the union. The researcher attended the first day of this four-day event as an observer which included the national president's conference address and a speech from the Canadian Prime Minister Justin Trudeau. The Union endorsed Trudeau's re-election bid that day.
20/08/2019	Ontario	Meeting of Unifor Shop Stewards	The purpose of the meeting was for the shop stewards to plan how they would attempt to resurrect the New Technology Committee which was enshrined in their collective agreement but had fallen dormant. I briefed the stewards on my research and observed their discussion.
21/08/2019	Ontario	Factory tour with Director of Operations	After a formal interview, the director of operations took the researcher on a tour of the factory's most technologically advanced assembly line. This included the director intervening in an argument between an assembly worker and a junior production manager over the sequencing of tasks.
21/08/2019	Ontario	Observation of the assembly process with the Director of Robotics	After a formal interview, the Director of Robotics took the researcher to the assembly line to show the researcher the operation of the 'drilling and filling' robots, including his interactions with the robot operator.
03/09/2019	Quebec	Factory tour with human resource management assistant	A junior human resource manager acted as the managerial gatekeeper for access to the Quebec plant. On the first visit to the plant the junior manager took the researcher for a walk through of the plant, pointing out different teams and assembly lines and introducing me to factory workers.
05/09/2019	Quebec	IAM Report Launch: "For a Renewed Commitment in Aerospace"	The launch of this union report was timed to coincide with beginning of the Canadian federal election campaign. The launch took place at the union's offices and was attended by around two dozen shop stewards, several journalists, and a handful of other observers. Speeches were given by a researcher from Hautes études commerciales de Montréal and the Quebec President of IAM who then took questions from journalists.
12/09/2019	Quebec	Observation of production and	This assembly worker, who worked the night shift, participated in a formal interview at their

		factory tour with assembly worker on nightshift	workstation where he operated a drilling and filling robot. After the interview, the worker showed the researcher around the factory which included introductions to other assembly workers.
17/09/2019	Quebec	Observation of the fabrication process	A fabrication worker, who was engaged in fabricating the 'skins' of the aircraft, both operating a robot and manually, participated in an interview at his workstation and demonstrated how to complete his principal tasks. The worker then walked me through the rest of the fabrication work stations and introduced me to other workers.
18/09/2019	Quebec	Observation of the operation of the 'drilling and filling' robot	The researcher completed a formal interview at the worker's workstation where he operated a drilling and filling robot. After the interview, the worker showed the researcher how the robot worked and demonstrated manual drilling and filling, which was also performed at this workstation.
23/09/2019	Quebec	Factory tour of Quebec Plant 2	An IAM shop steward guided the researcher on a tour of the second Laurier plant in Quebec. This included the assembly lines, interior finishing centre, the paint shop, the delivery centre, and the union's offices.
25/09/2019	Quebec	Factory tour of Quebec Plant 3	An IAM shop steward guided the researcher on a tour of the third Laurier plant in Quebec. This included the assembly lines, fabrication facilities, and the union's offices.

As a non-participant observer, the researcher was able to spend several hours sitting in on trade union meetings and conferences, and (perhaps most importantly) observing the production process during factory tours and interviewing workers at their workstations. Workers were generally enthusiastic to show the researcher how they worked, how they operated the production equipment, and how their workstation fit into the broader production process. As a participant observer, the researcher presented research updates to each trade unions' conference and to a group of shop stewards in the Toronto plant who were working to establish a new technology committee. After each presentation, the researcher took questions and feedback from the research participants. Finally, during an interview on the nightshift at the Quebec plant, a young assembly worker demonstrated to the researcher how the drilling and filling robot functioned and invited the researcher to briefly operate the robot under his close supervision.

All participant and non-participant observation was recorded with detailed field notes. Fieldnotes are a researcher's in-depth description of "people (including themselves), places, things, and events, as well as reflections on data, patterns, and the process of research. These details form the context and quality control that shape multiple qualitative data points into articulated, meaningful, and integrated research findings" (Brodsky 2008, p. 3). Fetterman (1998) separates field notes into two categories: (1) empirical observations; and (2) speculative personal reflections. A combination of these types of field notes were taken during this research which then formed part of C. Wright Mills (1999) called the researcher's 'file'. This, Mills (1999, p. 200) says, forms a "growing store of facts and ideas, from the most vague to the most finished." These notes were then analysed thematically and used to contextualise and triangulate the other data sources used in this study (Phillippi and Lauderdale 2018). Participant observation was also useful for recruiting new study participants, particularly through trade union conferences.

The participant observation conducted in this study was characterised by two principal limitations. First, the process was to some degree non-systematic, and unlike the other data sources for this study, the data produced for each case study was uneven between case studies. While in the field, I enthusiastically threw myself into any activity I was invited to join. I did not, however, have the luxury of picking and choosing what I was invited to observe. This meant that the data collected was somewhat non-systematic and asymmetrical between cases. For example, while attending the nightshift at the Quebec plant, the researcher found workers willing to invite the worker onto their workstations for extended periods of time. Night shift access could not be negotiated at the Ontario plant and thus the data is asymmetrical between the two case studies.

Second, participant and non-participant observation has the potential to compromise both the perceived and real objectivity of the researcher (Musante and DeWalt 2011). This proved a limitation in the Ontario plant where the researcher met with several shop stewards from one union local on two occasions after a day of interviews and other data collection at the plant. Subsequently, two shop stewards from the other union local cancelled their interviews with the researcher. Both interviews were eventually rescheduled but at the beginning of the interviews one shop steward said he had originally cancelled because he "thought you were with the other guys" (Field notes, Shop Steward, 21-09-2019). This took place in the context of broader tension between the two locals which is discussed briefly in the Ontario context chapter. The researcher managed to overcome this limitation to a large degree, and it can is considered here a necessary risk of the "extension of [the] observer into the lives of the participants under study" (Burawoy 2009, p. xv).

Document Analysis

Throughout the research process I collected a significant body of documentary evidence. Here these documents are discussed in two broad categories: primary documents and secondary documents. Primary documents are documents that were assembled for the purpose of the study and these were gathered from the firm, trade unions, and other sources such as the Ontario employers' organisation. Secondary evidence is data collected by somebody else for purposes other than the study (Karppinen and Moe 2019). Here, this includes histories of both the trade unions, a history of Laurier, previous studies of the institutional political economies of both Quebec and Ontario, and more. **Table 3** provides a non-exhaustive outline of the primary documents collected during the fieldwork conducted for this study. In total, more than 100 documents were collected; however, they are presented here in summary form for the sake of brevity. The table prioritises describing the documents that will be referenced most heavily in the case study chapters. Each line includes a title for the document or, more commonly, group of documents listed, the case study the documents relate to most closely (some relate to both), the source of the documents, and a brief description of the data.

Table 3: Primary Documentary Evidence

Title of Document(s)	Case	Source	Description
Collective bargaining agreements	Ontario and Quebec	Unifor and IAM	Collective bargaining agreements of all Laurier plants were obtained from the unions. In addition to Unifor's most recent collective bargaining agreements, the researcher was given a USB stick with all aerospace-industry collective agreements made by the union over the last 10 years. The researcher also obtained side notes from IAM relating to new technology.
Unifor Aerospace Union Local Conference Reports	Ontario	Unifor	At the Unifor annual conference of aerospace delegates each union local tabled a report of the local's activities over the past year. This includes reports from three union locals who organise Laurier Aerospace workers, two from the Ontario plant and one smaller local from Quebec.
Laurier Business Aircraft Magazine	Ontario and Quebec	Laurier Aerospace	This magazine, which was on display in the delivery centre in Quebec, is a glossy advertisement for the private jets Laurier produces and sells. A white-collar employee who worked in the delivery centre provided the researcher with 5 back issues.

Union policy reports	Quebec and Ontario	IAM and Unifor	Both IAM and Unifor release semi-frequent policy reports on the state of the aerospace industry, industry policy, and industrial relations. These included a 127-page report from IAM with detailed and thoroughly researched analysis of the Canadian aerospace industry which advocates a national industrial policy for the aerospace sector, mirroring the policy the government has for the automotive sector. Similarly, a "State of the Industry" report from Unifor ran to a almost 100 pages and outlined several policy positions.
Engineering Documents	Ontario	Laurier Engineering Team	The engineering team provided the researcher with several managerial documents. This included monitoring data produced from drilling and filling robots, the "New Technology Introduction Procedure" document, and some anonymised minutes from previous New Technology Committee meetings.
Managerial documents	Quebec	Production manager	A production manager shared a number of managerial documents including performance monitoring documents, technological change plans, and documents analysing different technologies at the stage of selecting new technologies.

Secondary documents are used to supplement primary evidence throughout this study. They were principally used for two purposes. First, they were used to place each plant in their geographical, historical, and institutional context as part of this study's truncated version of Burawoy's extended case method. This involved an analysis of historical development of each province's political economy, industrial relations frameworks, and the specific history of each factory. These are largely contained in the two contextual chapters which precede the findings chapters for Quebec and Ontario respectively. Here primary documents data, as well as interview data, are supplemented in this study with secondary data including previous comparative studies of the political economies of Quebec and Ontario (e.g. Haddow 2015), and policy documents including legislation, policy announcements, press releases, and peak body documents.

Secondary documents were also used to place the ideas, organisational structures, and actions of different workplace actors in historical context. This represents another effort to place the research in "extralocal and historical context" (Burawoy 2009, p. 14). It is argued here that understanding a trade union's approach to technological change on the shopfloor (or any new managerial initiative, for that matter) requires an understanding of the union's history and ideological tradition (Martinez

Lucio and Weston 1992). This thesis examines the ideological and organisational inheritance of the unions and Laurier "having recourse to a review of a range of political, historical, legal and employment relations literature, and analysing research… for the language and concepts they employ in relation to ideology" (Fry and Mees 2017, p. 485). Notable sources here on the union side include a history of Unifor (Wilson 2019), a history of one of its predecessor unions, the Canadian Automotive Workers (CAW) (Gindin 1995) and the United Auto Workers (UAW) (Howe and Widdick 1949), a history of the IAM (Rodden 1984), and previous studies of how these unions operate (e.g. Unifor: Stanford 2015 and Rutherford and Frangi 2020; Rutherford 2021; and IAM: Harrisson and Laplante 1996; Murray et al. 2013). On the employer side, this study draws on a history of Laurier published in 2006 and academic papers that examine the firm which cannot be cited for anonymity reasons.

On the first reading, documents were separated into relevance for a particular case study and categorised thematically as to their relevance to a particular issue such as a trade union's ideological inheritance and organisational history. This allowed for documents to be reread and analysed in 'batches' relating to their empirical content and then analysed using relational document analysis. Relational analysis is a type of content analysis where the concepts found in the text are evaluated by how they relate to each other (Saldana 2013). This analytical approach allows for the development and triangulation of themes emerging from semi-structured interviews and participant observation (Mayring 2014).

The obvious limitation here is the inability to cite the texts which relate directly to the firm or specific union locals as management at the firm requested that it not be identified by name in this study or resulting publications. Identifying an organisation and discussing it openly would produce a more situated account of the firm and generate research that has more impact in political or policy debates surrounding work, technology change and how social actors can act to shape that change (Taylor and Land 2014). Furthermore, facilitating a clearer line of impact stemming from qualitative research can aid a researcher or researchers in demonstrating the value of the work in informing public debate (Taylor and Land 2014). This study attempts to overcome this shortcoming by drawing on rich primary and secondary data and couching this study in contemporary theoretical debates about technology change at work to build generalisable theory (Wiles et al. 2008). A further limitation of the secondary data used in this study is the asymmetry between the two case studies. Notably, there are significant amounts written about the much larger Unifor, while there was no recent comprehensive history available of the Machinists union, and little available focused on its Canadian division.

Methodological Principles

The final section of this chapter outlines some of the methodological principles that underpin this study. First, it provides a very brief outline of critical realism, a philosophical approach to understanding science, which underpins this research. This includes a discussion of the abductive and retroductive reasoning approaches. Finally, it describes how multiple methods and data sources were used by this study to triangulate findings and improve the reliability of the findings and develop a comprehensive understanding of the phenomena studied.

A Layered Ontology and Abductive Reasoning

This research is underpinned by a critical realist research philosophy which sits between positivism and interpretivism. As Archer et al. (2016) put it, critical realism offers an alternative to: "scientistic forms of positivism concerned with regularities, regression-based variables models, and the quest for law-like forms; and also the strong interpretivist or postmodern turn which denied explanation in favour of interpretation, with a focus on hermeneutics and description at the cost of causation." This study maintains a materialist ontology, and a relativist epistemology, as per critical realism (Archer 1998). Critical realism's layered ontology distinguishes between the 'real,' the 'actual' and the 'empirical'. The 'real' refers to mechanisms and structures which have causal powers but cannot be observed. The 'actual' refers to everything that might be occurring at a single moment in time. The 'empirical' refers to events and phenomenon actually experienced or observed. The world as we understand it is constructed from our perspectives and experiences, or through what is observable. Critical realism advocates abductive and retroductive reasoning processes which seek to find causal explanations for these observable phenomena (O'Mahoney 2016).

Critical realism underpins much critical management and labour process research, particularly those associated with the post-Marxian materialist tradition to which this study contributes (Thompson and Vincent 2010). The critical realist approach is well suited to my research question, which seeks to understand the causal mechanisms—managerial and labour strategies—that shape patterns of implementation and debugging for new technologies. Furthermore, this study involves the study of "discourses, practices and events, [and] critical realism's strength is that it can conceptually underpin and integrate all of these" (O'Mahoney 2016). Throughout this study, empirical findings are placed in conversation with existing theories to extend and adapt them, in an abductive process of developing the most likely causal explanation for observed phenomena. Of course, no theoretical description of complex social phenomena will be complete or beyond contestation. However, some explanations are better than others, and a meticulous and cautious approach to data collection and

analysis can help extend existing theory in ways that have significant explanatory power (Sayer 1992).

Triangulation

In qualitative research, triangulation refers to the use of multiple methods or data sources to develop a more comprehensive understanding of an event or phenomena. Triangulation serves to increase the validity and reliability of findings (Seale 1999). This study deploys both method triangulation and data source triangulation to ensure the fundamental biases arising from the use of a single method or a data source are mitigated (Patton 1999). Method triangulation was achieved using multiple methods of data collection (semi-structured interviews, participant and non-participant observation, and documentary evidence) and corresponding methods of analysis, described at length above. This approach helps the researcher to overcome some of the weaknesses associated with any given method (Bogdan and Biklen 2006). Data source triangulation in this study involved seeking the answers to questions through different study participants as well as through other sources. For example, the process of the introduction of new robotics to the assembly line was described differently by shop stewards, engineers, assembly workers, and trade union officials. Additionally, managerial documents such as data gleaned from the robots was analysed by the researcher. Taken together, this enabled the study to gain a much more comprehensive and reliable understanding of the process of work reorganisation and technological change than any singular data source could have produced.

From Methods to Findings

This chapter has provided an outline of the broad empirical context of this study: the study design; how case studies were chosen and access arranged; how data was collected and analysed; and the methodological principles that underpin this research. In the following six chapters we turn to the outcomes of this research. Both the Quebec and Ontario plants are introduced with a context chapter, and each of the two cases nested in these plants is designated a chapter. This way, the findings for each plant are discussed within the framework of the plant's industrial context; the union organising the plant; and most substantively, the patterns of implementation and debugging of new technologies in each plant. In this way, the following six chapters demonstrate how the strategies of managers and trade unions shape how new technologies are implemented on the shopfloor.

CHAPTER FIVE: The Research Context in Quebec

This chapter draws on primary and secondary data to place Laurier's major plant in Quebec in its "extralocal and historical context" (Burawoy 2009, p. 14). As discussed in the methodology chapter, case studies chapters for each plant are preceded by a context chapter to maintain a level of "narrative structure" (Bruner 1997, p. 264) in the discussion of patterns of implementation and debugging. This chapter is split into two broad sections. The first examines the industrial context of Laurier Quebec including an overview of the aerospace ecosystem in Quebec, the province's model of political economy and industrial relations, and finally Laurier's operations in Quebec. The second section analyses the main union organising workers in Laurier's Quebec plants: the Machinists. This includes an examination of the union's history and approach to organising, how the union is structured today, and the union's view of technology change.

Industrial Context of Laurier Quebec

Aerospace *in Quebec*

Quebec is generally considered the home of the Canadian aerospace manufacturing sector. The province is the location of key manufacturing plants for many of the world's major aerospace manufacturers. A senior manager at Laurier Quebec noted that "Quebec is one of only three places in the world that can produce every element of the aircraft—landing gear, electronics, structures, skins—we can do it all here" (Interview 58 (37), Director of Methods and Continuous Improvement, 03-09-2019). In 2018 just over 50% of Canada's overall aerospace production occurred in the province—mostly centred on Montréal—generating $CAD15.3 billion in sales (Invest Quebec 2020). In terms of employment, the Canadian Department of Innovation, Science, and Economic Development, estimate that in the same year Quebec was home to 51% of the country's manufacturing jobs in the aerospace sector and 23% of maintenance, repair, and overhaul jobs. Aéro Montréal (2022) which describes itself as a strategic think tank "that groups all major decision makers in Québec's aerospace sector, including companies, educational and research institutions, as well as associations and unions," boasts that:

> *Montréal is now the third largest aerospace centre in the world, after Toulouse and Seattle. Our cluster has close to 60,000 workers, including 43,000 in the manufacturing sector alone. Its annual sales total more than $15 billion and 80% of production is exported, making it the largest export sector in Québec.*

The sector is supported by a significant ecosystem of training organisations, co-ordinating bodies, and other institutions. This ecosystem is largely governed in accordance with two principles that Haddow (2015) identifies as central to Quebec's model of interest mediation. First, ad hoc tripartite bargaining on economic and social policy. This manifests in several quasi-corporatist institutions and events such as sporadic summits, seminars, and industrial planning or advisory groups across the

Quebec economy. And second, Haddow (2015) identifies highly variable, sector-level bargaining. While industrial bargaining generally occurs at the enterprise level, this tendency was evidenced through the involvement of labour representatives in several of the central institutions of Quebec's aerospace ecosystem. For example, the Quebecois president of the IAM and a representative from Fonds de Solidarité (FTQ), the labour peak body of which Machinists and Unifor in Quebec are affiliates, holds a seat on the board of Aero Montréal, Montréal's peak body for the aerospace sector. A recent report examining skills development and technological change in the Canadian aerospace sector, funded by the Canadian government, argued that:

> *In Montréal, at the cluster level, many collective resources are offered through regional mediating organisations in terms of training, knowledge, and material resources. These organisations also create opportunities for low-power actors (e.g., SMEs and **unions**) to participate in decision making, agenda setting, and resource allocation (Lévesque et al. 2021 emphasis added)*

In addition to participating in these initiatives, the IAM also initiated its own tri-partite fora. Shop stewards from Quebec's Laurier plants described organising a summit on the future of work and skills in the Quebec aerospace sector in 2018. The summit brought together representatives from aerospace firms, government, other unions, and training institutions and had been designed to advocate for investment in training and upskilling of the Quebec workforce for jobs in the aerospace sector. Unionists noted Quebec's central role in Canada's aerospace sector and its strong institutional infrastructure supporting the industry in the province was sometimes a hinderance when advocating for investment in infrastructure and training—both within the union and more generally. As the Quebecois President of the union explained: "Whenever we advocate for industry support, labour market policy, anything really, people just think we are looking for a handout for Quebec" (Interview 7, IAM Quebec President, 19-06-2019).

The Quebec Model

These institutions for interest mediation are part of what Morissette and Charest (2010, p. 225) describe as Quebec's "hybrid" model of political economy in which quasi-corporatist institutions are "alloyed onto" a fundamentally liberal market institutional framework. Quebec's hybrid model of liberal market economy is deeply couched in the province's cultural and linguistic distinctiveness. Archibald (1983) traces this distinct model back to two key moments in the province's institutional formation. First, the Duplessis government of 1944-1959, which—while generally considered hostile to organised labour—was deeply influenced by Catholic social thought that encouraged a level of corporatism. And second, Quebec's quiet revolution in the 1960s, which saw the provincial government play an increased role in economic and industrial planning relative to other provinces.

Quebec's distinct history has often seen politics divided not by class or distributive interests but instead by matters of culture, and linguistic and provincial identity. In their discussion of electoral choice in Quebec, Bélanger and Nadeau (2009, p. 40) argue that:

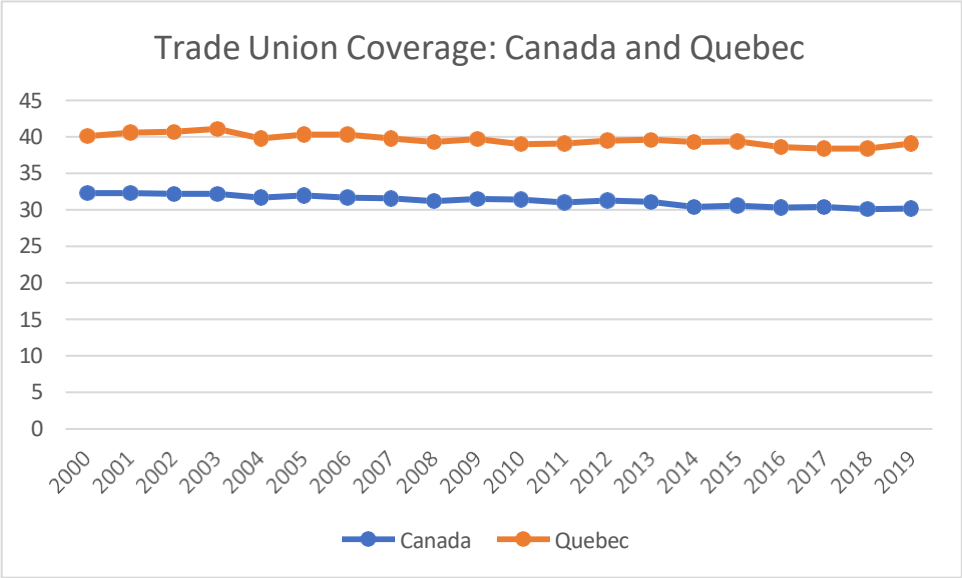
> *…the [left-right] ideological dimension appears less important [in Quebec] than elsewhere. The dimension that explains more about electoral behaviour is that which is linked to Quebec's political future. The attitude of Quebec voters vis-à-vis federalism and sovereignty exercises much greater influence in determining Quebeckers' electoral choices than does the left-right cleavage.*

In terms of industrial relations, the Quebec settlement has generally been more favourable to organised labour than other provinces. Trade union membership in Quebec surged from around 20% in 1945 to around 30% in 1960, and then to 39% in 1970. Organised labour's rise was not initially marked by a significant departure from North American adversarial industrial politics, however, and the 1970s were marked by high levels of industrial disputation. Some scholars posit that this period of militancy can partly be explained by the union movement's association with the Quebec sovereignty movement, which was highly active at the time— though the unions generally stopped short of explicitly endorsing Quebec independence (Denis and Denis 2004). Industrial disputation peaked between 1975 and 1980 when more days were lost to strikes annually than in Ontario, despite the latter province's significantly larger working population. Tanguay (1884) argues that this period of industrial unrest catalysed the development of Quebec's hybrid model and granted organised labour rights they do not have in other provinces, as employers and the Quebec government were motivated to find a modified industrial settlement that could prevent ongoing disruptions.

The institutionalised role of labour unions in the Quebec model is reflected in the relatively strong position of organised labour in the province. The province has maintained provincial regulations relatively favourable to unions and workers. For example, the threshold for union recognition is lower than some other provinces, and employers face restrictions on replacing striking workers that employers in other provinces do not face (Kozhaya 2015), though recent research suggests that the practice of industrial relations in Quebec is increasingly "focused on the needs of employers" (Hennebert and Pérez-Lauzon 2019, p. 240) relative to the needs of workers and their unions. Trade union density in Quebec has been consistently higher than other Canadian provinces and the country for several decades (see **Figure 2**). In 2019, union coverage in Quebec was 39.1% while union coverage at a national level was 30.2%. As Haddow (2015, p. 42) points out "(c)omparative inter-provincial data, available since 1976, indicate that significantly more workers have been

organised in Quebec than in Ontario since then, and that in most years density in Quebec is higher than in any other province."

Figure 2: Trade Union Coverage in Quebec and Canada 2000—2019



Source: Author's calculations from Statistics Canada: Table 14-10-0129-01

Laurier Quebec

Laurier was founded in Quebec in the 1940s to manufacture vehicles and machinery for recreational, transportation, and agricultural purposes. Established as a small family business by a Quebec engineer, the firm rapidly grew into a major industrial enterprise and the founder became a prominent Canadian businessman. Today, a small museum on Montréal's South Shore commemorates his life and work. In the 1980s the firm expanded into aerospace, acquiring several existing manufacturing facilities in Europe and North America between 1986 and 1995. This included acquiring an aircraft factory in Quebec, which remains one of Laurier's primary production facilities. Laurier had long maintained other manufacturing businesses building transportation goods out of a headquarters in Europe. At the time of writing, however, Laurier has recently wound down its other businesses to focus exclusively on aerospace, specifically the manufacture of business jets. This will once again make Quebec the exclusive administrative headquarters for Laurier globally, as it has long been for the Laurier Aerospace. The aerospace division's human resources, marketing, legal, and finance functions are all managed centrally out of Quebec and located on site at one of the plants in Quebec. While some of these functions had previously been housed in an office building in the downtown of a major city, they were centralised at Laurier's principal production facility during the initial fieldwork for this research.

Laurier operates three major manufacturing facilities in Quebec. One, on the outskirts of a major city, is home to Laurier's major research and development facility and manufactures the cockpit and aft fuselage for Laurier's business jets. The other two plants are closer to the centre of the city. One performs fabrication tasks and the final assembly and flight test of several Laurier product lines. The other, larger facility, hosts the administrative headquarters of the firm, performs final assembly for several product lines, fabricates many materials for assembly, fabricates and fits the aircraft interiors, and paints aircraft for final delivery to the customer at the delivery centre which is onsite. While I was given guided tours of all three plants and interviewed shop stewards from across the sites, the following two chapters are focused on the process of implementing and debugging new technologies at the second plant.

Research participants in Quebec were proud of Laurier's Quebecois history and its identity as a major Francophone business in Canada. Workers also felt that the firm's Quebecois identity shielded it somewhat from the threat of outsourcing, nearshoring, and offshoring. "So long as Laurier is operating it will do some of its work here in Quebec" commented one union official (Interview 3, IAM Organiser, 19-05-2019). And while managers also expressed their commitment to Quebec, this was not enough to insulate Laurier's Quebecois workforce from all external shocks. Since 2019 when the bulk of field research for this study was conducted, the firm has announced around 4,500 redundancies across the three plants in the province in the wake of the COVID-19 pandemic, a reduction of more than one quarter of the previous workforce, though some of these workers have since been rehired. This chapter now turns to how these workers organised and represented themselves with a discussion of their union, the IAM.

The International Association of Machinists and Aerospace Workers

Most unionised workers at Quebec's three factories are members of the Machinists. There is one assembly line consisting of a few hundred workers that is organised by another union—Unifor—but this is a result of this line being recently incorporated into the plant from another facility. At the time of data collection, the Machinists were in the process of challenging Unifor's jurisdiction over the line in the courts, but the IAM remains the focus here (Unifor will be discussed at length in the context chapter on Laurier's plant in Ontario). This section of the chapter examines archival documents and uses an extended literature review to frame a discussion of the IAM, its history, and ideology. This provides context for a discussion of the union today and its approach to organising, where I utilise interview data, document analysis and extended participant and non-participant observation. Finally, these findings frame a discussion of the union's approach to the implementation and debugging of new technologies.

History and Approach to Organising

On the 5th of May 1888, nineteen factory workers—most of whom were members of the Knights of Labour—met secretly after work in a locomotive pit in Atlanta, Georgia and founded The International Association of Machinists and Aerospace Workers (Green 2020). Perlman (1961, p. 3—5) argues that in its early years the IAM and its approach to trade unionism were shaped by three central influences: the "Knights of Labour Tradition;" the "Southern influence;" and the "pure-and-simple trade unionism principle." The Knights of Labour, a secretive organisation which advocated the cultural and social uplift of the working man, had its most lasting impact on the IAM in its formal structures and rules. To this day the structures of the union reflect what Perlman (1961, p. 31) called "the trappings and traditions of a secret society or fraternal order." For example, members of the union run for election to the leadership of lodges, or in the case of the international leadership "the Grand Lodge" (IAM 2021). Other idiosyncrasies of this historical influence included "a commitment to individual moral improvement, a hope for the eventual regeneration of society along cooperative lines, [and] an interest in political programs" (Perlman 1961, p. 32). The union is the oldest continuing labour union founded in the southern states of the USA (Rodden 1984). For Perlman (1961, p. 5) the "Southern influence" was "non-egalitarian in nature, emphasis[ing] the superiority of a particular type of white, fully trained craftsman" and restricting membership to "honest, sober men." In this vein the union was a strong advocate of craft unionism in Canada well into the 20th century, arguing overtly against organising the great mass of working people and instead favouring a more exclusive model of trade unionism (Lipton 1967).

While the union still bears the scars of these historical origins, Perlman (1961, p. 4) posits that by the mid-twentieth century "pure-and-simple trade unionism" had become the dominant organising principle of the union. Indeed, in 1990 the New York Times described the IAM as the prototypical model of "bread-and-butter unionists" (Salpukas 1990). In the early decades of the union, this meant the protection of the wages and conditions of qualified machinists through tackling "the problems of effective job control" (Perlman 1961, p. 9). The union's commitment to craft-based job controls was eroded, however, when forced to defend its position against insurgent industrial unionism. In this sense the Machinists' identity and structure is inherently linked to and shaped by its rivalry with Unifor and its predecessors the UAW and the CAW. The two unions have a long history of competition and even hostilities running from the antagonisms between craft and industrial unions in the 1920s and 30s to battles for coverage of aircraft plants during and immediately after the Second World War. Morton (1998, p. 217) notes that in the 1930s: "The International Association of Machinists battled with the UAW for jurisdiction in the aircraft factories. More experienced and more solidly financed, The American Federation of Labor… unions kept well ahead of their industrial

rivals' memberships – but at the expense of the cherished craft principle." As trade unions gained increasing recognition in the second half of the century, the core tasks of the union became improving and protecting the pay and conditions of workers through bargaining for enterprise level contracts and day-to-day contract enforcement (Arneson 2007).

Morton (1998, p. 108) described the Machinists in Canada as a "conservative craft union" that has had "radical phase[s]". This is reflected in how the union participates in politics and in policy advocacy. Rodden (1984) details the IAM's extensive involvement in politics and advocacy in both the USA and Canada which has generally erred on the moderate side of the labour movement's positions on many policy questions with the union supporting centrist political candidates. Notably more radical moments have included the union's strong defence of expanded labour union organising rights in the years after the Second World War (Murolo and Chitty 2001; Arneson 2007) and more recently breaking with other unions to express strong opposition to certain trade agreements (Penn and Diaz 2019).

The Union Today

The legacies of 'pure-and-simple trade unionism' and craft unionism's industrial moderation are observable in the Quebec division of the union today. Union officials and officers interviewed for this study were generally proud of their ability to work with, rather than against management; organisers and shop stewards frequently described the union as a "business union." At a union function, a senior organiser explained what this label meant to him: "we represent our members, but we are smart about it" (Interview 4, IAM Organiser, 19-05-19). Laurier's national human resources director said that the IAM, its organisers and officials were "very good to work with," and drew a direct contrast with Unifor, the other major union representing workers in Canadian aerospace and Laurier, describing them as "a lot tougher" (Field Notes, Human Resources Director, 28-06-19). The working relationship between human resources and the union often appeared genuinely friendly. During my time in the field, a Machinists union organiser invited me to the retirement of an industrial lawyer who had spent his career working for Quebec employers, including Laurier. When gaining access to Quebec plants, management and the union co-ordinated to ensure I was provided access to different parts of the factory, with a shop steward and a human resources manager sometimes guiding me together, making conversation and discussing issues of factory administration with one another.

Within the union, operations were highly professionalised and appeared hierarchical and disciplined. The IAM's annual Quebec conference, observed by the researcher, took place over three days at a hotel in a small town between Montréal and Quebec City. Delegates dressed in semi-formal,

business-like attire; they tucked their union polo shirts into slacks, wore business shoes, and carried leather binders emblazoned with union insignias. The room was arranged with senior union officials seated behind a long table on a stage at the front of the of the room and delegates sat at round tables placed around the room. Delegates wishing to speak would raise their hands, the chair (the Quebec secretary of the union) would call on them and the delegate would walk to a microphone at the front of the room which faced the stage. The forum was notionally democratic, though the researcher did not witness any contested votes over the three days of the conference, nor any substantive debate. In conversations at the conference (and more broadly), delegates and organisers often deferred to the leadership of the union, and were sometimes unwilling to express their own opinions if they thought they did not know the union's position on a particular issue:

> *I would prefer you ask [the President] about that… he knows the union's position on things a bit better than I do (Interview 5, Maintenance Worker and Alternative Shop Steward, 19-05-19)*

> *If you have already spoken to [the Quebec President] about this, I don't think I can tell you anything new. He knows more than me—he knows the union's policies on this stuff (Interview 47, Shop Steward, 20-09-19)*

On the shopfloor, the union's day-to-day operations sometimes appeared almost as an extension of the administrative function of management. One shop steward told me that "calming down" his members and soothing relationships with managers was a central part of his role (Interview, Shop Steward, 21-09-2019). While arranging access and during field research, shop stewards had strong and amicable relationships with human resources managers. In one instance, a shop steward had arranged for me to take a tour of one of the Quebec factories but when I arrived at the gate he was unable to check me in. He proceeded to call the national human resources director and asked him to rectify the situation before discussing hockey results with him. After hanging up the phone he said: "In some ways my relationship with him is more important than with my members" (Field Notes, Shop Steward, 21-09-2019). It can be said generally that the IAM's stewards were much warmer with managers, and more administrative with their members, when compared to Unifor's shop stewards who were more antagonistic with managers and more responsive to the workers they represented, both in Quebec and Ontario (this is discussed at length Chapter 8).

Technological Change and Union Approaches

The only available book approaching a comprehensive official history of the IAM was written by a senior union official, Robert Rodden, in 1984. The book's opening page quotes Tom Tippet, the IAM Director of Education from 1947 to 1956, at length. He says:

> *Without machinists there could be no machines; they make the die and the basic tools from which machines are made. From the initial blueprint the machinist fashions the original tool—the first step in the process. His is the essential skill at the core. He holds the key that unlocks the mystery of the mechanical age. He makes the miracle.*

At least at an abstract level, the relationship between workers and the machines they operate continues to be at the core of the IAM's concerns. At the IAM's Quebec annual conference, the Canadian president of the union made the central theme of his address the question of technological change. Making reference to a number of books on the topic, he described the potential of sudden and major technological disruptions to the organisation of work. Citing Martin Ford's *Rise of the Robots* (2015), he described how the internal combustion engine and the assembly line enabled the rapid replacement of horse drawn carriages at the beginning of the twentieth century. He suggested that we may be standing on the precipice of a similarly dramatic period of rapid technological change and that attempting to shape this change in a way that benefitted manufacturing workers was the central task of the union in the coming decades. He went on to say that:

> *During my time as a trade unionist, we have had three tools in our toolbox when it came to technological change. First, we sought assurance that nobody would lose their job. Second, we bargained for retraining for our members on the new equipment. And, third, if those things failed, we made sure we got our people some money to go away with—a decent severance package. I am now convinced that we need new tools to tackle this next wave of automation (Speech Transcript, IAM Canadian President, 20-05-2019)*

These three approaches to dealing with technological change appear to have been remarkably consistent over the course of the life of the union. Noble (1984, p. 253) noted that in the 1950s, when industrial automation was increasingly on the horizon of the trade union movement and industrial workers, the IAM began making "certain collective bargaining demands for dealing with the effects of 'advanced technology.'" These included "advance notice, transfer rights, moving allowances, retraining at full pay, severance pay, [and] early retirement" (Noble 1984, p. 253). The notable consistency between the union's agenda on technological change reflects two central concerns. First, the union appears overwhelmingly concerned with overall employment levels and the potential for technological unemployment. And second, that despite some rhetorical exceptions, the union has not made any concerted effort to challenge the managerial prerogative in shaping how work is reorganised.

Perhaps more than other unions, the IAM *has* sought out potential allies among employers and managers to deal with the potentially disruptive effects of automation. Noble (1984, p. 252) details how in 1962 the IAM began to "co-operate" with a U.S. Industries-funded foundation set up to help

worker displaced by industrial automation. The fundamental antagonisms between the interests of labour and capital appear to have limited the success of this kind of co-operation, as demonstrated by one union official's frustration with the progress of this initiative: "discussions went round and round and no one knew what to do […] beyond scheduling more conferences and recommending increases in severance pay" (quoted in Seligman 1966, p. 255). Despite these frustrations, the union maintains a less defensive stance towards integration with employers and other stakeholders on matters of work reorganisation, technological change, and the future of skills in the industry than other unions. And while the outgoing Canadian President of the union advocated for a new approach to technological work reorganisation beyond the industrial strategies he listed, and policy advocacy at a political level, no major departures from these strategies were evident during field research. Importantly for this research, the strategic engagement with the questions of technology change witnessed at a high level within the IAM—including two presentations from Quebecois academics and multiple discussions at the IAM's conference— did not translate to a well-developed strategy towards technology change on the shopfloor in the plant studied. How the absence of a developed strategy interacted with management's strategies around the process of implementation and debugging new technologies is explored in the following two chapters.

CHAPTER SIX: The Implementation and Debugging of Composites Robots at Laurier Quebec

This chapter examines the implementation and debugging of composites robots, which were used for the fabrication of the skin (the outer surface which covers much of its wings and fuselage) of the aircraft, at Laurier Quebec. Despite high level strategic engagement with the issue of technology change, the Machinists failed to deploy a timely and well organised strategy to the process of implementation and debugging the new robots on the shopfloor. For its part, management began the implementation process with a fostering approach, involving small groups of workers in the debugging of the new equipment. This co-opted pattern of implementation and debugging enabled a rapid initial rollout of the new technologies with considerable improvements in efficiency and accuracy. 'Superusers,' or workers involved in this co-opted phase of implementation, gained a deep knowledge of the production technologies and maintained a highly autonomous work process. However, in the absence of an organised worker strategy, these gains were not spread across the workforce. As the rollout progressed, management abandoned its fostering strategy and adopted a more forcing strategy, refusing workers requested training and coercing workers to transition into the new processes. The unilateral pattern that emerged continued the fast pace of the rollout but with significantly reduced efficiency gains and minimal training for workers, many of whom came to resemble mere machine minders.

Technological Context

As Laurier's administrative and manufacturing home, the Quebec plants were often used to trial new technologies before they were rolled out across other manufacturing sites. "We're the most advanced" (Interview 35, Operations Supervisor—Automated Production, 29-08-2019). And while the plant could not be described as an industry 4.0 facility the Director of Methods and Continuous Improvement said that "we are laying the groundwork for industry 4.0 with technologies that are entirely consistent with the principles. I don't think you should think about it as a binary. We are heading in the direction of Industry 4.0" (Interview 37, Senior Engineer, 03-09-2019). One of the central tasks performed at the Quebec plant was the fabrication of aircraft skins which later formed the outside of the wings and fuselage. Automation of this fabrication process had recently begun at the factory with the introduction of composites robots. The production task of these giant additive manufacturing robots is to place layer upon layer of carbon-fibre strips, infused with epoxy resin, onto a mould of a part of the aircraft's wing or fuselage, gradually building up the jet's composite skin. Once 42 plies are laid, the machine has produced a single piece of skin to cover, for example, the underside of the forward fuselage. While at the time of data collection these robots had been on

the line for around three years, their debugging process was still occurring. A senior operations manager at the factory explained the reason for the extended implementation and debugging phase:

> *Even after those years we have still manufactured less than only 100 airplanes, meaning that the full maturity of the robot is not there yet. In my previous work, I worked in the automotive industry. And we were doing maybe 2,000 parts per day. Here we will not do that in the entire life of the machine, so technological maturity takes longer (Interview 34, Operations Supervisor—Composites Fabrication, 29-08-2019)*

These robots were contained in a clean room to avoid contaminants entering the area. For participant observation, I was required to put on a lab coat and goggles before entering. According to managers and engineers, the central motivations driving the introduction of these robots were improved ergonomics, increased efficiency, and reduced errors. Ergonomically, the benefits of automation in this process were reasonably straightforward. The previous work process had involved workers applying layers of material on top of one another manually and then ensuring there were no bubbles or imperfections by pressing down the sections by hand. In the clean room where the robots were being used, this process was still used for sections of the skin with an uneven surface that the robots could not navigate. Workers rotated around the room to different stations and frequently remarked on how they enjoyed the variation: "We need to be able to do both. That's why most of us have come from doing the manual process […] I like this [the robot] but I also like the old way because I guess it's more of an art" (Interview 46, Assembly Worker, 18-09-2019).[4]

> *It's easier to fabricate or to manufacture parts with these robots, in my previous work […] we were doing parts more or less the same size, but it was fabricated manually. And it was a really, really long process. And really, really difficult for people doing it. So, with this robot, definitely it's easier from this perspective, and we have better productivity (Interview 34, Operations Supervisor—Composites, 29-08-2019)*

The new process also promised to fabricate skins more quickly and with fewer labour hours. For workers to be able to apply each ply of material by hand, the previous production process had fabricated significantly smaller skins: "The robot can make much larger parts than the manual way, around four times as large" (Interview 45, Assembly Worker, 18-09-2019). The shop steward representing the clean room said that once the automated process was generalised across the entire plant (there were still teams doing the entire process manually) it would result in a reduction in the working hours required to produce the skins. Managers denied it would result in redundancies, and

[4] In the final stages of data collection for this study a manager who had just returned from a trade fair in France mentioned that she had seen robots capable of navigating these more complex tasks, and that Laurier would be examining the prospect of introducing them to the line in the future.

the union had received assurances that they would not occur, but interviewees were unable to put exact figures on the changes and some maintained it was difficult to make exact comparisons between significantly different processes. Most participants were agreed however, that the robots—when operating at full capacity—had the potential to reduce the errors in the process of applying plies of material to the mould of the relevant part. The robot head, which laid the plies of material on the mould was fitted with a camera and one of the main tasks of the robot operators remained monitoring a screen for defects while the robot worked. As will be seen below, monitoring this screen became the central production task of many workers on the line.

Initial Implementation and Debugging: Co-opted Pattern

When the robots were first introduced to the assembly line, they encountered significant problems: "They were very buggy at the start" (Interview 34, Operations Supervisor—Composites Fabrication, 29-08-2019). These bugs can be placed into two broad categories. First, there were inconsistencies with inputs. Specifically, the spools of epoxy resin infused carbon-fibre strips were often imperfect or otherwise not fit for purpose which caused frequent defects on the surface of the skins being manufactured. Second, the robots themselves consistently produced error codes and required reprogramming. To overcome these problems management pursued a fostering strategy, seeking input from a range of workplace actors, including unionised workers. The union failed to deploy any developed strategy towards the introduction of the new robots, tacitly allowing a group of union members to be integrated in the debugging process but not demanding any generalised concessions from management. Managerial fostering met an undeveloped trade union approach and a co-opted implementation pattern emerged.

The problems with the materials occurred with the epoxy resin infused carbon-fibre strips, which came on spools and were loaded into the base of the robot arm then were heated to high temperatures and spread onto the mould. Early on, these spools were unreliable, frequently not rolling off their spool correctly and creating bubbles and other problems in their application. The process of debugging these problems was one of trial and error. Representatives from the firm supplying the spools worked alongside Laurier's managers and engineers to test different temperatures, speeds of application, and to tweak the content of the materials themselves to iron out problems and reduce errors. Management integrated several unionised workers with experience in the previous manual process who were needed during this process as the frequent bubbles and tears in the skin needed to be repaired by hand. This manual process closely resembled the previous labour process.

> *The robot does everything now, but at the beginning of it, obviously we had a lot of problems. There were a lot of abnormalities in the material and we had to fix them manually, and the robot had a lot of bugs we had to figure out. But, yeah, now it runs pretty well (Interview 51, Assembly Worker, 25-09-2019)*

The robots themselves also presented frequent error codes. These robots were specially designed for Laurier and this meant that the debugging process was specific to the organisation. Here, integrated assembly workers who would become robot operators worked alongside representatives from the firm that had built the robot and Laurier's inhouse engineers to learn the error codes and reprogramme the robots when necessary. This was necessary as error codes sometimes appeared when there was in fact no problem. "We had a lot of bugs to sort out early on. That's learning the machines but also reprogramming them when there's something not right" (Interview 46, Assembly Worker, 18-09-2019). The unionised workers involved in this co-opted phase of early implementation and debugging—both in repairing errors caused by the materials and in debugging and programming the robots—enjoyed high levels of discretion during the debugging process and acquired high levels of skill on the new equipment.

> *I was in here from the start. The guys who have been here from the beginning—we learnt a lot from the original equipment manufacturer guys and our managers. We learnt a lot of programming and maintenance while we were helping them set everything up (Interview 46, Assembly Worker, 18-09-2019)*

The union for its part did not demand a new job code, institutionalised training, or a differential pay rate for the robot operators, and was content for its members to be involved in this initial debugging phase at management's discretion.

> *I think the union knew we were helping out to get the robots working. I think their position is just… "If this helps the factory work better and the workers are happy, that's good." So the union didn't have any problem (Interview 46, Assembly Worker, 18-09-2019)*

While local union officers and officials were generally aware this process was occurring, they were open about not having a developed strategy towards shaping the process of implementation:

> *Our guys are really good at their jobs, really skilled… there's really no reason to not let them help set these things up that I can think of. Why not? (Interview 49, Shop Steward, 20-09-2019)*

The manager of the clean room said that worker involvement in the process of implementation and debugging had helped bring the robots online more quickly and with less problems. She noted that this was not only about the workers' previous skills in the manual processes, but that worker involvement in the process of implementation and debugging helped make the robots generally

production ready. “Yes, we needed those guys. Not just for the repair of the imperfections [in the material] but for the machining and programming as well” (Interview 34, Operations Supervisor—Composites Fabrication, 29-08-2019).

> *We all worked together on this, it was very important to have different groups involved to get things working quickly… including the unionised guys (Interview 37, Senior Engineer, 03-09-2019).*

The group of workers who were integrated with management as part of the co-opted phase of implementation gained skills and knowledge that granted them high levels of discretion and problem-solving capacity in their labour process when using the robots in general production. Specifically, they gained the capacity to perform programming and troubleshooting tasks that workers who had not spent significant time working alongside engineers and managers during the debugging process would not have the opportunity to learn. These workers were also called on by managers to perform preventative maintenance, retooling, and more complex setup tasks. The manager for the clean room explained that these operators became his designated “superusers.” He described their role at length:

> *This group, superusers you can say, they are the ones who are doing, for instance, the main setup and the main preventive maintenance. They are the ones also linked really to maintenance, they do the troubleshooting to understand what issues there are and so on. But definitely, it's these workers who are the best, the best mind, the best analytical capacity (Interview 34, Operations Supervisor—Composites Fabrication, 29-08-2019)*

In summary, management’s fostering strategy combined with the absence of a developed union strategy to produce a co-opted pattern of implementation which helped the efficient debugging of the first group of robots, realised significant early efficiency and accuracy gains, and facilitated the significant upskilling of a limited number of integrated workers. Managers and engineers attributed this success in significant part to the involvement of assembly workers in the implementation process. Workers who were integrated into the implementation process—dubbed ‘superusers’ by management—gained high levels of skill in programming and debugging the new robots. Management also recognised that the workers involved in this process developed a high level of skills on the robots and that this contributed to their smooth operation: “Because the robot is quite reliable. I mean, as long as you know how to use it, you should have exactly the same thing every time” (Interview 34, Operations Supervisor—Composites Fabrication, 29-08-2019).

Implementation in General Production: Unilateral Pattern

The successful outcomes of the co-opted pattern in the initial implementation and debugging in terms of rollout speed, efficiency gains, and worker upskilling did not mean management was committed to their fostering approach. As the implementation and debugging process proceeded, input materials were increasingly standardised, technical errors became less frequent, and the work process for robot operators became increasingly codified. As the robots reached a higher level of productive maturity and were implemented in general production, management switched to a forcing strategy, refusing to involve workers in this next phase. The union failed to respond in a timely, considered, or organised way, making no observable demands for new job codes or universal training, and while they made some noises about potential ongoing worker involvement this was no longer required by management. The resulting unilateral pattern of implementation granted workers in this second cohort minimal training on the new machines even though this resulted in some errors and limited the potential efficiency gains. This was nonetheless considered acceptable by management which was more concerned with satisficing production targets and the speed of rollout than upskilling workers or pushing the new machines to achieve maximum efficiency gains.

Unlike the earlier phase of implementation and debugging, production and assembly workers in this phase did not volunteer to be involved and were instead simply directed to work on the new technology by management. One worker compared his selection process with those workers who had been integrated in the co-opted phase: “It wasn’t like that for us. The manager just told me to go there and I had to go” (Interview 51, Assembly Worker, 25-09-2019). A production manager acknowledged that those workers introduced to the robots under a unilateral pattern of implementation received minimal training compared to those in the co-opted phase. He explained how workers who had not been part of the co-opted phase of implementation and debugging pattern did not have the same proficiency in troubleshooting, problem solving and programming the robotics:

> *Some of my other guys are already able to run the robot. But that's it. When there is an issue they can do the standard error codes. But if it's out of the standard, then they are not really skilled enough to understand what to change or to know what to do (Interview 34, Operations Supervisor—Composites Fabrication, 29-08-2019)*

The change in implementation pattern created a divide between robot operators on the shopfloor despite them all being employed on the same job code. The superusers who had been integrated into the debugging process developed a qualitatively different relationship with their managers when compared to workers who were introduced to the robotics later. Superusers continued to

enjoy a highly collaborative relationship with managers and were often called upon and deployed as problem solvers and trouble shooters. This collaborative relationship was the envy of other workers who had not had the opportunity to develop programming and troubleshooting skills on the robotics. These workers were monitored more closely by management and relied more heavily on operations managers, engineers and maintenance when a problem did occur. This was frequently the cause of frustration. "Management watches us more closely… It would be good to know the things they [workers involved in the co-opted phase] know, but I haven't been told how to do it, so I wait for maintenance when something goes wrong" (Interview 51, Assembly Worker, 25-09-2019).

In this team, however, unlike with the implementation and debugging of other technologies (see the following chapter on drilling and filling robots) some managers were—at least rhetorically—in favour of a more generalised training in these functions. One manager in the clean room had advocated for a continuation of a more fostering strategy, including extended, formalised training for workers who had not been involved in the co-opted implementation process to improve efficiency in general production. He claimed that he was rebuffed by more senior managers:

> *It also means that the top management needs to understand that if they are just thinking that you will put a new machine on the shop floor, you will put through two or three guys with your manufacturing team and the rest will be fine then we will get it working but we won't get the most out of the machine (Interview 34, Operations Supervisor—Composites Fabrication, 29-08-2019)*

The same manager felt that this reflected the fact that the firm was primarily concerned with satisficing production requirements, rather than realising the full efficiency and accuracy potentials of new production technologies. In other words, it appears that involving workers in the process of implementation and debugging of new technologies, and thus upskilling those workers in the process, was the most efficient approach to the initial phase. However, upskilling or involving workers in the process of implementation in general production was not necessary for the machines to work *well enough*. In fact, involving workers throughout the process of implementation and debugging would have likely slowed the rollout despite the efficiency and accuracy gains it promised. The use of composites robots was gradually extending to the entire factory and the number of robot operators was growing accordingly. Thus, the robots were only operated at their full capacity when the increasingly small minority of workers involved in the initial process of bringing the robots online were at the workstation, and management accepted this. The frustrated Operations Supervisor from the work area summarised managerial decision making like this:

> *So we have a target for the new equipment's performance, when the target is reached, [implementation] is done. But unless you know what your target should*

> *be, then you don't know if you have to move on or not, to carry on or not. And sometimes, it means that you may say, "Okay, that's good enough for me, I will stop supporting people to learn and we will just run production." But you haven't seen yet all the problems that could occur, and all the things we could actually achieve if we gave workers more control of the equipment. So, it really depends on what you want from your machine (Interview 34, Operations Supervisor—Composites Fabrication, 29-08-2019)*

When questioned about the skill polarisation among their members on the shopfloor, IAM shop stewards appeared either unaware or indifferent. One shop steward dismissed the idea out of hand, while another explained that he thought workers would gain the skills and knowledge of the new equipment through using the new robots: "They will learn as they use the robots. The difference is experience" (Interview 59 (49), Shop Steward, 27-01-2021). The other evidence presented here appears to contradict this position as some workers who had been introduced to the robots during the unilateral phase had been operating the new equipment for almost two years and had not acquired any trouble shooting or programming skills. Nonetheless, the union's shop stewards did not see their role as intervening in the emerging skill gap among their members and maintained an uncritical, undeveloped approach.

In conclusion, after the composites robots reached a high level of process rationalisation the co-opted pattern of implementation dissolved and was replaced with a unilateral pattern as management shifted to a forcing strategy. This reflected management's desire to make the robots work well enough in general production and the IAM's inability or unwillingness to deploy a developed strategy towards the implementation and debugging of the new technologies. In broad terms, the latter pattern enabled a reasonably fast rollout of the robots in general production while the lack of worker involvement and training meant that worker upskilling and the ultimate functionality of the robots were limited substantially.

CHAPTER SEVEN: Implementing and Debugging Drill and Fill Robots at Laurier Quebec

This chapter discusses the patterns implementation and debugging of drilling and filling robots at Laurier's Quebec plant. These robots were introduced to the major structural assembly line to drill holes and install fasteners to join the major components of the aircraft. They were introduced at both the Quebec and Ontario assembly lines around four years prior to the first tranche of field research. The first section of this chapter examines the technological context of the introduction of the drilling and filling robots. It then describes how this technology was implemented and debugged in two phases. In the initial phase, management deployed a fostering strategy, inviting a small group of workers to be integrated into this phase of debugging. The union was largely absent from this process with some local representatives apparently ignorant of the fact it was happening at all. This co-opted implementation pattern and debugging resulted in fast initial, small-scale rollout, significant initial efficiency gains, and the development of a highly autonomous group of "superusers". This co-opted pattern faded, however, as the robots were implemented in general production and management switched to a forcing strategy—refusing workers requested training and engaging in strict direct supervision. The union remained largely absent from the process and a unilateral approach resulted. While management was able to rollout the robots in general production quickly, efficiency and accuracy gains were limited by a lack of worker upskilling and empowerment.

Technological Context

The central production task on the final assembly line at the Laurier's Quebec plant is the joining of major components—fuselage, tail, cockpit, and wings—of the aircraft. From an assembly worker's perspective this involves drilling holes in both components and installing fasteners (e.g.: rivets) to join them. Until recently, all drilling and fastening tasks had been done manually using handheld drills and percussion riveting guns, both guided by an assembly jig. Around four years prior to this fieldwork, Laurier had begun to automate these processes with the introduction of what workplace actors referred to as 'drill and fill' or 'drilling and filling' robots. These robots have a large head that glides along the skin of the aircraft, drilling holes and installing fasteners. Robot operators monitor this process from a workstation with two screens, one which shows live video footage broadcast from a camera mounted in the head of the robot and allows the worker to monitor the drilling process. The other screen displays data and tables providing information to the operator on the progress of the join as well as data for predictive maintenance and other tasks.

Managers, engineers, unionists, and workers were in broad agreement that the drill and fill robots had not—to this point—been a labour replacing technology. Most maintained the number of labour

hours to complete a join had not been reduced. Instead, the driving force for the robots from a managerial perspective was increased accuracy and reduced errors. Errors, either in the process of drilling of holes (for example double holes), or in the process of installing fasteners (such as installing a fastener of the wrong size) could be extremely costly. In discussing the line's efforts to fix a double hole that he had drilled on the forward fuselage, one assembly worker said: "If they can fix it, it still costs tens of thousands of dollars. If they can't fix it and they scrap it, well, let's just say it's really, really bad" (Interview 44, Assembly Worker, 17-09-2019). The robots did not eliminate errors completely, but shopfloor actors broadly accepted that errors were progressively decreasing under the new production process.

> *It might work a little quicker when it's working, I think. But it does a more precise job and it's a cleaner job that has a cleaner finish to it. Yeah. So, accuracy is probably the one big thing (Interview 2, Assembly Worker, 19-05-2019)*

The automation of previously manual processes was met with mixed response from assembly workers. Some workers preferred the manual process as they did not consider operating robots to be "real assembly work" (Field Notes, Assembly Worker, 12-09-2019). It was also perceived by some as an exercise in deskilling. One assembly worker talked at length about how "the young guys" could operate the robots but "can't drill a hole" (Interview 1, Assembly Worker, 19-05-2019). The degree to which this reflected the actual operations of the robots is discussed at length below. For now, it is enough to say that some workers felt or feared the loss of mastery of their previous labour process strongly, and that many workplace actors viewed the robots as requiring less skill to operate efficiently and in a way that avoided errors than the previous, manual process.

The drilling and filling robots were introduced to the assembly line and initially ran into several problems. The robots frequently stopped operating and displayed a range of error codes. The process of learning what actions were required, if any, in response to more than 100 error codes took significant effort from integrated workers, managers, and engineers from both Laurier and the firm original equipment manufacturer. The process was complicated by the frequent appearance of error codes when there was, in fact, no issue. In these instances, the debugging teams would verify the error code manually before either overriding the error code or restarting the computer.

> *All of a sudden, it just stops working and you don't know why, you know, it gives you a glitch. Like, uh, there was contact with the nose. Something like that. There was an example yesterday of how I had contact with the nose, but you look and there's nothing around it. Nothing touched it, stuff like that. We have to learn which codes to listen to [and] when to ignore some error codes (Interview 44, Assembly Worker, 17-09-2019)*

Initial Implementation: Co-opted Pattern

Like the process for bringing the composites robots online, the implementation and debugging of drill and fill robots involved management leading with a fostering strategy. They selected assembly workers to work closely with engineers (both Laurier's and those from the firm that supplied the robots) and production managers to bring the new robotics to full functionality in the production process. The procedure for selecting workers to be integrated with management in this way had generally favoured assembly workers seen by management to be highly reliable and to have strong technical skills. As one manager put it: "We need good guys for this" (Interview 35, Production Supervisor—Automated Production, 29-08-19). The union again approached the process of implementation and debugging without anything approaching a developed approach. It is difficult to know if the union was even aware of their members' integration at an institutional level, with local shop stewards and organisers apparently largely ignorant of the details of the implementation process. In this way workers chosen for integration with management were selected on an informal basis and no concessions such as new job codes or universal training were demanded by workers in any organised way. This co-opted pattern allowed management to use informal channels for worker selection, choosing workers who were enthusiastic to learn the new techniques, were seen as bringing value to the process, and unlikely to cause problems.

> *[It] all depends on your boss, he makes the call… behind closed doors they already know who they would like… there is some maintenance, so they want somebody responsible (Interview 42, Assembly Worker, 17-09-19)*

Neither the IAM nor its shop stewards were formally involved in the process of selecting the workers who were involved in these tasks by management. Since the union did not advocate a new job code the role remained an informal one, and it did not involve a separate rate of pay. This meant the union's potential to influence who was selected and how was limited. Assembly workers did not generally see their union as having a role to play in regulating how they were involved (or not involved) in the process of implementation and debugging: "The union doesn't really deal with stuff like that. The union is more for if you get into trouble" (Interview 42, Assembly Worker, 17-09-2019). One of the workers involved in the process described the absence of union involvement like this:

> *At the beginning there was maybe ten of us [assembly workers], you know, with production [managers], methods and engineering working together. And yeah, there was no union involvement or anything like that (Interview 43, Assembly Worker, 17-09-2019)*

The initial co-opted pattern of implementation had three main outcomes for the organisation of production. First, worker involvement in implementation and debugging accelerated the progression

of the robots to full functionality. Despite having been introduced at around the same time as the drill and fill robots at the Ontario factory, the Quebec robots reached full functionality significantly earlier. Management attributed this smooth implementation process in part to worker involvement. The second was significant accuracy gains in the operation of the new robotics. This improvement was measurable against both the old labour process and the less developed rollout in Ontario. As one manager reflected:

> *We're the best so far in terms of errors and accuracy. At least with the superusers. We have seen a real reduction in errors compared to how we used to do things (Interview 35, Production Supervisor—Automated Production, 29-08-19)*

The third outcome was the significant upskilling of integrated workers. The group of workers selected by management to be involved in the implementation and debugging processes developed a high level of competence in the more advanced functionalities of the machines—including some who had a proficiency in over 100 error codes and the performance of programming tasks including setup. Despite the successes of this co-opted model, it quickly disappeared as the machines reached a higher level of maturity in the production process and management switched to a forcing strategy.

Implementation in General Production: Unilateral Pattern

As the implementation and debugging of the drilling and filling robots progressed, technical errors became less frequent, and management worked to develop a more codified labour process. As the production process reached higher levels of maturity, management found less need to involve workers in the implementation process and switched to a forcing strategy. This involved placing workers on the robots with minimal training and instructing them to call maintenance when errors occurred. The IAM was, once again, unable or unwilling to switch to a more developed strategy and a unilateral pattern of implementation emerged. Like the implementation of the composites robots, a unilateral pattern of implementation resulted in the drill and fill robots reaching a satisfactory level of efficiency in general production, with limited but tangible improvements to accuracy, while workers experienced a degradation of work in comparison to those workers involved in the co-opted pattern of implementation, as well as in comparison to their previous labour process.

As discussed above, the unionised workers involved in the co-opted pattern of implementation gained high level skills in troubleshooting, programming, and tooling. By contrast, workers introduced to the robots later received extremely limited training—a two-day introductory course—and came to resemble simple machine minders. These workers observed the operation of the robot and called for maintenance when something went wrong. In other words, the informal nature of worker involvement in the process of implementation and debugging the robots meant that training

was not institutionalised and resulted in work degradation for those assembly workers not involved in the earlier phase. One of the workers who experienced the degraded work process observed that:

> *The little tricks that they've learned from getting the robots online, that's what helps the most, yeah, for sure. I think the college two days was just pretty much, um, almost safety and what not to do rather than what to do (Interview 44, Assembly Worker, 17-09-2019)*

This skill polarisation was starkly illustrated by two robot operators who worked on back-to-back shifts at the same workstation both of whom were interviewed for this study. The first had been part of the original group of assembly workers involved in the co-opted pattern of implementation and debugging the robots. By working closely with engineers during this period he learned to perform programming and troubleshooting tasks on the robot. The second assembly worker had begun work on the robots more recently and had not been involved in the co-opted phase of implementation. His skills with the robot were significantly lower. He demonstrated his role in their operation to the researcher: watching a screen with his hand poised next to a red button he was to push when he recognised a problem. The night before these two workers were interviewed and observed, the less skilled night-shift worker had been unable to complete much work on his shift as an error code had appeared on the screen that he did not know how to fix. No maintenance staff had been available, and he had spent most of his shift sitting and waiting for assistance. The following morning, the more skilled worker had been able to troubleshoot the problem in a matter of minutes. “He just doesn’t know how to do it” (Interview 43, Assembly Worker, 17-09-19) the more senior worker reported of his junior colleague.

> *I wanted to learn the robot… But learning is not easy, many of the things he (the day shift worker) knows, I don’t know (Interview 44, Assembly Worker, 17-09-19)*

This incident broadly reflects the three central outcomes of the unilateral pattern of implementation when compared to the co-opted pattern. The rollout continued quickly, as the technologies had reached a level of technical maturity that allowed them to be deployed along the assembly line with limited training and close managerial supervision. However, gains in accuracy and efficiency were restricted by the limited understanding of the new operators who made errors better trained operators likely would not have made. Finally, workers introduced to the new technologies during the unilateral pattern of development experienced a degradation of work and often came to resemble mere machine minders rather than sophisticated robotics operators like those integrated in the co-opted phase of implementation.

Workers introduced to the robots during the unilateral pattern of implementation experienced dramatically different relations with managers. Another assembly worker recruited by management

for the initial debugging phase described a productive relationship with managers in which they worked co-operatively on the continued improvement of the production process. Workers not integrated into the debugging process reported much closer scrutiny from managers under the unilateral pattern. One of these assembly workers, now working on the robotics but who had not been involved in the co-opted phase of implementation, described how his lack of skill in troubleshooting the robots led to scrutiny from managers. He worked on the evening shift, and so direct managerial supervision was rare. However, his managers could use data taken from the robots the following morning to monitor his working patterns. Despite having volunteered to work on the robots, he regretted not receiving more training and was envious of other workers whose greater skill at troubleshooting on the robots meant their jobs were more interesting and that they were less likely to come into conflict with managers.

> *It gets stressful… It's just when things could happen like all of a sudden, it stops working and you don't know why. You know, it gives you a glitch... And then you're questioning yourself. Did something happen? Did it? Is it broken? Do I continue or not? You know, do I make a call to maintenance and waste all this time or just continue. And so that can be stressful… Some of the guys know what to do… for them there's confidence and [it] means less attention from the managers (Interview 42, Assembly Worker, 18-09-2019)*

Again, the union's representatives on the shopfloor were largely absent on these questions. This was the case even though the skill polarisation observed was resulting in higher levels of managerial surveillance and even discipline, issues the union generally viewed as closer to its remit than implementation and debugging. When asked about this surveillance and performance management, one shop steward told me: "Well, our members do need to do a good job. They all received training on the robots" (Interview 48, Shop Steward, 20-09-2019). Union involvement in this phase only appeared in an observable way when workers who had received minimal training on the new robots were subject to performance management, actions firmly within the scope of a minimal interpretation of 'bread-and-butter' unionism. Even then, union shop stewards did not appear to make the connection between the varied processes of implementing and debugging new technologies.

The managers who had been involved with the co-opted pattern had tended to have a high level of technical skill and knowledge of the production process. A different group of managers were involved in the unilateral pattern, however. A significant number of managers responsible for implementing the robots in general production had little or no background or formal training in the aerospace sector or engineering. Previously, managers in the plant had generally either been drawn from the ranks of unionised workers or had high level technical qualifications in aerospace

engineering or a similar field. Many newer managers came to the shopfloor as recent graduates with management degrees rather than engineering or technical qualifications. The number of this new type of professional manager (many had business degrees or other management qualifications) at this plant was still relatively few (particularly when compared to Laurier's Ontario plant; see chapters 9 and 10) but they were the source of significant disquiet among workers and unionists.

From an organisational perspective, these managers were supposed to oversee and co-ordinate a codified production process and ensure that workers met their production targets. In this sense they reflected managerial visions of a highly standardised and codified production process, one that required minimal technical expertise to oversee. From a worker perspective this situation reflected a lack of willingness among unionised workers to take managerial positions, which they saw as less secure. One assembly worker in his 30s said he had refused several offers to step into the management team citing his father, who had also worked at the plant and had taken a managerial role but was made redundant shortly after: "My seniority is improving, which means I'm more secure" (Interview 42, Assembler Worker, 17-09-2019). Another assembly worker said he saw managerial jobs as more stressful and offering little by way of reward: "I mean it's stressful, you know you're being pushed to get the job done by your managers... so you have that stress and then you get negative feedback and tension from workers. It's not for me" (Interview 40, Assembly Worker, 12-09-2019).

This new class of managers tended to be put in charge of the teams where the production process was more mature—they had little to offer the earlier stages of implementation and debugging. Far from the collaborative approach taken with workers involved in the co-opted pattern of implementation, this group of managers relied heavily on direct and technical forms of control. In one drilling and fastening team the manager had recently come from outside the aerospace sector and assembly workers reported being micromanaged to a point where they felt harassed. Workers described being time studied as many as four times in the six months prior to being interviewed. While time studies were not a new phenomenon for experienced assembly workers, they were a particular source of frustration for workers who felt that those conducting the studies had little understanding of their labour process:

> *Yeah, because we all assume that the people who are doing the time studies have no idea what it's like to do the job. You know, to them, okay, you have 40 holes, that should take 15 minutes. But there's a whole slew of things involved. But these people who do the time study assumed it should only take certain amount of time to do that and don't necessarily take into account retooling or waiting for maintenance and things like that. I don't know how they come to their decision on time. I have no idea. How can they do that without knowing the work? But it*

seems a lot of times it's like they have no idea what's involved in doing the task (Interview 40, Assembly Worker, 12-09-2019)

Despite the firm's hope that this manager (and others with little or no experience in the aerospace sector) might oversee a codified and standardised production process, even occasional technical problems represented a significant barrier to the realisation of this promise. When errors occurred, or problems such as sequencing issues that caused bottle necks, the managers lacked the technical knowledge to assist workers in overcoming or rectifying these issues. Under these conditions, the relationship between managers and workers became highly antagonistic. Interviewees from this team said that yelling between workers and supervisors was frequent and that on occasions confrontations had bordered on physical violence: "It was like Vietnam out there before, us and the bosses" (Interview 40, Assembly Worker, 12-09-2019). Workers often needed to find workarounds to make the production process work while managers demanded they complete tasks in ways that simply would not work. "With him it was a pretty much an us and them relationship… there was no emphasis on team" (Interview 40, Assembly Worker, 12-09-2019).

The higher levels of tension observed under the unilateral pattern in this team had eased somewhat in recent months, however. The previous director who had no background in the aerospace sector had been replaced with a temporary 'director-supervisor'. This hybrid position was filled by a unionised employee with considerable experience of the production process and corresponding technical skills. Instead of spending most of his time monitoring other workers like the previous director, the director-supervisor spent significant time on the shopfloor helping to co-ordinate the production process, problem solving sequencing issues and assisting less experienced workers with technical tasks. He had also abandoned the repeated time studies favoured by his predecessor. "We like him," said one assembly worker noting the supervisor-director's deep understanding of the production process and suggesting that supervisors were often a "useless layer" and "a waste of time" (Interview 40, Assembly Worker, 12-09-2019).

Conclusion

This chapter and the preceding chapter have discussed the process of implementing and debugging two new technologies at Laurier's Quebec plant: composites robots, and drill and fill robots. In both cases, managerial fostering and undeveloped union strategies produced an initial co-opted implementation pattern. The co-opted patterns involved management selectively integrating unionised workers in the process of debugging and were characterised by fast initial rollout, significant accuracy and efficiency gains, and integrated workers gaining a high level of autonomy in the new labour process. As will be considered at more length in the discussion chapter, the co-opted implementation pattern was never sustained beyond the initial rollout. This suggests that, in the

absence of an organised trade union effort to co-ordinate worker involvement in implementation and debugging it is unlikely to result in widespread benefits for workers. Instead, when both technologies were implemented in general production and the union failed to deploy a developed strategy, management switched to a more forcing strategy. The resulting unilateral implementation pattern allowed for the relatively fast rollout of the technologies in general production but limited efficiency and accuracy gains and a degradation of work for workers not involved in the previous phase. This thesis now turns to Laurier's plant in Ontario. The following chapter places Laurier's Ontario plant in a similar historical and geographic context, examining the province's political economy, aerospace ecosystem and a discussion of Unifor, and the union organising workers at the plant. Chapters 9 and 10 then examine the patterns of implementation that occurred during the rollout of virtualisation technologies and drilling and filling robots at the Ontario factory.

CHAPTER EIGHT: The Research Context in Ontario

Like the role chapter 5 played for the Quebec case studies—placing the findings for these cases in their "extralocal and historical context" (Burawoy 2009, p. 14)—this chapter provides broad economic, political, and industrial context for the Ontario case studies. Again, this context is presented here rather than in the methodology chapter to maintain the "narrative structure" (Bruner 1997, p. 264) of the plants and the cases of technological implementation and debugging occurring within them. First, this chapter outlines the industrial context of Laurier Ontario including a discussion of the aerospace ecosystem in the province, its industrial and employment relations institutions, and a brief discussion of the Laurier plant's history. Next, this chapter provides an in-depth discussion of Unifor, the union organising workers at Laurier Ontario. In discussing Unifor this chapter examines the union's history, ideology, current operations, and its approach to technological change and approach to the managerial prerogative.

Industrial Context of Laurier Ontario

Aerospace in Ontario

Aerospace is one of Ontario's major industrial sectors. In 2017, the Government of Ontario (CEDC 2020) boasted that the province was "home to over half of the world's top 25 aerospace companies." According to the Ontario Aerospace Council (2019), a peak body representing around 200 aerospace firms, the aerospace sector contributed around $CAD10.8 billion to the gross domestic product (direct and indirect) of the province in 2018. The Department of Innovation, Science and Economic Development Canada (2019) estimates that Ontario accounted for 30 percent of aerospace manufacturing jobs in Canada, trailing only Quebec which accounted for 51 percent. Ontario was also home to 25 percent of the maintenance, repair, and overhaul jobs in the Canadian aerospace industry, slightly ahead of Quebec with 23% (Innovation, Science and Economic Development Canada 2019).

A significant ecosystem of firms, training institutions, research and development facilities, and peak body co-ordinating organisations constitute the Ontario aerospace sector. The Ontario Aerospace Council (2019) releases an annual Capabilities Directory, listing hundreds of companies working in aerospace, defence, unmanned arial vehicles, maintenance, repair and overhaul, and research and development in the province. Additionally, the directory lists 26 education and training institutions, including several major universities, offering over 40 degree and diploma programs in applied aerospace, aviation, and space disciplines across Ontario. This institutional infrastructure largely excludes any formal representation of organised labour. Unlike in Quebec, where trade unions were represented on the boards of training institutions and other industry bodies, unions do not generally

have a seat at these tables in Ontario. Indeed, it largely did not occur to industry leaders that organised labour might have a role in peak bodies or similar organisations:

> *We have no union [representatives] on the board of Ontario Aerospace Council… I'm trying to think if - I don't believe there any union reps on the Next Gen board, which is the super cluster for advanced manufacturing… We don't really have [union involvement] at that level here (Interview 9, Executive Director Ontario Aerospace Council, 08-07-19)*

Another significant institution in the Ontario aerospace ecosystem is Downsview Aerospace Innovation and Research (DAIR). With funding from federal, state and local governments, DIAR aims to bring together aerospace firms and post-secondary education institutions with the objective of "increase[ing] collaborative research and development, accelerat[ing] technology adoption, and address[ing] the projected skills shortage in the aerospace industry" (DAIR 2020). Laurier committed around $CAN2 million to support DAIR's research and training capacity in 2018. The institute was partly responsible for training significant numbers of workers who took entry level, unionised positions at Laurier. Additionally, it hosted some formal training and upskilling programmes for existing Laurier employees. Again, however, organised labour had no role or representation in the management of DAIR. The director of operations at DAIR saw the role of trade unions as being purely in the workplace:

> *Not really… I mean, I am always happy to meet with them… It's because we're not really a manufacturing or production hub… And that's kind of where the majority of the union perspective is going to be. So to date, no, not really too much interaction on the trade union side (Interview 10, Director of Operations Downsview Aerospace Innovation & Research, 10-07-19)*

In summary, Ontario has a significant ecosystem supporting the aerospace industry including peak bodies, training institutions, and initiatives fostering technological change in the sector, many with funds supplied by firms in the industry but also by local, state, and federal governments. However, there was virtually no organised labour representation on these bodies. As Lévesque et al. (2021, p. iii) argue, each aerospace cluster in Canada has developed its own idiosyncratic ecosystem with a differentiated role for employers and organised labour: "each region has created resources through a distinct approach: a firm-centric approach in Toronto and a more co-ordinated approach in Montréal."

Industrial Relations in Ontario

Canada is generally seen to have maintained a higher level of trade union rights than many comparable liberal market economies (Stanford 2019). Within this broad institutional framework, however, Canadian provinces maintain distinct traditions which help shape patterns of industrial and

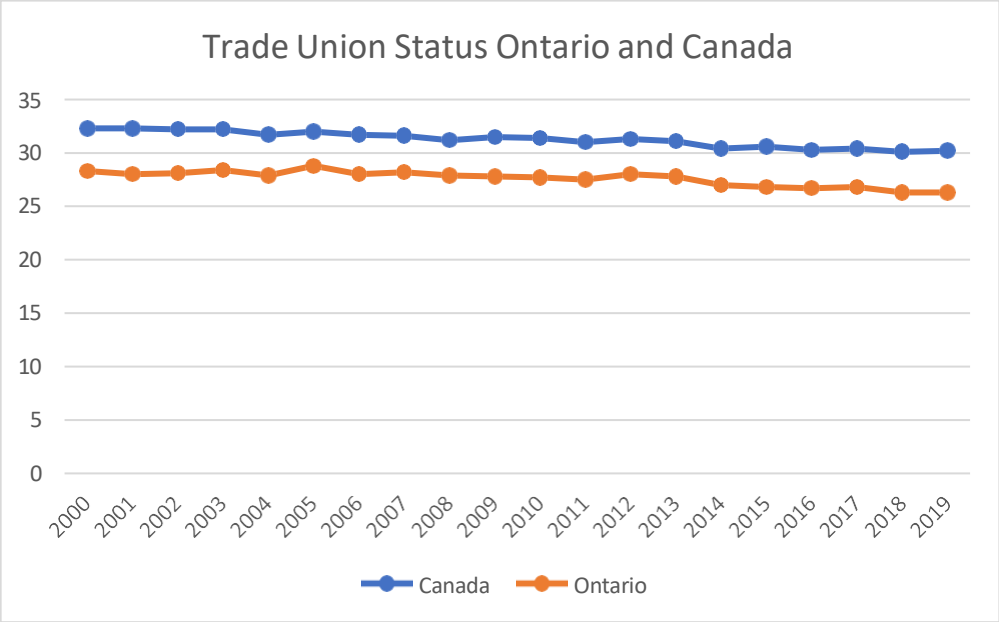
workplace relations. Throughout its history, Ontario has generally been viewed as a more hostile environment for labour unions than most other Canadian provinces. Observers of Ontario's politics, going back to its origins in Upper Canada in the late 1700s, tend to stress its conservatism. Haddow (2015) demonstrates that in the decades after World War II, Ontario was one of the more reluctant provinces in developing a Canadian welfare state, and since the 1970s has been one of the most enthusiastic in gearing its political economy towards market principles. Since 1943, the centre-right Progressive Conservatives—generally the most hostile to organised labour out of the major parties—have governed Ontario for 54 years, while the centrist Liberal Party has governed for 20 years, and the centre-left New Democratic Party—generally the most sympathetic to organised labour's concerns—has governed for only 5 (Elections Ontario 2022). Savage (2021) notes that the one NDP government in the province's history was seen as a disappointment by many union leaders for implementing anti-union legislation and suppressing wage growth through policies like public sector wage caps.

In terms of industrial relations, Ontario is generally considered a more difficult environment for organised labour than other provinces, especially when compared to Quebec. In the Varieties of Capitalism literature, Ontario is understood as a pure example of a liberal market economy (Hall and Soskice 2001; Haddow 2015). This is despite some halting steps towards what Haddow (2015, p. 53) describes as a "high-level corporatist consultation and bargaining during the late 1980s and early 1990s." These included measures such as government support for union sponsored investment funds which NDP Premier Bob Rae said would "put democracy into the economy [and] give workers a chance to participate" (quoted in Mackie 1991). It is worth noting that this measure (and others in a similar spirit) were rejected by the Ontario Federation of Labour and the CAW (Unifor's predecessor). Organised labour was not convinced that the funds represented a genuine opportunity to extend workers' influence over the economy and campaigned strongly against them (for an extended discussion of organised labour's rejection of these schemes in Ontario and elsewhere in Canada see Stanford 1999).

Canadian trade union membership has proven relatively resilient over the past several decades when compared with other liberal market economies (Stanford 2019). Ontario, however, has had consistently lower rates of unionisation than Canada as a whole (see **Figure 3**). According to Statistics Canada (2020), in 2019 unionisation rates in Ontario were the second lowest of any Canadian province at 26.3%, higher only than Alberta with 24.6%. Ontario's relatively low rates of union coverage may be partially explained through an analysis of the province's industrial landscape. For example, the province has seen a significant decline in manufacturing employment and public sector employment is lower than in some other provinces. Nonetheless, Ontario also has lower rates

of unionisation within many sectors when compared to other provinces, suggesting organised labour faces other geographically and historically specific barriers to organising (Haddow 2015). For example, the provincial regulatory framework maintains a higher threshold for union recognition than other provinces and places less restrictions on employers replacing striking workers present in other provinces (Kozhaya 2015; Haddow 2015).

Figure 3: Trade Union Coverage in Ontario and Canada 2000—2019



Source: Author's calculations from Statistics Canada: Table 14-10-0129-01

Laurier Ontario

Aircraft have been manufactured at this Ontario plant since World War II. During this time, the plant has been owned as a state enterprise, as well as being owned and operated by several different private firms and has produced a variety of types of aircraft. A gallery in one of the main foyers of the factory displays photos of each model of aircraft that has been produced at the site over its 80 years of operation. Each display includes a large photo, the specifications of the aircraft, their use (during World War II the plant produced military aircraft) and the lifespan of the product line (e.g.: 1970-2000). The gallery was a source of pride for workers, managers, and trade unionists alike; no less than four research participants (a shop steward, the president of a union local, a production manager, and an assembly worker) gave me informal tours of the display while I was visiting the site. Phrases like 'We've been doing this for 80 years' were common in interviews, and the plant's role in building aircraft for Canada's WWII effort was mentioned on multiple occasions. In short, the plant's history was a source of pride for a wide range of workplace actors.

Many workers and unionists extrapolated from this long history an accumulation of know-how and skill. While showing me through the gallery of aircraft built at the plant a shop steward repeatedly remarked that firms could not "just invent" (Field Notes, Shop Steward, 27-08-2019) this kind of history and institutional knowledge at a greenfield site. The discourse surrounding Laurier's Ontario history was sometimes deployed politically, especially in conversations about outsourcing, offshoring, or nearshoring. Around ten years prior to the research being conducted, most fabrication and sub assembly tasks had been moved from Ontario to Laurier's new plant in Mexico. Several months after the new plant's launch, management approached workers who had previously performed the tasks that were being offshored and asked them to travel to Mexico to help train their replacements. This story was steeped heavily in the folklore of the plant, and was brought up frequently to illustrate managerial incompetence, the apparent lack of skills in the Mexican plant, and the difficulties Laurier would face if they chose to offshore, nearshore, or outsource further functions.

> *The rear fuse was built here for years and years, and we moved it to Mexico, and they had a horrible time trying to get to rate, and we ended up moving people down there to build it for them, basically. And then eventually when we got it right, and the people came back here, that legacy of, "No-one can do it as good as us… everybody's crap," right? "Everybody's crap." The guys think we should have built the wing, because [Texas] are crap. They think we should be building it all here because [they] had to go down to Mexico and build the rear fuse for them (Interview 26, Production Manager, 21-08-2019)*

The idea that the history of building aircraft at this site somehow protected the Ontario workers from the prospects of further offshoring or even closure was not shared by management, however. Indeed, management sometimes juxtaposed Ontario's history of aircraft manufacturing with that of Quebec, which was seen to have a stronger ecosystem to support the industry as well as a more pliable or co-operative trade union. Laurier's headquarters are situated in Quebec along with three major manufacturing facilities and the final delivery centre. And while these plants had not been manufacturing aircraft for as long as the Ontario site, they were nonetheless used by management as a discursive tool in conversations with trade unionists and workers. When the Ontario plant began assembling Laurier's new flagship jet in 2014, a senior human resources manager from Quebec came to discuss the launch with shop stewards at the plant. Several shop stewards remarked with some anger about a speech given by the manager about how Laurier felt about assembling their new flagship product in Ontario:

> *He used Porsche as an example. He said, "Where does Porsche have their head office? Everybody?" Well, it's Germany. He says: "So what's Porsche's flagship product?" Of course, their flagship is the 911. And he said "Well, where do they*

> *build a 911?" It's in Germany, not Poland or wherever else they have factories. So, then he used [Laurier] as an example and said, well, what's the flagship right now? It's this new jet they're marketing the shit out of right now, right? We are building that here in [Ontario]. And he says: "Laurier's headquarters is in Quebec, where do you think they want to build it?" Of course, he was basically letting us know that they wouldn't mind getting rid of us if we don't behave ourselves (Interview 30, Logistics and Inventory Worker, 22-08-2019)*

Laurier's Ontario plant held a special significance to Unifor as it had been the site of several industrial disputes considered foundational to the union's history. It had also been the place where several prominent unionists, including two of the most senior current union officials nationally, had started their working lives and their union activism. This chapter now turns to a discussion of the union and its history.

Unifor the Union

Unifor was the only union organising workers at the Ontario plant. Unifor is the result of a series of union mergers, and this section discusses the union today along with a history of its most relevant predecessors the UAW and CAW. The discussion is focused on a history of these unions and how it operates today, which leads to a discussion of how the union approaches technology change.

History and Ideology

Unionised workers at Laurier Ontario were members of Unifor, Canada's largest private sector union. Assembly workers belonged to Unifor local 113[5], this local can be understood as organising "any worker who actually touches the plane" (Interview 32, Shop Steward, 22-08-19). Methods, logistics, inventory, and other non-managerial workers supporting the production process were organised in a separate bargaining unit and belonged to Unifor local 674. Unifor shop stewards, organisers and elected officials prided themselves on a union philosophy that was frequently described with phrases like that used by the National President when addressing the union's annual aerospace council "militant, democratic trade unionism" (Field Notes, National President, 29-07-19). Several shop stewards emphasised their commitment to "social movement unionism" (Interview 20, Shop Steward, 17-08-19). One unionist drew a direct contrast between the philosophy of Unifor and that of the Machinists, the other major union present at Laurier and in the Canadian aerospace industry:

> *We co-operate with management when it's in our interests. The difference between us and the Machinists is that we don't think it will get us any favours down the track (Interview 41, Former Senior Union Official, 16-09-19)*

[5] The numbers of the union locals have been changed to obscure the identity of the firm.

Management generally viewed the union and its representatives in a similar light. Laurier's head of employment relations, when comparing Unifor to the IAM commented that "those guys are a lot tougher" (Field Notes, Human Resources Director, 15-06-19). This militancy was deeply couched in the union's history, and the history of the unions that preceded it. Unifor is the result of the 2013 amalgamation of the CAW and the Communications, Energy and Paperworkers Union but these founding unions were themselves the product of many breakaways and amalgamations. After the formation of the CAW in 1984, for example, forty-five mergers with smaller unions brought around 150,000 members into the union prior to the formation of Unifor in 2013 (Wilson 2019). The history discussed here skews towards the CAW and before that, the UAW as the aerospace membership has its roots in these unions.

Unifor traces its origins back to the industrial union movement of the early 20th Century. Gindin (1995) suggests that the UAW, founded in 1935, had its antecedents in the Knights of Labour and the revolutionary Industrial Workers of the World (IWW), noting the strong early influence of communist organisers. The IWW was a revolutionary strand of industrial unionism. Daniel De Leon, a socialist politician who provided the "the theoretical basis of the new labour movement" argued that the IWW was "the 'sword' of the revolution, to 'take and hold' the means of production" (Turner 1967, p. 7). In contrast to craft trade unions which limited themselves to organising skilled workers, the UAW belonged to a tradition which aimed to organise all workers: industrial unionism. Gindin (1995, p. 2) argues that "this type of unionism was democratic and universal, reaching out beyond skill level, gender, colour, and accent." This renders a slightly rosy view of the early period industrial trade unionism in North America. Howe and Widdick's (1949) history of the early years of the UAW is peppered with examples of racial tension and even racially motivated violence between members of the union, and examples of workers of colour being deployed to break pickets made up of predominantly white workers. Nonetheless, while varied in practice, the official stance of the industrial unions was more universalist than their craft union counterparts. This perspective also reflects the broader understanding of the divide between craft unionism and trade unionism in the USA and Canada and the official ambitions of the UAW at the time (Lipton 1967; Parker 2008).

The period between the 1930s and 1940s saw the UAW fight on multiple fronts for industrial and political recognition as an organisation. One of the key strategies of this wave of organising was 'sitdown strikes,' whereby workers would occupy their factory and refuse to allow any production to occur unless the UAW was recognised as the bargaining representative of the workers.

> *The sit-down was designed to overcome the depression reality of high unemployment, which was creating large numbers of potential scabs, and the*

> *willingness of anti-union bosses to use hired thugs, police, or the army to bring scabs in (Gindin 1995, p. 53)*

Howe and Widdick (1949, p. 47) suggest that, to that time, no other trade union action in North America had so sharply "posed the issue of 'property rights' versus 'labor rights.'" They go on to argue that "[t]he sit-downs were the closest American workers have ever come to the modes of revolutionary action developed by European workers." These strikes are now broadly considered to be a seminal moment in the development of North American trade unionism in the 20th century (see Kraus 1985) and remain central to the union's understanding of itself well into the twentieth century (Wilson 2019).

By the end of the World War II, however, the union had achieved broad recognition. In the mid-1950s around a third of the workforce in both the United States (Greenhouse 2011) and Canada (Lipton 1967) were organised in labour unions. With automotive manufacturing a dominant industry and the major employer of men during the post war decades, the UAW became a major force in both industrial and political life in North America. The Canadian division of the union was no exception here. In fact, it developed an increasing reputation for militancy and resistance to the moderating and centralising tendencies of the union's post war leader, the American Walter Reuther (Gindin 1995; Wilson 2019). In broad terms, however, the union was able to gain widespread acceptance by abandoning some of its more radical ambitions. Commenting on the consolidation of trade union influence in the late 1950s, Alfred Sloan (quoted in Gindin 1995, p. 107), the President of General Motors commented that:

> *What made the prospect [of unionisation] seem especially grim in those early years was the persistent union attempt to invade management prerogatives… We have moved to codify certain practices, to discuss workers' grievances with union representatives, and to submit for arbitration the few grievances that remain unsettled. But on the whole we have retained the powers to manage.*

The union's approach to technological change is discussed at length in the following sub-section. For now, it is enough to say that the union has long balanced a tension between its tradition of democratic militancy and a desire of union leaders to abandon more radical ambitions in relation to the frontier of managerial control. This reflects a broader tendency in North American trade unionism in which even militant unions have generally respected the managerial prerogative and favoured militancy in relation to pay and working conditions (Marglin 1974; Perline 1999).

In the decades following World War II this type of militancy took the form of pattern bargaining. This strategy involves a process whereby a collective agreement in one bargaining unit is used by trade unions to demand similar conditions and entitlements in another bargaining process. Pattern

bargaining systematically raised the pay and benefits of union members across industries while simultaneously allowing union leaders to co-ordinate the strategy centrally (Marshall and Merlo 2004). While auto workers remained the largest segment of the UAW's membership in the post war decades, aerospace represented a growing portion. In the Canadian division of the union in particular, the aerospace membership represented a militant group within the union, with members determined to keep pace with and even surpass their union brothers and sisters in auto sector *as well as* aerospace locals in the USA. For a time, this involved following major auto makers in pattern bargaining with the auto makers, with Canadian aerospace workers following the lead of the auto sector to achieve higher rates of pay and better conditions. A 1940s UAW pamphlet from what is now the Laurier plant in Ontario reads: "The only opportunity […] workers have for bettering their wages is through comparison with the auto industry, since their wages are now as high as any paid in Canadian aircraft plants."

The UAW continued to organise workers across Canada and the USA until the Canadians split from the American branch of the union in 1985. This divorce is generally viewed as the result of the Canadian division's rejection of the UAW's acceptance of wage constraint and other forms of concession bargaining (Gindin 1995; Stanford 2019; Wilson 2019). Unifor locals at the plant discussed here played a prominent role in this history, including industrial action in the 1970s that directly confronted the American union leadership's acceptance of concessional bargaining and wage constraint. Indeed, these locals were part of the vanguard which pushed for independence of the Canadian union. Gindin (1995, p. 151) writes that the:

> *[…] conflict was an indicator of a new surge of nationalism in the country which linked economic demands to political perspectives […] The arrogance of this […] multinational company, the weakness of the American UAW's response to wage controls, and the apparent order from Detroit to end the strike fed into and reinforced a growing left nationalism in Canada.*

The Canadian union's split from the American division remains core to Unifor's identity. As the union's then President wrote in 2019 "rank-and-file democracy and an independent trade union movement are part of our DNA" (Diaz 2019, p. 9).

Unifor Today

In 2013, the CAW merged with the Communications, Energy and Paperworkers Union of Canada to form Unifor. This merger was driven by a desire to create 'a new kind of union' as the union's official history of the merger describes:

> *To become the social movement they must be, unions must move beyond 'transactional solidarity' based on jurisdictional lines and cost-benefit analyses.*

> *Unions must renew their organising, representation and political models on the basis of values and genuine social unionism (Wilson 2019, p. 23)*

Discussion of how this philosophical tradition manifested on the shopfloor at Laurier Ontario will largely be discussed in the following chapters examining the politics of technological change on the shopfloor. It must be noted, however, that the perception of the union's commitment to "militant, democratic unionism" was shared by many of its members but not all. At least some viewed the union as largely divorced from their day-to-day working lives. This view was sometimes emphasised when union members were asked about the role of the union in technological change on the shopfloor. Some workers viewed the union as having a limited role in such changes. This indifference extended to a deeper critique with a small minority of unionised employees viewing shop stewards as largely self-interested. Any assessment of this claim will necessarily be partly subjective, but there was no primary empirical evidence gathered in this study to support the view that unionists were motivated primary by self-advancement or similar.

> *They are just here to hold lunch... [They] just want to put their time in and then retire. Yeah. And that's it. When you're a committee person. That's top money. That's like 45-50 bucks an hour. Right. So that's good coin (Interview 25, Lead Hand, 21-08-19).*

Among workers with more seniority there was also a general acknowledgement the union's militancy had receded in recent decades. Average annual working days lost at Laurier Ontario appear to have declined gradually over the decades prior to this study though complete data was not accessible.[6] The change in shopfloor relations and bargaining was linked to a broader political philosophy, with some workers remembering when the union was 'socialist'. This shift was not necessarily lamented or applauded, but often merely observed.

> *[The union is] not as militant as it used to be, you know, you go back a generation or two generations ago there was a lot of you know… butting heads with management. [The] trade union philosophy, if it wasn't socialist it wasn't, you know, whatever. Yeah. There is a little more of a co-operative philosophy now, I guess. So, we've definitely seen that change (Interview 14, Assembly Worker and Technical Skills Instructor, 11-07-19)*

The union's 'militant, democratic' ideological inheritance and its commitment to social movement unionism was manifest, albeit unevenly and in a contested way, in the patterns of union governance and organisation observed in this study. This was perhaps most evident at the union's annual council

[6] In the time since data was collected, Unifor members at Laurier engaged in an extended, often bitter dispute with management over the negotiation of a new contract. During this dispute production was shut down for an extended period due to strike action and workers deployed isolated instances of militant direct action.

of Aerospace delegates and the union's Constitutional Convention, held consecutively in Quebec City in August 2019. Evidence of the union's commitment to broader social movements was evident from the beginning of the congress when each delegate and visitor was presented with a badge as part of their conference pack which invited them to write and display their preferred gender pronouns. I did not witness any aerospace delegates who had chosen to display these badges. The congress also featured well attended seminars on the union movement's role in confronting family and domestic violence, and in tackling disadvantage among Canada's first nations and indigenous peoples.

The Aerospace Council met for three consecutive days prior to the general congress. According to the Aerospace Council's bylaws: "The primary purpose in the formation of the Aerospace Council is to discuss problems related to wages, hours, benefits and other conditions of work within the aerospace industry and to assist in the establishment of Unifor contractual provisions within the industry" (Unifor Aerospace Bylaws 2019). Each union local (or bargaining unit within a local) in the aerospace sector was entitled to representation on the council, with two delegates for the first 500 members, and one additional delegate for every 800 members thereafter. In total, around 60 voting delegates and a handful of observers (including the researcher) attended the Aerospace Council.

In both form and content, the council meeting projected a serious commitment to democratic processes. Delegates sat at tables set up as a large square so that all participants could see one another. Each place had a microphone equipped with a button that, when pressed, would turn on a red light that indicated the delegate's desire to speak on a particular matter. Each delegate was given a set of headphones which could be adjusted for translation between English and French, beamed to participants from a team of translators in a small booth at the side of the room. Voting on motions was a frequent occurrence and based on a "one vote per delegate" basis (Unifor Aerospace Bylaws 2019). Voting on many issues was a formality, such as when voting to accept a particular local's report or to endorse this or that union initiative. There were times when the democratic culture appeared to extend into trivial areas. For example, on the second day of the council meeting a delegate moved a motion from the floor to extend break times from 15 to 20 minutes to allow delegates who wished to smoke a cigarette time to walk to the designated smoking area outside the hotel complex and return to the meeting room. While the motion was met with muted groans from some delegates, it was seconded, and the chair of the council opened the floor to speakers for and against. After the one speaker in favour and one opposing, the motion was put to a vote and narrowly defeated. The delegate who had moved the motion commented quietly that he would have to run if he wanted a cigarette.

The ethos of democratic contestation also extended to matters of more consequence. On the final day of the Aerospace Council, the morning after the council dinner, a delegate was granted the floor to express his concern that two members of his delegation had been refused entry at the restaurant the evening before and that he believed that this had occurred because the two delegates were first nations people. He went on to express his concern and disappointment that their delegation had not received adequate support from other attendees at the dinner, in particular the leadership. In response, the acting chair suggested that the conversation could be better dealt with on a break, away from the council floor. The members of the delegation refused, with one remarking that "people need to hear about this stuff" (Field notes, Conference Delegate, 18-08-19). Several other delegates then took the floor to express their regret at the incident and their solidarity with their "union brothers" before it was agreed that the delegation would meet with a group of council leaders at the lunch break to discuss the matter further.

A motion pertaining to the union's approach to national politics was also contentious. On the final morning of the Aerospace Council, the national President of one union local announced on the council floor that the Canadian Prime Minister Justin Trudeau would be endorsed in the upcoming national elections by the national union at the Constitutional Convention the following day. In moving a motion asking the Council to support the endorsement, the council chair acknowledged that while the delegates may prefer or even be members of another party, it was ultimately a race between the Liberals (Trudeau's party) and the Conservatives, noting that the NDP was polling "in single figures" (Fieldnotes, Aerospace Council Chair, 18-08-19). Several red microphone lights had flashed on while she spoke. Delegates raised concerns at the politics of the Liberals, another asked why such a motion was necessary at all, and a French speaking delegate said that the position did not reflect the situation in Quebec. In speaking for the motion, the chair of the council argued that it was important to show support for the national leadership of the union. After several speakers for and against the motion was ultimately put to a vote and passed narrowly; around a quarter of the delegates abstained from voting.

Technological Change and the Frontier of Managerial Control

Outside of the reports from union locals—which provided updates on collective bargaining and general overviews of union activities like grievance procedures—technological change and its impact on production in the aerospace sector was a major focus of conversation at the Council. This included a presentation from two members of the Unifor research staff entitled "The Future of Work is Ours: Confronting the risks and seizing the opportunities of technological change." This presentation was framed around six potential impacts of technological change: (1) job loss,

displacement, and estrangement; (2) changes in work organisation and required skills; (3) productivity enhancements and work intensification; (4) increased surveillance; (5) health and safety and ergonomics; and (6) changes in pay and employment security. On the matter of work reorganisation and technological change, the presentation acknowledged the potential of upskilling: "workers displaced by technological change may upgrade their skills to fill new roles that complement and support new technologies." And the potential for deskilling or "the slow erosion of skill requirements and experience due to increasing automation."

> *One of the focuses of our council this time is tech change. We are hearing a lot about it from the guys in the shops so we try to listen to that and present some information that will be useful (Interview 18, Unifor Aerospace Director, 17-08-2019)*

> *Technological change and what it means for our members has been a big area of concentration for the research team. Not only for researchers like me who work with members in manufacturing, but the whole union in other sectors as well (Interview 11, Unifor National Research Representative, 10-07-2019)*

The research team's presentation reflected the concerns and ideas of the union more broadly on matters of technological change. Delegates and trade union officials understood technological change to be inevitable and even desirable, both for ergonomic reasons and to ensure the competitiveness of their employers in the global marketplace. Unifor simultaneously maintained significant concerns for the potential for technological unemployment and the undermining of traditional union strategies such as job controls. This reflects the historic ambivalence of the UAW (Steigerwald 2010) and CAW (Gindin 1995) to the potentials and threats of industrial automation; the union has long held hopes for the emancipatory potentials of technological change but also concerns around the potential negative outcomes, especially job displacement and technological unemployment.

Going back to the post war period, UAW leaders shared widespread hopes that new production processes could relieve their members of the drudgery of heavily Taylorised assembly line work. At the same time, however, union leaders were concerned that unchecked technological change would generate a wave of structural unemployment by displacing experienced workers and denying new, unskilled labourers the opportunity to get a foothold in labour markets. This was, of course, during a period when much of the consumer market for products manufactured in North America was domestic. In a now well-known anecdote reflecting this economic context, Walter Reuther—President of the UAW from 1946 to 1970—was being given a tour of a Ford plant in Detroit when a company official proudly pointed to some new, automatically controlled machines and asked

Reuther: “How are you going to collect union dues from these guys?” Reuther replied: “How are you going to get them to buy Fords?” (quoted in Thompson 2015, p. 39).

Steigerwald’s (2010) account of the UAW’s approach to technological change in the post war period maintains that the UAW developed a dual strategy of job controls on the shopfloor and supporting progressive political policy at both state and national level as its two principal strategies designed to shape the trajectory of technological change. From the automation in the post-war period through to the turn of the century, the UAW/CAW’s leadership was generally opposed to any form of co-management arrangements (Rinehart et al. 1997). This extended from automation, robotics and other physical artefacts through to the implementation of managerial technologies like high performance work systems and lean management techniques (Rutherford and Frangi 2020). At the plant level, however, evidence suggests a more pragmatic approach has prevailed. Several scholars have noted, for example, that while the national union has taken strong stances against certain new technologies, for example elements of lean manufacturing, union locals have been more flexible when plants have been threatened with closure (Wells 1997) or when they faced fears of offshoring after the global financial crisis (Rutherford and Frangi 2020). The union has also advocated legislative policy solutions to the problems presented by automation. This was reflected, for example, in the union’s support for a shortened working week. A pamphlet from the early 1950s on the union’s approach to automation advocated legislation shortening the working week: “The reduction of the workweek to 35 or 30 hours in the coming decade can be an important shock absorber during the transition to the widespread use of automation.”

Again, however, the union only developed intermittent efforts to influence how automation impacted the organisation of production. Gindin (1995, p. 115) argues:

> *[…] the union made no concerted effort to influence how the emerging technologies and organisation of workstations could be more sensitive to workplace conditions… and in spite of progressive rhetoric suggesting further possibilities, discussion of sharing the ultimate benefits of the higher productivity was narrowed to wages and benefits.*

One notable exception to this tendency was the CAW’s Work Organisation Unit which was run out of the union’s research team in the late 1980s and early 1990s. Though this unit was small and existed several decades ago, it was frequently mentioned by more experienced union officials in discussions of union strategy around technological work reorganisation: “We had the work organisation unit, and to my knowledge that was the only thing of its kind in the world” (Interview 41, Former Senior Union Official, 16-09-2019). The unit consisted of two researchers and was supported by government funding. A senior union official described how money was secured: “there was a

government programme for studying technology, of which 98% of the money went to business, but we had won an argument for labour getting about 2 percent of the money" (Interview 38, Retired Senior Union Officer, 05-09-2019). These researchers were tasked with researching technological work reorganisation and developing union strategies for shaping these changes.

> *At one point, we had this very ambitious goal, taking every job in an assembly plant and examining how it's operated in every plant in the world. But the Germans would do a study there, the Australians would do their study, the Americans would do their study. And from this we could put together a binder that had the best way, from a working-class perspective, of organising work with the new technologies (Interview 38, Retired Senior Union Officer, 05-09-2019)*

This information would then be used to bargain over technological change in the workplace. The same official emphasised that this unit was not geared towards any sort of co-management arrangements but rather towards expanding the scope of bargaining between capital and labour to explicitly include technology change and the organisation of production:

> *We weren't strong enough to prevent management from doing certain things, so the position we took was management has its agenda… and we had our own agenda. And we had to see technology change as a bargaining issue. It was not a question of joint management, it wasn't a joint thing that was in everybody's interest. It was actually a matter of conflict. And that's how we would approach it (Interview 38, Retired Senior Union Officer, 05-09-2019)*

Almost without fail, senior union leaders interviewed for this study mentioned the Work Organisation Unit when discussing the Unifor's strategy towards technological work reorganisation. Nonetheless, the Work Organisation Unit project was discontinued after its government funding was exhausted. This reflected a profound division within the leadership of the union around the role the union should play in technology change. Despite the union's successful bid for funding to study technological work reorganisation, two interviewees reflected that many union leaders at the time were uneasy about moving away from what they considered to be 'bread and butter' unionism. This division had existed throughout the project and was hotly debated within the upper leadership of the union: "It was the longest discussion we'd ever had at a council meeting, it just went on and on, with people arguing. And to [the leadership's] credit, and the board's credit, they agreed– 'Well let's see what happens'– rather than bureaucratically saying no" (Interview 38, Retired Senior Union Officer, 05-09-2019). While the union's leadership was willing to "see what happened" it was not willing to re -fund the Work Organisation Unit when government funding was used up. The union official felt the leadership's reticence to continue the Work Organisation Unit reflected a concern about empowering shop stewards in a way that might undermine the union's leadership:

> *You had this symbiosis between the union, that is looking to centralise things, so that it can win wages, and offering management, "We won't fight you over workplace stuff, to the extent we don't have to. And you're going to have to give us the stuff that legitimates ourselves." So it's this process of taking workplace struggles out of the equation. So yes, it's kind of this pact, they're both getting something bureaucratic out of it… But the struggle continues on the workplace for a long time, it's never completely defeated (Interview 38, Retired Senior Union Officer, 05-09-2019)*

Today, the union continues to emphasise formal level bargaining as the central sphere of union influence over technological change. In a major 2018 report entitled 'On Technological Change', Unifor (2018, p. 17) argues that collective bargaining is "the most obvious way we can address technological change in our workplaces." The report goes on to argue that workers can bargain for rights to be informed about impending technological change and consultation rights around the implementation process. A separate report by two former Unifor officers, entitled *Bargaining Tech: Strategies for Shaping Technological Change to Benefit Workers* (Stanford and Bennett 2021) holds that technology is indeterminate and has contradictory and complex implications for skills and work organisation. "Technology is neither a villain nor a saviour. How technology affects us depends on how (and by whom) technology is managed and controlled" (Stanford and Bennett 2021, p. 5). Methodologically, the report conducted a systematic review of hundreds of Canadian collective agreements and categorised the central types of clauses that can be used by labour unions to shape the trajectory of technological change in the workplace. These clauses are summarised under the following twelve categories:

- Definition and significance of technological change
- Notice of technological change
- Technology committees and consultation
- Commitment to negotiate
- Adjustment and job security
- Severance pay
- Other compensation issues
- Training
- Technology-specific health and safety issues
- Surveillance and monitoring
- Working from home
- Other technology provisions

Unifor's collective agreements at Laurier include clauses that fit into all twelve of these categories. Discussions at the Council, however, confirmed the finding of this study that many of these clauses were not always utilised by the union locals (for example New Technology Committees) and that some shop stewards were more preoccupied with matters of pay and benefits. After formal

collective bargaining, the Unifor (2018, p. 18) report discusses "[t]he role of regulation" at "all three levels of government" as the other central mechanism by which technological work reorganisation can be influenced.

On the shopfloor at Laurier Ontario, unionised workers had mixed views about the union's role in shaping the trajectory of technological change in the workplace. When discussing his desire to receive further training in a recently introduced drilling and filling robot (discussed at length below) I asked an assembly worker what role the union might play in that process. He replied "The union isn't really involved in things like that. They do grievances mainly, stuff like that" (Interview 23, Assembly Worker, 21-08-2019). Others, however, noted how active their shop stewards were in enforcing job controls and advocating for training. As will be seen below, the union played an active role in the ongoing negotiation of technological work reorganisation at Laurier Ontario. But this role was limited both by institutional factors and some resistance within the union to anything that resembled co-management which manifested for some unionists as a preference for 'bread and butter' unionism.

CHAPTER NINE: Implementing and Debugging Virtualisation Technologies at Laurier Ontario

This chapter examines the implementation and debugging of virtualisation technologies at Laurier's Ontario plant. The head of engineering at Ontario's Laurier plant argued that while the plant "have not completely embraced Industry 4.0" there were "certain technologies consistent with Industry 4.0" and "independent cells of pretty advanced" technologies, in reference to the virtualisation technologies (Interview 27, Director of Engineering, 21-08-2019). When the virtualisation models were first introduced, they experienced significant problems. Management adopted a fostering strategy to overcome or find workarounds for the issues with the new technology, integrating assembly and methods workers in the process of debugging. Unifor deployed a developed strategy, with shop stewards immediately working to maintain as much work with unionised workers as possible and avoid it being performed by engineers in offices. This co-ordinated implementation pattern allowed for workarounds to be developed quickly to address the major issues presented at the initial introduction of the technologies. This fast rollout translated to efficiency gains and significant empowerment for the workers involved in the debugging process. This chapter begins by examining the technological context into which these technologies were introduced, and then examines the patterns of implementation and debugging that surrounded the virtualisation technologies in-depth.

Technological Context

Laurier's Ontario plant is almost exclusively a final assembly facility. Unlike the Quebec plant studied above where a significant amount of fabrication and sub-assembly occurs onsite, the Ontario plant is almost exclusively geared towards the final assembly of aircraft. Here, assembly lines 'marry up' the major structural components of the aircraft—nose, cockpit, fuselage, wings, and tail. The plant had previously maintained the capacity to manufacture and fit aircraft skins as well as some structural fabrication capacity, but these capabilities had largely been centralised in the Quebec plants, transferred to other Laurier factories offshore, or outsourced altogether. At the time of data collection, the wings were transported up on trucks from Laurier's newly acquired facility in Texas, the fuselage and other major components were shipped from Laurier's Irish plant and outsourced suppliers in France, and other parts come from Laurier's Mexican plant. While the Ontario plant had long imported components for assembly, this process had been accelerated in recent years by several political and economic forces, as well as managerial preferences. Most notably, the USA's new tariffs on manufactured imports were credited by several shopfloor actors for Laurier's move to manufacture wings in a plant in the USA in 2018 and then acquire the facility and its workforce in January 2019.

When wing production was outsourced to the USA, around a year prior to fieldwork, Laurier had introduced advanced virtualisation tools in the hope of smoothing the increasingly disintegrated supply chain. Before major components are shipped to Ontario a series of critical characteristic interface points (CCIP), or key join points, are measured to within a fraction of a millimetre using laser metrology, reflecting the extremely tight tolerances that regulate aerospace manufacturing. These CCIPs are then used to create virtual models of the components. By combining these virtual models (for example models of the wings and the fuselage), engineers can map how they will be joined and generate digital workbooks with precise measurements to instruct methods and assembly workers on how different components should be 'married up'. This technological development was enabled by advances in laser metrology for measuring the components and computer-aided design programmes for building virtual models and planning the joining process. The appeal to management and engineering teams here is reasonably straightforward. If such a technology were to be effective it would allow the firm to minimise the costs of outsourcing, offshoring, or nearshoring fabrication capabilities by seamlessly integrating imported components into the assembly process. Within the plant it would allow a small group of engineers to virtually map and provide detailed instructions to production teams for the joining of major aircraft components. This would centralise the conception of work tasks with a small group of managers and engineers and allow them to digitally map the work of the operators and assemblers responsible for executing the tasks with high levels of precision.

> *What they do is they shoot it on a computerised system down there in [Texas] and they create data points for all of the join. So then when they take it apart, they bring it up here, replicate those data points and then join it. So in other words it should all match. It should be simple (Interview 29, Lead Hand, 21-08-2019)*

> *We are getting data packages in from our supply chain. So as they produce a component like a cockpit, fuselage component or tail component, or a wing, they are doing their own assessments and mapping these digitally and providing us that data. Yeah. We then use that data to enter it into our systems to then check that component and then join it to its respective partners. Right. So we are utilising supplier generated data sets in our assembly process (Interview 27, Director of Engineering, 21-08-2019)*

Additionally, this technology is used to monitor and regulate components provided by suppliers. Each component must meet certain specifications and tolerances before they can be shipped to Ontario, and the digital and virtual mapping tools are used in this way to monitor the work of suppliers in terms of inputs. "We take all the CCIPs from all the suppliers and dump it into a model and say, 'Yes, everything's good,' or, 'Don't send me that. Rework these stringers,' or whatever, and so you would predict what the joint's going to look like, right? It's real industry 4.0 stuff" (Interview

26, Production Manager, 21-08-2019). Production and inventory managers, for example, detailed how when Laurier began procuring wings from Texas in 2018 (it finalised the purchase of the plant in January 2019) many were not meeting specifications when they were measured prior to shipping. The issue was so pronounced that it risked leaving workers in Ontario with nothing to assemble. Eventually, tolerances were relaxed, and the wings were shipped to Ontario where they were made production ready onsite. The Texas plant is now meeting product specifications more regularly. This demonstrates the capacity of the virtual mapping tools to regulate supplier quality, although its utility is limited by the need for continuous inputs.

The technology change ran into initial problems which had deep roots in the supply chain, with many components meeting specifications and tolerances upon completion at the origin plant but shifting significantly during shipment to the Ontario plant. This was a source of both frustration and some amusement for many assembly workers, who were on hand to recognise the limitations of the virtual models when the actual components arrived on the shopfloor: "So, they have all these fancy measurements. Wow! You know? And when it comes here and we put it together, it's never the same. It doesn't match up" (Interview 24, Assembly Worker, 21-08-2019). Production managers also recognised the shortcomings of the virtual models:

> *Our predictions don't match up. I get a virtual join every time from cockpit to fuse and rear fuse to centre fuse, the wing, whatever. Some of them look horrendous and they go together great, some of them look like they're reasonable and when we get them the fucking floor beams don't match (Interview 26, Production Manager, 21-08-2019)*

Workplace actors were in broad agreement that discrepancies between the virtual reality of joining components from various suppliers and the actual reality of joining those components was not a problem with the technology itself but with shipping processes. After being digitally mapped in their origin plants, components are packed for shipping. The major components of the aircraft are clamped to a timber profile board to prevent the skins from collapsing. Major structural parts like floor beams are further reinforced with wooden beams. These are then loaded into containers and placed onto ships (if coming from Europe) or trucks (if coming from other parts of North America) and transported to Ontario for assembly. During this shipping process however, the components could shift significantly. This was the case with components from both Europe and from Texas. "It's a long drive from [Texas] to [Ontario]" laughed one lead hand (Interview 29, Lead Hand, 21-08-2019). A production manager was able to pinpoint the specific cause of some of the shifts that occurred in the shipping process from Laurier's Irish plant:

> *Say, for example, fuselages, and we've proved this happens before… we discovered that, the dockers [in Ireland] were paid by the number of units per hour they loaded and unloaded from shipping containers, and they would lift the container off the dock and take it onto the ship and rapid drop it from a foot off the floor, so it would go like that. Thud! Yes, we put all sorts of stress gauges in there, and figured it out, we found exactly what did it (Interview 26, Production Manager, 21-08-2019)*

Due to the size of the product and the tightly regulated tolerances, even minor discrepancies between the virtual model and actual parts made for significant changes in the join process. So, while the output is a strictly regulated product, on arrival at the plant the inputs vary significantly. For this reason, many participants involved in the final assembly viewed each aircraft as a 'custom build'. "Each plane is basically custom built, because at every level you're having to make stuff align, trim it, fit it" (Interview 23, Assembly Worker, 21-08-2019). The lead hand in the station where the wings and fuselage are joined described the build process like this:

> *I consider each one a custom build, because you have plus or minus tolerances on everything. Especially with things coming in from elsewhere. The output has to be completely standardised, but the inputs are not perfectly standardised because they move in shipping. When we're marrying up wings to a fuse, one's done in from Mexico, one's done in the [Texas]. You know, what's a quarter of an inch? In aviation it's a world of difference (Interview 25, Lead Hand, 21-08-19)*

In short, managerial hopes of being able to seamlessly extend supply chains through outsourcing, nearshoring, and offshoring by using laser metrology to build virtual models collapsed when they collided with the realities of shipping large aircraft components over long distances. While some engineers made half-hearted defences of the virtual mapping technologies—"We've had some successes" (Interview 27, Director of Engineering, 21-08-2019)—it was generally accepted that virtual maps based on the measurements supplied by plants in the supply chain were practically useless.

Co-ordinated Implementation

When the parts arrived in Ontario they had to be remeasured and the join remapped virtually. From the beginning, Unifor's shop stewards pursued a highly developed strategy and attempted to ensure as much of the remeasuring and virtual modelling work was performed by unionised workers instead of engineers who had offices off the shopfloor. One shop steward in particular had campaigned hard for the remeasuring and mapping of the join to be the responsibility of unionised methods and assembly workers, rather than non-union managers and engineers. This had involved efforts to enforce job controls as well as ensuring management was training workers on the new metrology and computer aided design tools. "We follow the work, it doesn't matter if the technologies change,

the job code says it's ours, so it's ours" (Interview 32, Shop Steward, 22-08-2019). One manager reflected on this engagement: "He's been very active—he said from the beginning the work was for unionised workers[...] It's working OK for the most part" (Interview 26, Production Manager, 21-08-2019). For the shop steward's part, he said:

> *Of course, we would prefer the wings were built here. But we saw the [components] moving during shipping as an opportunity. We were going to get as much of the work for our guys as we could (Interview 55 (32), Shop Steward, 10-10-2020)*

To overcome the discrepancies between virtual reality and actual reality, management deployed a fostering strategy, seeking out the input of methods workers in debugging technical problems in the process of remapping and remodelling, and relying heavily on the manual skills and know-how of assembly workers to join components. The resulting co-ordinated pattern of implementation helped overcome or develop workarounds for many of the bugs faced by the new technology quickly and unionised workers were significantly empowered during the process.

> *So they have the data package, they upload the data package. They perform, or they're overseeing all of the numbers as manually we do the actual join, but if there's an issue, like a collide or the shooting portion of it prior to the join we deal with it on the floor, the assembly workers with the tool and die makers (Interview 25, Lead Hand, 21-08-19).*

Management expressed a preference to bring a small group of workers—considered highly skilled and reliable—into the process of implementation. Unifor was strident in enforcing job classifications for the team that was assembled for troubleshooting and planning the new join. By restricting management's control of the selection of workers, the union had the opportunity to intervene and exercise some control over the process. Rather than increasing the physical and political distance between the conception and execution of tasks, the initial bugs in the technology opened the door for the union to narrow that distance. Instead of the join being planned by engineers working in offices away from the shopfloor, managers, methods and assembly workers planned the join together on the shopfloor. Unionised methods workers also gained skills in the use of the computer aided design tools that they otherwise would not have acquired.

The narrowed distance between the conceptualisation and execution of work represented an opportunity for workers to influence the organisation of production. During participant observation, I witnessed an assembly worker take issue with a methods worker and a supervisor about the sequencing of a workbook. After a few minutes of spirited discussion, with the assembly worker repeatedly expressing concerns that the existing sequencing would likely result in a bottleneck later in the day, another production manager intervened and agreed that the process would be looked at

again. The worker made a point of mentioning that her shop steward would be made aware of the discussion to ensure she was not held accountable for an issue she had tried to address. While this problem might still have arisen under a more automated system, it is unclear what capacity the worker would have had to protest the sequencing of her book if the join had been planned via a virtual process which was overseen by people who were not present on the shopfloor.

Managers also came to rely intensely on the manual skills and know-how of the most experienced assembly workers. The significant variation in the components meant that within a supposedly standardised manufacturing process there was significant scope, and indeed need, for highly skilled and non-standardised work processes. “That was the other thing, obviously, with the discrepancies caused in shipping they need the assembly guys to make the join work” (Interview 55 (32), Shop Steward, 10-10-2020). When attempting to marry-up components of the aircraft managers, engineers, and assembly workers reported that the tolerances frequently didn’t ‘stack up,’ meaning that the two components could not easily be joined. In these instances, management again relied on fostering strategies, integrating experienced assembly workers considered to be ‘good with their hands.’ As one manager put it: “When you have a difficult interface, when tolerances don’t stack up and it’s a struggle for you say, ‘Hold it, hold it. Let’s get one of the experienced guys on this’” (Interview 39, Automation and Robotics Supervisor, 10-09-2019). Another supervisor attested to this approach:

> *So, out of the team here, of all of my people, there are some […] who are fantastic with their hands. Like, when you get in trouble with things not matching up like they should, I say “Get [assembly worker’s name] to look at that.” When I get in trouble there are a few people that you would want (Interview 16, Production Manager, 11-07-2019)*

The shop steward was comfortable and even encouraged this kind of integration with management but worked to regulate how management selected these workers, including by arguing for less experienced workers to be trained in these processes in addition to enforcing job classifications and seniority. While some workers at the plant felt the union had little capacity to influence work organisation, workers in this team said their shop steward made frequent interventions, mainly through enforcing job controls but also on training and other issues.

> *Yeah, he’s always around on the job classification stuff. He’s very active—always checking up. I think it’s probably a good thing. Some other union guys don’t spend as much time on the floor (Interview 24, Assembly Worker, 21-08-2019)*

> *Job controls are really important. We get everyone trained up in how to do things and then the job controls give us some influence on who is doing what and things*

of that nature. But yeah, job controls and training, that's really how we deal with this stuff (Interview 13, President Local 673, 11-07-2019)

The team of workers who worked with management to help problem solve in this way developed a qualitatively different relationship with their supervisors than other parts of the assembly line. Managers seemed aware that their reliance on this group of workers and this granted the assemblers and methods workers more power and influence over both their own labour process and over how work was organised more generally. There was also a culture of upskilling in the team, as workers gained high levels of autonomy in their work process, and more junior workers were encouraged to learn from more experienced workers.

Conclusion

In summary, the bugs in a technology intended to smooth the process of extending supply chains through outsourcing, offshoring, and nearshoring had the unintended effect of allowing the union to empower workers on the assembly line. Furthermore, instead of relying on engineers, virtual models and the join plans they generated, management relied heavily on the problem solving and technical abilities of assembly and methods workers, and thus maintained a fostering strategy. The union allowed worker integration within the boundaries of negotiated job controls, seniority rules, and advocated training. In this way, workers managed to gain some control of the labour process and new work organisation. This co-ordinated pattern of implementation allowed for the production team to overcome bugs in the new technologies relatively quickly and empowered workers with significant control over their labour process at the same time.

In follow up interviews almost a year after the original tranche of data collection, there is evidence to suggest the co-ordinated implementation strategy had been maintained. "They [management] realise they need us when things don't work perfectly, when things go wrong" (Interview 55 (32), Shop Steward, 10-10-2020). While the union maintained a strong stance when enforcing job classifications for keeping tasks with unionised workers and seniority in selection for certain positions, the continuing need for worker involvement and high levels of task discretion among workers at this workstation meant that they were required to work more closely with management. Rhetorically, the union remained firmly committed to opposing any forms of co-management arrangement but in the context of the ongoing inconsistencies with inputs workers could integrate with management largely on labour's terms. "We need those workers to be involved because there have been so many problems. The union want to have some control of that—that's what the job classifications and stuff is about—but we need the workers to help sort things out in that station" (Interview 56 (26), Operations Manager, 14-10-2020).

CHAPTER TEN: Implementing and Debugging Drill and Fill Robots at Laurier Ontario

The final findings chapter examines the introduction of robots for drilling holes and installing fasteners to join the major components of the aircraft at Laurier's Ontario plant. As discussed in Chapter 7, which examined the introduction of the same robots in the Quebec plant, these processes had previously been done manually, but drilling and filling robots promised to automate significant portions of the join process. Unlike in Quebec, however, the union deployed a highly developed strategy in response to the introduction of the new technologies. This included distributive tactics such as demanding a new job classification for robot operators, as well as integrative tactics such as attempting to resurrect a New Technology Committee to facilitate co-ordination between workers and management through the debugging process. The union's developed strategy was met with a forcing strategy from management. Local managers refused the union's demands for a new job classification, limited training for new robot operators, and dragged their feet on the union's demands to re-establish a New Technology Committee. This contested pattern of implementation and debugging had three broad outcomes. First, despite the robots being introduced at around the same time as in the Quebec plant, the rollout was significantly behind and was continuing at a slower pace. Second, the efficiency and accuracy gains were observable but constrained by the limited training granted to robot operators. Finally, while worker training was limited, it was generalised to all workers who wanted it, and resulted in workers having some—admittedly limited—control over the new equipment.

Technological Context

The central production task on these final assembly lines is the joining of major components of the aircraft. From an assembly worker's perspective this involves drilling holes in both components and inserting fasteners to join them. Until recently, all 'drilling and filling' tasks had been done manually using handheld drills and percussion riveting techniques guided by an assembly jig. Around four years prior to this fieldwork, Laurier had begun to automate these processes by introducing 'drilling and filling' robots. While comparable robotics have existed in other manufacturing sectors for some time, advances in metrology and orbital drilling have only recently allowed for these technologies to be used in the aerospace sector. As one engineer put it: "There's a reason that aerospace is always slow when it comes to technology adoption, because of the extra safety and accuracy steps you have to go through you have to make sure that your technology is mature" (Interview 28, Director of Robotics, 21-08-2019).

Management, engineers, workers, and trade union representatives generally maintained that the introduction of robotics had not, to this point, reduced the overall number of workers employed on

the assembly line. Some workers and shop stewards, though, were intensely concerned about a loss of skill among assembly workers (discussed below). Instead, the central promise of the drilling and filling robots was improved accuracy and reduced errors. An assembly worker who was generally sceptical of the efficacy robotics was willing to concede that: "There's some good side to them. Yeah, one is consistency of measuring holes for accuracy, and the length [of the hole] is accurately recorded" (Interview 23, Assembly Worker, 21-08-2019). The engineering team, was particularly keen to emphasise this point:

> *From our (the engineering team's) perspective, generally, the aim with robots is not so much to impact the numbers [of workers] but more in the impact on the quality of the product and the consistency of the build (Interview 28, Director of Robotics, 10-09-2019)*

Drill and fill robots would improve quality and reduce errors partly through the accuracy of drilling and partly through the data collected during the drilling process. The length of the holes drilled by the robots was measured with a high level of precision, and this data could be fed back to operators who could then select a fastener that matched the hole. Engineers also stressed the cost saving capacity of the data gathered by the robots. For example, production teams had previously used cutting pieces to drill a predetermined number of holes before replacing them. Through data collected from the drilling robots a more accurate assessment of the condition of the cutting tools could be attained, extending the use of the tools and saving time in the retooling process: "Where before we would say to an operator, 'Hey, 200 holes, you have to change the cutter every 200 holes. We're taking out a $2,000 tool.' Well, with the new electronic data logging solutions, we're now able to watch and we're able to see hey, we're at 200 holes, we're still getting quality holes. Yeah. Okay, so let's go to 210 Okay, we even get to 220 to 230" (Interview 27, Director of Engineering, 21-08-2019).

> *So a big benefit with automated drilling […] we're able to collect a significant amount of data. We use that data to you know, assess for quality, to reduce inspection requirements, and to produce a very repeatable product. We're quickly alerted to when things are wrong. So your error recognition is significantly improved (Interview 28, Director of Robotics, 21-08-2019)*

Managers and engineers continually highlighted quality improvements and savings in areas such as retooling and predictive maintenance but not all the potential uses of this data were benign or apolitical. There was significant potential for the data collected through the robots to be used for employee surveillance and performance management. Indeed, the engineer in charge of monitoring data from the robots claimed that she was "able to pinpoint which operators have run cycles without even knowing they were in that seat, just by looking at the times right, the data starts to

speak, right? Some are relatively slow while some are pretty good. And some are just absolutely terrible and don't know what they're doing" (Interview 28, Director of Robotics, 21-08-2019). To this point, however, this kind of monitoring was not considered a major concern by operators, who were generally dismissive of this kind of surveillance. Equally, their union representatives had not yet seen it deployed for performance management purposes. Indeed, one shop steward saw this data as a potential tool to demonstrate the need for more worker training.

> *If they came to me with something like that, the first thing we would say is 'OK, there's a problem with the training. We need to get this dude some more training. This is a training issue' (Interview 20, Shop Steward, 17-08-2019)*

The robots ran into several issues in their early stages of implementation. One quality inspector observed that he would often come into the plant to find the robots were not in use: "when we go through the bays… Yeah, well, robot doesn't work again… Right? The robot's down for maintenance" (Interview 15, Quality Inspector, 11-07-19). Depending on the shift and the corresponding staffing profile of the plant at the time, the robots could be down for hours at a time. Nonetheless, the robots were over some of their initial teething problems at the time of data collection and management had begun to roll them out in general production.

Contested Implementation

Management deployed a forcing strategy in the rollout of the drilling and filling robots at the Ontario plant. They did not seek—indeed, they explicitly rejected—worker involvement in the substantive tasks of implementation and debugging such as exploring how to deal with error codes. Management also rejected calls from Unifor shop stewards and the engineering staff to increase levels of worker training on the robots (this is discussed at length below). Unifor met management's forcing strategy with a developed strategy. Initially the union demanded a new job classification for robot operators and when management rejected this the union insisted on upskilling in the use of the robots for all workers who wanted it. Shop stewards also attempted to resurrect a New Technology Committee in the hope this would allow them to influence the process of implementation and debugging. The contested pattern of implementation that prevailed had several observable outcomes.

Despite observable improvements in quality and accuracy, the implementation and debugging of the drill and fill robots at the Ontario plant had been a slow process. Around four years after their introduction only one out of three robots on the final assembly line had reached full functionality (both drilling and fastening). In the other stations, the robots completed their drilling function and fasteners were installed by hand by tow assembly workers (this contrasted with Quebec where the

robots were completing both functions in most stations). A small number of assembly workers and production supervisors attributed these problems to the technologies themselves. They held that this kind of automation was well suited to other industries but ill-suited to aerospace. A much more common argument, however, from engineers, most assembly workers, the shop stewards representing this assembly line and some supervisors was that the slow implementation and debugging process could be traced back to a lack of operator training and worker involvement in the process of implementing and debugging the robots.

> *So they throw people in without training them. And they just never seem to realise that it costs them ten times more with mistakes and people not knowing what they need to know (Interview 21, Shop Steward, 17-08-2019)*

> *I'd have a manager come to me and say, well, the robot's not drilling the holes properly. But that's not true. It's that the operator doesn't know how to set up the settings properly (Interview 28, Director of Robotics, 21-08-2019)*

Several workplace actors held the view that greater worker involvement in implementation and debugging was needed to accelerate the rollout of the machine and increase efficiency. Shop stewards representing these lines were the most vocal advocates of increased operator training on the robots. They framed their interest in more training both in terms of increasing the skills of workers and reducing the monotony of their work, but also in terms of improving the accuracy and efficiency of the work process. Engineers and workers here shared common concerns around productive efficiency and upskilling the workforce. These shared concerns led the group of engineers responsible for the robotics (the automation team), and a group of newly elected shop stewards from within both union locals to try and resurrect a New Technology Committee which was enshrined in the collective agreement but had not met in over a year. Notwithstanding their readiness to revive the New Technology Committee, shop stewards were sometimes sceptical of the engineers' capacity to deliver on agreements made in meetings. Similarly, engineers expressed misgivings about the union's willingness to compromise. Despite these reservations the shop stewards and engineers had broad agreement about the problem and a potential solution: that, through training, workers could be taught to troubleshoot the robots and perform entry-level programming tasks and that this way productive efficiency would be improved significantly: "We've brought training up with management as a huge, huge hurdle. And they seem to resist" (Interview 17, Quality Assurance Technician and Alternative Shop Steward, 11-07-2019).

> *Training is a huge issue… You need to be very well in tune with your equipment and understand what you're doing for you to reap the benefits it can provide, you know… I don't want somebody doing low value work that's extremely repetitive…*

push this button, then this button, then this button (Interview 27, Director of Engineering, 21-08-2019)

The automation team was enthusiastic to make the robots function at full capacity and thus maximise productive efficiency. However, their detachment from the social relations of production—they were not responsible for supervising assembly workers or the production process—meant they often appeared naive to matters of shopfloor politics. They failed to fully understand the rationale behind production managers' forcing strategies. The engineering director described the approach of the engineers to working with different groups in the plant: "[We] engage with the assembly staff, the electrical staff, [we] support production, you know, go investigate a problem… that's how it should work" (Interview 27, Director of Engineering, 21-08-2019). Ideologically committed to maximising output, the engineers simply viewed upskilling workers as the best way to achieving optimal production results. Production managers were much less inclined to see upskilling workers as a priority and were principally concerned with satisficing production targets. For the shop stewards, many of whom were recently elected, attempting to resurrect the New Technology Committee represented an opportunity to forge an agenda outside of filing grievances and contract bargaining. They recognised the motivations of the automation team as broadly compatible with their own and were willing—if with some reservations—to co-operate with the engineers. Both the automation team and these shop stewards expressed frustration with production managers and supervisors who resisted workers being given further training on the new robotics:

Their mindset… is that there's a fear of dealing with the union or even unionised employees (Interview 33, Methods Worker and Alternative Shop Steward, 22-08-19)

[production managers] tend to think that, 'Oh, just give him a couple hours of training and he'll use the robot.' But it's not like that (Interview 28, Director of Robotics, 21-08-2019).

Production managers' reluctance to increase worker training was usually framed in terms of satisficing short-term efficiency requirements. Production managers and supervisors were overwhelmingly concerned with meeting the production rate, or the number of days it took to assemble a jet. This rate was subject to more senior management's improvement targets which were only sometimes being met. Production managers argued that increasing the level of training for assembly workers operating robots would require them to be booked off the machines for a period and had the potential to disrupt production. This was despite the obvious benefits of upskilling and worker involvement in technological change observed in the early phase of implementation at the Quebec plant. The tension between driving to improve output and refusing

workers further training sometimes led production managers to be defensive during interviews. “These are not highly skilled workers anyway” (Interview 26, Production Manager, 21-08-2019) one production manager tersely responded when asked why he did not consider worker training a priority.

While the training agenda of the tentative coalition between shop stewards and engineers met opposition from production managers, the coalition itself was viewed with scepticism by the union’s local presidents and some shop stewards, who expressed concerns about the potential risks of such integrative practices. Instead, the union’s leadership had advocated a new job classification for robot operators when the robots were introduced. The President of the assembly workers’ union local argued that this would have provided for the upskilling of operators while protecting the overall number of jobs on the line. It would have also allowed the union to negotiate for a separate rate of pay for the operators. “We went for a new job classification but we were unsuccessful. The classifications are, I guess, the most tried and tested thing for us with new robots and technologies. This time we didn’t get it” (Interview 19, President Unifor Local 673, 17-08-2019). The demand was rebuffed by management: “The union will let you change things, but they want to be paid for it. That’s what the job code stuff was about: they wanted paid” (Interview 26, Production Manager, 21-08-2019).

The same local President was cautious about the prospects of bargaining for more training through a New Technology Committee. This was despite wording in the collective agreement stipulating a New Technology Committee made up of two management representatives and two union representatives “shall meet monthly, unless otherwise agreed to, during which meetings the members will exchange information on training schedules, identify employees who are to be trained and provide follow-up status reports on employees who have been trained since the previous meeting.” Both unions’ local presidents expressed reservations about the capacity of the engineers to deliver on agreements made in the committee meetings. At the national union council of aerospace delegates observed by the researcher, during a discussion of union strategies around technological change, the president of one of the locals at the Ontario plant argued that New Technology Committees need to be approached carefully, cautioning that the union would be seen as responsible for decisions made in the meetings. Union leadership, in this instance, appeared more concerned with political risk than the potential benefits to workers or the company of union involvement in less formalised bargaining processes.

> *If you're involved in these conversations, you want to make sure that you're involved appropriately, not a third wheel that is just in the room (Interview 15, Quality Inspector, 11-07-19)*

Notwithstanding these reservations, the local President allowed the shop stewards to work towards re-establishing the New Technology Committee, albeit under close supervision. Despite differences on questions of tactics, the union's shop stewards were adamant that a high activity strategy towards technology change was necessary for their union and were, for the most part, highly organised in implementing the strategy. Shop stewards were intensely aware of the changes occurring on the line and there were active in—often animated—discussions within the union about how best to respond to them. One shop steward articulated the role of the union on new technology like this:

> *Bargaining doesn't end the day we sign a new contract, it's really just beginning. We've got all these great clauses in the contract, job controls, early consultation, new tech committee. Great. Fine. But now we need to make sure they are interpreted on the line in a way that is good for us, that is good for our people on the line (Interview 31, Shop Steward, 22-08-2019)*

Managers and Contested Implementation

The group of managers tasked with overseeing the operation of the drilling and filling robots had qualitatively different skill sets and qualifications to those involved in the more collaborative process of implementing the virtualisation tools. According to several research participants managers had traditionally had a significant background in the industry, either being promoted off the shopfloor or having significant industry-specific training in aerospace engineering or another relevant discipline. This was changing, however, with increasing numbers of supervisors and managers having backgrounds in other industries (e.g.: automotive manufacturing), degrees in business management, or being promoted into supervisory positions with limited experience on the line.

> *The whole focus on how important the Master of Business Administration is to these people. And it really takes away from all the technical aspects of everything that's involved in [this] business (Interview 33, Methods Worker and Alternative Shop Steward, 22-08-19)*

Workplace actors attributed Laurier Ontario's growing class of professional managers and supervisors to different causes. Workers and shop stewards generally felt it reflected management's lack of appreciation of the technical requirements of production. Managers, however, suggested that there was a lack of candidates with managerial training or expertise who also had technical knowledge. Whatever the cause, while some supervisors and managers had deep backgrounds in aerospace production, an increasing percentage did not. Management generally hoped that this burgeoning professional group of managers could oversee a highly standardised and codified production process and deploy their managerial training and experience to ensure production ran smoothly. The reality, however, was messier.

One example of this messiness occurred when experienced assembly workers were made to report to supervisors with limited technical experience. Traditionally, quality supervision roles had been taken up by assembly workers with considerable production experience. However, these roles were increasingly occupied by younger workers who had recently begun work in the sector. When these quality supervisors identified a problem in the production process, they were often unable to advise shopfloor workers on how to fix it. Unable to provide technical advice or assistance when a problem arose, these supervisors were often left reliant on their notional subordinates to find solutions. This left the ideological position of the supervisors exposed to the workforce: they had no capacity to co-ordinate the technical aspects of the production process and were therefore only able to conduct control and surveillance functions of management.

> *Well, what I find is that particular group are extremely smart, no doubt, but they don't have the practical skills. It does [cause conflict] not because of the fact that he's young and has a higher position. It's more that this guy's got experience and knows what he's doing and the young guy doesn't have the technical knowledge (Interview, Assembly Lead Hand, 21-08-19)*

This frustration was not only reserved for the inexperienced group of quality supervisors. Laurier Aerospace had recently hired several managers with little experience in aerospace manufacturing. This included managers from the automotive industry and recent graduates with management degrees. Shop stewards and workers, as well as some long-time managers, all recognised this as a significant source of conflict on the assembly line. Due to their lack of understanding of technical processes of production, the role of these managers was reduced to a largely disciplinary one. For example, these managers were largely unable to assist when problems with the sequencing of tasks occurred. In one such instance, observed by the researcher, a young manager was told to "fuck off my line" by an assembly worker who later explained that the manager had "no idea what he's talking about" (Field Notes, Assembly Worker, 19-08-2019). This was a somewhat extreme manifestation of a broad sense among unionised workers that this new professional managerial group lacked technical legitimacy.

> *And this is especially true when it comes to the actually certified aircraft mechanics that we have and avionics technicians, and they really know what they're doing. And they know half the time their boss tells them to do something that they know they have to do, and their boss has no clue what they're talking about (Interview 31, Shop Steward, 22-08-19)*

Managers with limited technical understanding of the production process were concentrated in areas with more codified labour processes, where management was involved in forcing strategies. While workers often sought out managers and engineers seen as having high technical knowledge

for assistance, they tended to resent interventions from the new class of supervisors and managers who were less able to assist with the technical aspects of production. Without the capacity to play a technical role in the production process, these supervisors and managers were only capable of worker surveillance and monitoring. Worker antipathy to these interventions was acknowledged by more experienced managers as well as workers. “It’s a huge source of tension” one production manager conceded (Field Notes, Production Manager, 11-07-2019). Here, shop stewards played an active role in protecting members from arbitrary managerial interventions. Though one shop steward noted that: “It’s harder with those guys (the new mangers) because they don’t really know what they’re doing” (Interview 31, Shop Steward, 22-08-19). As has been seen in other sections, the process of implementing and debugging new technologies was rarely as smooth as imagined. Without the buy-in of workers the process of implementing these changes was complicated significantly.

Conclusion

In summary, the contested pattern of implementation that surrounded the introduction of the drill and fill robots at the Ontario plant had three broad outcomes. First, the rollout of the new robotics was slow compared to the rollout of comparable technologies at the Quebec plant. Only one robot had reached full functionality at the time of data collection in the Ontario plant, while drill and fill robots were running at full functionality down most of the assembly line in Quebec. Participants agreed that the rollout process had been a slow and sometimes clunky one. While research participants from across the spectrum of job roles attributed the slow implementation and debugging, and ongoing issues with the drill and fill robots, to lack of worker training and worker involvement in debugging, this did not appear likely to change. This impasse is closely related to the second outcome: the only partial realisation of technological promise in the production process. While some improvements to efficiency and accuracy were observed—notably connected with the data collected by the new machines—these were offset to some degree by slow rollout and limited by lack of worker training.

Third and finally, the contested implementation pattern resulted in workers receiving limited but generalised upskilling through union negotiated training. The capacity to programme and troubleshoot the robots existed at the point of production and robot operators had some (admittedly limited) understanding of these more advanced functions. Many experienced assemblers did not wish to work on the robots as they were deeply attached to the mastery they had developed in their previous way of working. One lead hand assembler remarked: “It takes years to learn how to drill a hole. To really be able to do it, right? The training for the robots is a week”

(Interview 25, Lead Hand, 21-08-2019). This fear of a loss of mastery meant that some assemblers were not interested in being trained on the new robots, despite universal training being made available. This was not shared by all operators, however: “I use multimillion dollar robot on a $80 million jet. I think that’s pretty cool” Interview 23, Assembly Worker, 21-08-2019). The labour process of robot operators was nonetheless limited in autonomy and skill. It can be said generally, however, that the median robot operator at the Ontario plant received more training (the union had secured 5 days rather than 2) and had a higher skill level than the median robot operator at the Quebec plant. Many workers viewed the role as simple machine minding, monitoring the robot and when an error occurred the operator would usually have to call either maintenance or a member of the automation team. Despite many participants believing upskilling of operators would benefit both workers and efficiency, the political stalemate discussed above meant work remained fairly repetitive.

CHAPTER ELEVEN: Discussion

In this chapter, I put the findings of this study into conversation with the existing scholarship discussed in the literature review to elaborate the argument developed in this thesis. The findings chapters that precede this chapter have fleshed out a framework for understanding how union strategies interact with managerial strategies to shape patterns of technological implementation and debugging on the shopfloor. The purpose of what follows is to demonstrate the ways in which my findings confirm, differ, and conflict existing research. This will include efforts to engage with and extend existing theory in the vein of Burawoy's (et al. 1991; 2007) extended case method. This chapter is structured into three broad sections. First, it discusses the learnings of this study around managerial strategy towards the implementation and debugging of new technologies. Here, it demonstrates how this study confirms the tension between managerial drive for efficiencies and the managerial need to maintain control of the labour process animate the relationship between forcing and fostering strategies. Second, it discusses how concerns around co-optation and impulses to centralise power interact with the possibility of opening up new bargaining agendas shape union activity around technology change on the shop floor. Through this discussion it further demonstrates the explanatory value of varying union strategies in shaping the implementation and debugging process. Finally, it applies the patterns of implementation framework to a series of studies of technological implementation and debugging from the extant literature, demonstrating its generalisability and broad explanatory value, and discussing the patterns in comparison.

Managerial Priorities: Efficiency or Control?

Under what circumstances is management likely to emphasise a forcing strategy in the context of technological change? And when is a fostering strategy more advantageous? The labour process literature around the shopfloor politics of technological change has tended to emphasise the drive for managerial control. More recently, the managerial tension between empowering workers for greater efficiency and disempowering workers—through deskilling, Taylorisation, and other mechanisms—to maintain control of the production process has become a more central concern. This has most explicitly been articulated by Vidal (2019) in his discussion of contradictions within the capitalist labour process. This thesis has demonstrated that, whether consciously or not, managerial fostering strategies were generally correlated with greater efficiency gains, while managerial forcing strategies generally allowed management to maintain a higher level of control over the production process. This section synthesises the empirical findings of this study with the broader literature on these questions.

Many studies have claimed to have empirical evidence of management at different levels choosing a less efficient technological alternative for the purpose of maintaining or increasing control of the labour process. In one of the most prominent examples, Noble (1984) examined the evolution of numerical control machines alongside several alternative which were ultimately rejected by industry and policy makers. He argued that these were abandoned in favour of less efficient numerical control machines which amassed control of the shopfloor with management and engineers, rather than workers. Other foundational theorists like Richard Edwards (1979) emphasised a similar line of argument. Indeed, Bélanger (2006) argues that the understanding of managerial control has been one of two central theoretical contributions of labour process analysis. Vidal (2019) is highly critical of labour process scholarship's 'obsession' with control. He argues that authors like Noble and Edwards fail to provide sufficient evidence that there were equally or more efficient techno-economic system choices available than those that were ultimately chosen. Further, he contends that there is little empirical proof to demonstrate that capital introduces technologies to enhance managerial control, and instead suggests that technology change in capitalist firms is generally driven by efficiency goals. But, as Thompson and Laaser (2021, p. 146) point out, Noble and others "argued that employers and managers made choices over design and deployment of technology that were not based on perceived efficiency criteria alone, but also by increasing options to organise work in the interest of capital."

The empirical evidence presented here supports the generalised theoretical argument that managers can empower workers in order to increase efficiency or disempower workers in order to maintain or increase managerial control of the production process, and that either or some combination of both may be deemed to be in the interests of capital at a given moment. Most workplace actors agreed that technologies were *selected* by management with the intention of improving efficiency and reducing errors (itself a form of efficiency improvement). However, in the process of implementation and debugging the technologies studied here proved highly variable in how they were deployed, and the control of the debugging process itself was subject to significant intra-organisational bargaining among managers. On the one hand, several engineers expressed frustration at other managers' unwillingness to pursue greater efficiency outcomes more vigorously, often through empowering the machine operators through training and other integrative approaches. An operations supervisor at the Quebec plant expressed their dissatisfaction in relation to the later stage implementation and debugging of composites robots:

> *So we have a target for the new equipment's performance, when the target is reached, [implementation] is done. But unless you know what your target should be, then you don't know if you have to move on or not, to carry on or not. And*

> *sometimes, it means that you may say, "Okay, that's good enough for me, I will stop supporting people to learn and we will just run production." But you haven't seen yet all the problems that could occur, and all the things we could actually achieve if we gave workers more control of the equipment. So, it really depends on what you want from your machine (Interview 34, Operations Supervisor—Composites Fabrication, 29-08-2019)*

At the Ontario plant, similar intra-organisational bargaining was observed among managers in the implementation and debugging of drill and fill robots. Here, engineers wanted the firm to invest in training robot operators to maximise efficiency. "Training is a huge issue… You need to be very well in tune with your equipment and understand what you're doing for you to reap the benefits it can provide" (Interview 27, Director of Engineering, 21-08-2019). Production managers were largely dismissive of these suggestions and were centrally preoccupied with satisficing production targets on a day-to-day basis. These examples of intra-organisational bargaining among managers and engineers in both Laurier plants reflect the tension between managerial "maximising versus satisficing" (Vidal 2017, p. 3). Here, maximising behaviours can be seen as managerial behaviours that reflect the central aim of increasing production efficiency. Satisficing managerial behaviours reflect a willingness to "settle for good enough" (Vidal 2017, p. 1) and may stem from a desire to maintain control of the labour process. In other words, the need for managers to maintain a high degree of control over the production process places a theoretical limit on the efficiency gains that can be realised in the capitalist workplace, an example of capitalist inefficiency (Fairris 1995; Vidal 2019).

An important finding of this study is that some managers lacked the skills to perform what Armstrong (1983, p. 345) called the "productive" or co-ordination function of capital and instead were forced to revert to the "non-productive" or control function of capital. This phenomenon was evident in both plants but more pronounced at the Ontario plant where a larger number of graduates with management qualifications had been employed to supervise teams of experienced production workers. These teams were the site of the most explosive conflict between managers and workers at both plants observed in this study. "It was like Vietnam out there before, us and the bosses" (Interview 40, Assembly Worker, 12-09-2019). This was also observed by Armstrong (1983, p. 349) who concluded: "In terms of class relationships the role of the foremen in the control function of capital… was left ideologically exposed to the workforce since they had lost the 'worker' function." In this sense, a deskilling of management was observed at an aggregate level as managers without technical expertise had little productive to offer and could only participate in the non-productive managerial function. This increasingly closed off the option of more fostering approaches

in the process of technological implementation and debugging, and necessitated a drive towards a more Taylorised work process.

In summary, while acknowledging that managerial strategies are "multiple [and] often incoherent" (Vidal and Hauptmeier 2015: 10) the argument developed throughout this study broadly supports the labour process perspective that employers and managers make decisions over the implementation and debugging of technology not based on perceived efficiency criteria alone, but in the interest of capital broadly defined (Edwards 1979; Noble 1984; Thompson and Laaser 2021). This may involve increasing control over the workforce, maximising efficiency by empowering workers, or some balance of the two. However, this study also supports Vidal's (2019) call for labour process scholars to engage more deeply with the tension for managers presented by the competing goals of control and efficiency. Such tensions are exemplified by the intra-organisational bargaining among managers and engineers witnessed in this study and are likely amplified by managerial deskilling (Armstrong 1983).

Labour Concerns: Bread-and-Butter Unionism or New Bargaining Agendas?

The framework developed in this study draws on and attempts to extend two broad sets of literature. First, the broader industrial relations literatures on actor strategies. And secondly, the literature around the shopfloor politics of technological change, especially but not exclusively the labour process literature. The labour process literature has observed that unions are often absent from the political and social processes of implementation and debugging even when they have an otherwise strong presence in a workplace. This study has demonstrated the inadequacy of the forcing and fostering dichotomy—variations of which are frequently deployed in the industrial relations literature—when examining union approaches to technology change on the shopfloor. Instead, it has outlined levels of union strategy development around the process of technological change as a factor with higher explanatory value. Here, I briefly consider three (and mention another) reasons unions hesitate to engage more deeply on questions of technological change on the shopfloor as observed empirically in this study. Later this section discusses the prospects of unions prising open new bargaining agendas by developing timely, considered, and organised strategies around the implementation and debugging new technologies.

Trade union hesitancy—or flat-out refusal—towards deploying a developed strategy towards technological change on the shopfloor has some base in empirical evidence. Studies have demonstrated that high levels of union involvement in what otherwise might be considered managerial decisions carry significant risks for unions and often require them to submit (to some degree) to managerial and capitalistic logics (Danford et al. 2005). These patterns have been

observed when trade unions in liberal market economies have been heavily integrated into managerial processes. This was observed empirically in several so-called partnership arrangements in around the turn of the millennium in the UK (see for example Jenkins 2007; 2008; Martinez Lucio and Stuart 2005). A further contribution emerging from the studies into these partnerships was the observation that under financialised capitalism, well-intentioned local managements were unable to deliver on their side of partnership arrangements as decisions made by distant shareholders undermined local agreements (Thompson 2003; 2013). Indeed, many of the plants where unions participated in partnership arrangements of these kinds ultimately faced closure when capital was withdrawn and work offshored.

Similar concerns helped drive Unifor's strong resistance to anything approaching co-management arrangements (Rinehart et al. 1997; Rutherford and Frangi 2020). As one former senior Unifor official said: "We co-operate with management when it's in our interests. The difference between us and the Machinists is that we don't think it will get us any favours later on" (Interview 41, Former Senior Union Official, 16-09-19). This scepticism extended to the dynamics within union locals and on the shopfloor. The presidents of both Unifor locals organising workers in the Ontario plant were highly sceptical of any form of integration, even some which the union had, at some point, notionally advocated. For example, when shop stewards attempted to resurrect a New Technology Committee that the union had bargained for during contract negotiations, leaders of both union locals frustrated these efforts. Indeed, they expressed direct concerns that the young shop stewards advocating the reestablishment of the committee risked being co-opted by managers. The Machinists were less dubious about integration with management in a general sense. This was partially due to the ideological inheritance of the union, which was less militant or combative than Unifor, and partially to do with Quebec's more corporatist industrial relations tradition. Concerns around co-optation are closely related to many unions' preference for 'bread-and-butter' unionism. Several union leaders, organisers, and shop stewards in both unions studied here could be placed in this category. This style of unionism favours the negotiation of pay and benefits and contract enforcement while largely respecting the managerial prerogative and declining to campaign on broader social issues (Porter and Hertel-Fernandez 2018). Bread-and-butter unionism has long been a central tenant of North American trade unionism, with some scholars observing that unions have rejected proposed institutional changes that would expand the scope of formal bargaining in ways that include unions in managerial decision making (Morgan and Hauptmeier 2020).

Here, we return to the ideological inheritance of the unions studied. Delegates, officers, and sympathetic authors variously described Unifor as committed to "militant democratic trade unionism" (Field Notes, National President, 29-07-19), "social movement unionism" (Interview 20,

Shop Steward, 17-08-19) or a "new type of unionism" (Wilson 2019). By contrast the Machinists described themselves as a "business union" (Interview 4, IAM Organiser, 19-05-19) while the New York Times described them as an example of North American "bread-and-butter unionists" (Salpukas 1990). What is not taken into account in the dichotomies between militant and business, or social movement and bread and butter unions, is the degree of interest taken by the union into matters intrinsically related to technology change and work organisation. In fact, some of the most committed militants among Unifor's shop stewards and the least confrontational of the Machinists' business unionists shared a disinterest in deploying a developed strategy towards technology change in common.

This did manifest in different ways among different union cohorts, however. Sometimes, this stemmed from an apparent ignorance or indifference to questions of work organisation and technological change. Most notably in this study was the apparent obliviousness of some Machinists shop stewards to the emerging skill polarisation among their members. "They all received training on the robots" (Interview 48, Shop Steward, 20-09-2019). Some of the most committed social movement unionists—a strand of unionism that aims to campaign on issues beyond just pay and benefits (Porter and Hertel-Fernandez 2018)—at Unifor were either actively or passively opposed to their union taking a stronger interest in how technology change occurred. These findings appear to confirm Lévesque and Murray's (2010, p. 341) argument that "unions can have power resources… but are not particularly skilled at using them." It nonetheless must be said generally that there was a stronger awareness and deeper strategic engagement with these issues among Unifor's shop stewards and officials than those of the Machinists.

While the leadership of both unions expressed a rhetorical commitment to developing a proactive agenda on matters of technological change, this only filtered down to the shopfloor in highly varied and often limited ways. As outlined in the finding chapters, both unions' conferences contained extensive discussions about how technology change should be approached. These addresses generally remained at an abstract-level, however. As discussed, technology change was the central theme of the Canadian President of the IAM's speech to the Quebec congress of the union, but at no point did the conference discuss anything that could be described as a developed or organised shopfloor strategy. Indeed, the President appeared to be at a loss for what such a strategy might look like:

> *During my time as a trade unionist, we have had three tools in our toolbox when it came to technological change. First, we sought assurance that nobody would lose their job. Second, we bargained for retraining for our members on the new equipment. And, third, if those things failed, we made sure we got our members*

> *some money to go away with—a decent severance package. I am now convinced that we need new tools to tackle this next wave of automation (Canadian President, IAM, 15-05-2019)*

Unifor was generally more able to translate their abstract concerns into more tangible strategies and tactics. This included discussion of shopfloor tactics relating to the implementation of new technologies at the National Aerospace Council meeting, notably a robust discussion around the utility of New Technology Committees. In another example, a report by two former Unifor officials (Stanford and Bennett 2021), surveyed hundreds of Canadian collective agreements and categorised the different clauses and provisions which could be bargained for to exercise some power over technology change in the workplace. While many clauses from these categories were contained in Laurier's Ontario collective agreements, some did not appear to be used proactively in the workplace studies. As referenced above, there was active resistance to shop stewards re-establishing a New Technology Committee which was enshrined in the agreement.

Some scholars have demonstrated that strong trade union strategies around control of the labour process, including technology change, can empower shop stewards and workplace activists at the expense of union leadership (Beynon 1974; Hinton 1973; Holgate 2021). Indeed, Steigerwald (2010, p. 437) argues that this was partly responsible for the UAW largely leaving "questions of management" alone in the post war era. Similarly, Gindin (1995, p. 115) suggests that the CAW's leadership failed to make a "concerted effort to influence how the emerging technologies and organisation of workstations could be more sensitive to workplace conditions… and in spite of progressive rhetoric suggesting further possibilities, discussion of sharing the ultimate benefits of the higher productivity was narrowed to wages and benefits." He attributes this in significant part to the union leadership's preoccupation with maintaining control over the union and checking some of the power of more radical workplace leaders.

It is argued tentatively here that union leaders' concerns with maintaining control of the union was partly responsible for the Machinists failure to develop more comprehensive approaches to technology change on the shopfloor, as well as the resistance faced by some of Unifor's shop stewards from more senior unionists at Laurier Ontario. It should be noted that despite the best efforts of shop stewards in Ontario, some unionised workers at both plants did not see their union as having much say over the labour process and technological work organisation. As a retired Unifor official explained:

> *You had this symbiosis between the union, that is looking to centralise things, so that it can win wages, and offering management, "We won't fight you over workplace stuff, to the extent we don't have to. And you're going to have to give*

> *us the stuff that legitimates ourselves." So it's this process of taking workplace struggles out of the equation. So yes, it's kind of this pact, they're both getting something bureaucratic out of it… But the struggle continues on the workplace for a long time, it's never completely defeated (Interview 38, Retired Senior Union Officer, 05-09-2019)*

This brings us back to Marglin (1974, p. 78), who argued that unions did not want to confront the relationship between "men [sic] and their work" because they would: "find themselves in conflict with the very principles of capitalist organisation, not merely in conflict over the division, at the margin, of the capitalist pie. No longer could labour's spokesmen be pillars of the established order." In short, for union leaders there is security both within the democratic structures of the union and externally with bosses in respecting the frontier of managerial control and focusing the union's resources on 'bread-and-butter' issues like pay and benefits.

This thesis has argued that some of the reasons for union hesitancy towards developing a more comprehensive strategy are unjustified or misguided. This does not, of course, mean that a developed strategy is without risks or pitfalls. What is advocated here is a re-examination of the potential roles trade unions might play in shaping technological implementation and debugging. Trade unions in Canada—like other liberal market economies—have relatively weak institutional mechanisms at their disposal to influence the implementation of new technologies and technological work reorganisation more generally. This, along with the historic decline of organised labour in developed countries, have caused the scholars of technology change and the labour process to neglected to incorporate the trade union strategies into their analyses. But as argued by Martinez Lucio and Stewart (1997), collective worker struggles remain ever present in the capitalist workplace. As outlined in the Unifor report on bargaining around new technology (Stanford and Bennett 2021), there remain many mechanisms for unions to channel these collective struggles in ways that influence technological change in the workplace. The successful application of these mechanisms on the shopfloor was highly varied, however. As discussed above, this reflects the historical concern of many industrial relations scholars who hold that unions best serve members when they maintain a clear line of demarcation with management (see Martinez Lucio and Stuart 2005 for discussion). The fact that the co-opted patterns of implementation witnessed in the early phases of introducing new technologies at Laurier Quebec quickly faded into unilateral patterns provides an illustrative example here.

There is nonetheless a highly indicative literature that suggests that gaining influence over managerial decisions does not require any form of integration, nor submission to capitalistic logics. In a highly cited study, Taylor and Bain (2001) examined differentiated union strategies towards

confronting the frontier of managerial control in British calls centres. In a similar vein, Danford (2005) examined union strategies and job controls in British factories, showing that unions can carve out space to bargain for better workplace conditions at the point of production using oppositional strategies. Stewart and Martinez Lucio (1998, p. 66) demonstrated that trade union interventions on the shopfloor "modif[y] the development of central elements of new management practices." The broad argument that underpins this group of studies is perhaps best articulated by Murphy and Cullinane (2021, p. 288) who argue that:

> *While unions can acquiesce to new management [technologies] by securing compensation in other areas, they can dissent and try to prise open bargaining agendas that extend their influence on these innovations.*

It has been demonstrated in the empirical findings of this study that certain union strategies can begin to "prise open new bargaining agendas" as Murphy and Cullinane (2021, p. 288) suggest. In the case studies, unions were most successful in influencing the implementation and debugging of new technologies when they pursued high activity strategies incorporating both distributive and integrative tactics. When drill and fill robots were introduced at Laurier Ontario, Unifor aggressively pursued new job classifications, enforced existing job controls, advocated high levels of worker training, and defended seniority rights. And while groups within Unifor were sceptical of certain tactics, notably the use of New Technology Committees, the union generally had a high awareness of technological change and more developed shopfloor strategies to shape it. Somewhat counter-intuitively, Unifor's strong historical hostility to anything resembling co-management (Gindin 1985; Rinehart et al. 1997; Rutherford and Frangi 2020) actually came along with what appeared as more developed efforts to influence technological change in the workplace. This suggests that any ostensible dichotomy between integration with management, on the one hand, and non-involvement in questions of technology change on the other, is unsustainable. As Streeck (1993, p. 194) put it, "there is no paradox here at all." The Unifor approach is reflected in the following interview extract:

> *We weren't strong enough to prevent management from doing certain things, so the position we took was management has its agenda… and we had our own agenda. And we had to see this as a bargaining issue. It was not a question of joint management, it wasn't a joint thing that was in everybody's interest. It was actually a matter of conflict. And that's how we would approach it (Interview 38, Retired Senior Union Officer, 05-09-2019)*

The above quote comes from a discussion of Unifor's Work Organisation Unit. This appears to have been a genuine effort to develop something approaching a wholistic union approach to bargaining over the use of technologies and the labour process couched in the conflictual philosophy of the

CAW. Limited data is available here, but it demonstrates the union's ongoing interest in these issues. Further research would be required to analyse the degree to which the work of the Work Organisation Unit translated to union action on the shopfloors of factories. On the other hand, the Machinists had intermittently engaged in high level integrative initiatives with employers and their organisations about questions of technological change, though the literature on these negotiations suggest they had limited success (Seligman 1966; Noble 1984).

This study has demonstrated the inadequacy of the commonly deployed frames to categorise union strategies towards technological change. Variations of the "forcing" and "fostering" dichotomy (Walton et al. 2000 25—27), such as "integrative" and "distributive" bargaining (Walton and McKersie 1965, p. 179) and "integrated" and "adversarial" (Turner 1991, p. 223) fail to capture the fact that a developed union strategy will likely contain elements of both forcing and fostering. They also fail to demonstrate that integrative tactics can be couched in a conflictual strategy (Streeck 1993). Simultaneously, this framing fails to recognise that unions may fail to develop anything approaching a meaningful strategy towards technology change on the shopfloor. This study draws on the findings of a range of shopfloor studies that have found that unions can have highly developed strategies towards technological change (e.g.: Danford 2005; Frenkel 1988; Murphy and Cullinane 2021; Taylor and Bain 2001) and others that have observed the conspicuous absence of unions in the process of implementation and debugging new technologies (e.g.: Bilsland and Cumber 2018; Delbridge 2000; Thompson and Bannon 1985). This framing—the presence or absence of a timely, organised, and considered strategy—generates a deeper understanding of patterns of implementation and debugging that better reflects realities of shopfloor politics than variations of the forcing and fostering dichotomy.

Patterns of Implementation and Debugging

A survey of previous studies of implementation and debugging new technologies in the workplace illustrates the generalisability of the framework outlined here. It is worth reiterating that the framework for understanding patterns of implementation and debugging elaborated in this thesis applies to a specific set of circumstances. Firstly, and most broadly, it applies to the shopfloor politics of implementing and debugging new technologies. The framework is not intended to apply to other patterns of conflict and compromise between labour and capital in the workplace. Secondly, this framework was developed in the study of technological change in a liberal market economy. Despite the idiosyncrasies of the Quebec model of political economy, the cases of technological change examined here essentially occurred in the context of an antagonistic labour relations framework. It is possible that this framework would require alteration in the context of a

co-ordinated market economy where institutions like works councils and codetermination enshrine workers' rights to participate in technology change in their workplaces. Similarly, formalised voluntarist arrangements like formal partnership would likely fall outside the framework outlined in this thesis. Below, each of the patterns of implementation and debugging are used as a framework to discuss a previous study of implementation and debugging.

Contested Implementation

Murphy and Cullinane (2021) conducted an action research study working with 'Bank Union' on their strategic response to the introduction of new performance management technologies in the retail and banking operations of a UK bank referred to as 'FinCo'. The technology change examined consisted of the introduction of software programs that allowed for the continuous monitoring of the performance of bank workers "by providing metrics on individuals' daily or weekly performance benchmarks, allowing for early intervention when such targets went unmet" (Murphy and Cullinane 2021, p. 294). Management deployed a forcing strategy when implementing the new technologies, initially flatly refusing to engage with union concerns about the new performance management technologies. The union responded with a highly developed approach. The strategy was subject to significant consideration and debate in union forums and involved input from the authors of the study. Bank Union deployed a wide-ranging organising campaign to recruit members and filed a high number of individual grievances on behalf of their members contesting the new performance management approach. Management's forcing strategy and the union's high engagement strategy resulted in a contested pattern of implementation.

Consistent with the framework developed in this thesis, the contested pattern of implementation resulted in a slow rollout of the new technologies. Murphy and Cullinane point out that the use of the system was not settled and applied across the business for several years, despite managerial plans for a speedy implementation process. It should be noted that the technology was partially operational during this time, but the scope and nature of its use was not agreed by workplace actors for many years. The technology resulted in limited productivity improvements as the workers and their union campaigned strongly to restrict management's performance targets to what they considered to be achievable and reasonable. Finally, while the technology was explicitly introduced to restrict the autonomy of workers through real time, digitised performance management, workers' loss of autonomy was substantially controlled by the union's campaign to reduce performance targets and limit managerial monitoring.

The authors note that the introduction of the new technologies provided a "crisis point" for many workers which pushed the union to explore "novel approaches" to organising (Murphy and Cullinane

2021, p. 302). Their conclusion supports a central finding of this study: with a timely, considered, and organised strategy "unions can carve out potential influence over new trajectories" (Murphy and Cullinane 2021, p. 302) of technological change, even in the context of a hostile employer. In fact, the researchers argue that management failing to consult with the workforce, or involve the union in the implementation new performance management processes, forced the union to develop innovative approaches to influence technology change in the workplace. Applying the framework developed in this thesis to an example of performance management technologies in a retail banking context demonstrates that the patterns of implementation framework can be applied to a wide range of technologies and in the context of significantly different work processes.

Unilateral Implementation

Thompson and Bannon's (1985) study of technology change in the British telecommunications sector provides an example of unilateral implementation. The study follows a series of technological changes at the Plessey plants in Liverpool culminating in the implementation of the automatic telephone exchange 'System X'. The authors note that inter-union sectionalism precluded the deployment of an organised, considered, and timely response from the multiple unions in the plants. In the context of this disorganisation, many workers opted for 'escape' taking voluntary redundancies rather than taking the fight to management to protect their jobs and influence the new division of labour. The study also observes management's forcing approach suggesting new technology was used by management to create divisions between workers and drive wedges between the different unions organising within each plant, as well as to deskill workers.

The unilateral pattern of implementation and debugging observed at Plessey had outcomes consistent with the framework developed in this thesis. The system was rolled out quickly, with the authors noting minimal trade union intervention in the process of implementation and debugging (though some union activity followed the introduction it can accurately be described as taking place after the fact). One engineer commented on the speed of the rollout: "'System X was quickly put together… But recognised standards the procedures—from a company viewpoint—were not always rigorous'" (Thompson and Bannon 1985, p. 75). This quote reflects both the speed of the rollout and managerial satisficing in terms of the efficiency gains realised from the technological change. As observed elsewhere, a forcing managerial strategy is inconsistent with an efficiency maximising approach to technological change. Finally, while the authors noted this trend had some very limited exceptions, general deskilling was observed for the workers on the line as a highly Taylorised work process resulted from the technology change.

While the unions' undeveloped strategy resulted largely from division between unions, rather than apparent indifference as with the Machinists at Laurier, the result was broadly similar. Thompson and Bannon concluded their study with a highly pessimistic view of the trade unions' capacities to develop organised, considered, and timely responses to shape technological change in ways that would benefit their members. Similar to the case of the Machinists at Laurier, a central issue appears to be the inability of unions to translate a high level, abstract interest in technological change into tangible and effective strategies on the shopfloor. In a passage that could equally apply to the instances of unilateral implementation at Laurier Quebec, Thompson and Bannon (1985, p. 132) concluded their study pessimistically:

> *The underlying factor is a failure to translate principles into effective bargaining and organisation at plant level […] There are two consequences. First, shop steward awareness, interest and capacity to act effectively is further limited. Second, even when union initiatives do take place it is often too late.*

Co-ordinated Implementation

Wilkinson's (1983, p. 48—54) study of technology change at 'The Rubber Moulding Company' provides an example of co-ordinated implementation. The main manufacturing process in this plant was the precision moulding of medium and large rubber components for the automotive industry. The study examines the implementation and debugging of two new production technologies: injection moulding and flashless moulding. Both changes replaced previous manual processes and promised significant productivity improvements. Unlike the other cases in Wilkinson's (1983, p. 49) broader study, the union adopted a highly developed strategy, demanding their members be trained in the use of the new technologies instead of employing "green labour," and arguing for increased pay to match the productivity improvements. Management deployed a fostering strategy, involving workers in the process of implementation and debugging, and simultaneously removing the loathed piece rates from the work on the new equipment. The union allowed and even encouraged worker integration in the process of implementation and debugging, alongside the more forcing tactics described above.

Workplace actors broadly viewed the co-ordinated pattern of implementation and debugging as a successful one. "Productionisation" (Wilkinson 1983, p. 50) occurred quickly, as experienced operators were able to bring the new machines online using their high levels of technical skill and deep knowledge of the production process. The study also noted significant improvements to productivity and efficiency. Perhaps the most striking feature of this case study was the control that workers involved in the process of implementation and debugging gained over the new labour process. One manager noted that debugging the new machines on the shopfloor with the

involvement of workers had handed those workers high levels of control over the shopfloor. "Development in the production environment meant that the operator would productionise machinery, and rather than management giving production parameters to operators, the operators would to some extent give them to management" (Wilkinson 1983, p. 50). This control translated into significant industrial power. Wilkinson points out that management ran into significant problems when they attempted to reintroduce piece rates to the operators of the new machinery as workers put up strong, organised resistance. Management eventually had to 'buy out' the operators with a significant lump sum payment before they would agree to the reintroduction of piece rates.

Despite significant successes in terms of speed of rollout and the efficiency gains realised through the implementation and debugging process, the loss of control suffered by management in this process meant they were planning a different strategy for future technology changes. Wilkinson (1983, p. 53) suggests that management "expressed no dissatisfaction with the eventual outcome of the changes" in terms of efficiency gains or speed of rollout but nonetheless would not use the same fostering approach in future. Instead, they had developed a separate "development area" (Wilkinson 1983, p. 53) where management and engineers could debug new technologies without the participation of shopfloor workers. Management's plan was to debug without worker involvement: "[a]s soon as the new machinery comes into the hands of the production function full-scale production will be immediately possible, and negotiations straightforward" (Wilkinson 1983, p.54). Thus, the co-ordinated implementation pattern observed in the introduction of injection moulding and flashless moulding would likely be superseded by another pattern of implementation with future technology changes. The outcomes of this co-ordinated implementation process in terms of efficiency (significant improvements) and worker autonomy (increased) are highly similar to those observed during the introduction of virtualisation technologies at Laurier Ontario.

Co-opted Implementation

In a study of the spatial rearrangement of an IKEA store in the UK, Bilsland and Cumbers (2018) observed a fostering managerial approach to workplace reorganisation in the absence of a developed union strategy. Here, the spatial reorganisation of the workplace can be understood as a technological change that would reshape the work process of shopfloor workers. In other words, the authors observed a co-opted pattern of implementation and debugging. The study found that the "space planners," including managers and the Communication and Interior Design Team (CID), were rhetorically committed to involving "space users" or sales co-workers in the process of spatial reorganisation (Bilsland and Cumbers 2018, p. 132). "[I]t was evident that the store's CID team were keen to emulate perceived Scandinavian participatory approaches in everyday spatial planning"

(Bilsland and Cumbers 2018, p. 135). This involvement took the form of asking sales co-workers to interview customers on how they would like to have spaces arranged, and notionally having the opportunity to contribute their own suggestions as well. This fostering strategy occurred in the absence of a developed union strategy. The authors note that the "lack of an established union presence in the store" meant there was no "impartial voice for workers" in the process of spatial reorganisation (Bilsland and Cumbers 2018, p. 147).

The co-opted implementation pattern had several observable outcomes. In terms of efficiency, management was able to selectively harvest the ideas of shopfloor workers while maintaining control of the ultimate spatial reorganisation. One manager described the involvement of shopfloor workers like this "'their job is to actually influence us on how we plan. They're like mini business managers in their areas'" (Bilsland and Cumbers 2018, p. 138). But the authors of the study argued that this worker participation was highly restricted:

> *This arrangement may constitute an attempt to involve Sales co-workers in decision-making. However, a closer reading of the language in this commentary suggests otherwise. While Sales co-workers could 'influence' how CID plan shop floor spaces, there was no indication of their direct involvement in the co-production of the work plan from the outset (Bilsland and Cumbers 2018, p, 138)*

Management found observable benefits to involving shopfloor workers in the decision-making processes of spatial rearrangement, but in the absence of an organised worker response, they found no need to substantively empower workers. In this way, the authors conclude sales co-worker "input was valued insofar as it contributed to business success" (Bilsland and Cumbers 2018, p. 139). From a worker perspective, empowerment through upskilling or participation in managerial decision making was minimal, though the shopfloor workers did learn some new skills with participatory work practices "offering employees opportunities to hone their skills and develop competence" (Bilsland and Cumbers 2018, p. 137). There also appear to have been some cases in which their ideas were taken seriously by management. However, the authors conclude that at a more fundamental level managerial fostering in this context can be better understood as "token participation, legitimating organisational decisions with a veneer of inclusion" (Bilsland and Cumbers 2018, p. 137). The co-opted patterns of implementation observed in this study—which soon mutated into unilateral patterns—could be described in the same way as the IKEA case in that worker participation in implementation was only valued "insofar as it contributed to business success" (Bilsland and Cumbers 2018, p. 139).

The Framework Elaborated

Figure 4: Patterns of Implementation Elaborated

		UNION APPROACH			
		DEVELOPED STRATEGY		ABSENCE OF DEVELOPED STRATEGY	
MANAGERIAL STRATEGY	FORCING	*1. Contested Implementation*		*2. Unilateral Implementation*	
		Drill and Fill Robots Ontario: ○ *Slow rollout* ○ *Limited efficiency improvement* ○ *Generalised but limited upskilling*	***'FinCo' (Murphy and Cullinane 2021):*** ○ *Delayed rollout* ○ *Limited efficiency gains* ○ *No major impact worker autonomy*	***Late-Stage Debugging Quebec:*** ○ *Rapid rollout* ○ *Managerial satisficing* ○ *Reduced worker autonomy*	***Plessey (Thompson and Bannon 1985):*** ○ *Rapid rollout* ○ *Managerial satisficing* ○ *Limited worker autonomy*
	FOSTERING	*3. Co-ordinated Implementation*		*4. Co-opted Implementation*	
		Virtualisation Ontario: ○ *Steady rollout* ○ *Measurable efficiency improvement* ○ *High worker autonomy*	***'The Rubber Moulding Company' (Wilkinson 1983):*** ○ *Steady rollout* ○ *Significant efficiency improvements* ○ *High worker empowerment*	***Early-Stage Implementation Quebec:*** ○ *Fast initial rollout* ○ *Isolated efficiency improvements* ○ *Isolated upskilling*	***IKEA (Bilsland and Cumber 2018):*** ○ *Rapid rollout* ○ *Limited efficiency improvements* ○ *Limited worker empowerment*

Figure 4 presents the case studies discussed in this chapter alongside the empirical findings of this thesis. This table demonstrates that despite the different temporal, geographical, and production contexts of the eight cases, they can all be accommodated within the framework elaborated in this study. By presenting the cases alongside one another, I can demonstrate the high degree of generalisability achieved by the framework. For example, the contested implementation at Murphy and Cullinane's (2021) FinCo shared its broad contours with the pattern of implementation of drilling and filling robots at Laurier Ontario. While the unions' tactics varied—Unifor demanded new job classifications and training while at FinCo Bank Union resisted new frontiers of managerial control by filing mass grievances—both deployed timely, considered, and organised strategies. Both patterns were characterised by a slow rollout of the technologies to the frustration of the relevant managements. At Laurier Ontario this was a result of insufficient worker training on the new equipment while at Finco slow rollout was caused by worker resistance to the performance management applications of the new technologies. It can be said at a general level that the slow rollouts in both workplaces was caused by a lack of worker involvement or buy-in to the new

technologies. For similar reasons, both technology changes realised limited efficiency improvements. Finally, both cases resulted in limited observable changes to workers' level of autonomy under the new labour process and changes were experienced similarly by all workers as the unions negotiated for workforce-wide outcomes.

Similarly, the two examples of unilateral implementation and debugging show highly similar outcomes. They also demonstrate that union strategy can vary within the binary category of 'undeveloped'. In Thompson and Bannon's (1985) study at Plessey, the undeveloped union strategy was characterised by a divided group of unions failing to develop any organised or timely approach to the technological changes occurring in their workplaces. In a variation of an undeveloped strategy, the Machinists in Quebec failed to execute an observable strategy towards technology change on the shopfloor despite significant consternation about the potential impacts of automation among union leaders. The approaches varied but were both ultimately characterised by an absence of timely, considered, and organised strategy relating to the processes of implementation and debugging. In both cases, management forced the change on workers without meaningful consultation or integration. In terms of efficiency outcomes, both cases of unilateral implementation resulted in fast rollouts but managerial satisficing in terms of the ultimate productivity gains. This was, in both cases, partly due to a failure to train workers sufficiently on the new equipment meaning workers were not empowered to realise the full potential of the new machinery. Engineers, who were in both cases motivated by maximising the efficiency gains from the new technologies, expressed highly similar frustrations by what they saw as managerial satisficing:

> *'System X was quickly put together… But recognised standards the procedures—from a company viewpoint—were not always rigorous' (Thompson and Bannon 1985, p. 75).*

> *So we have a target for the new equipment's performance, when the target is reached, it [implementation] is done… And sometimes, it means that you may say, 'Okay, that's good enough for me, I will stop supporting people to learn and we will just run production.' But you haven't seen yet all… the things we could actually achieve if we gave workers more control of the equipment (Interview 34, Operations Supervisor, Laurier Quebec, 29-08-2019)*

Figure 4 describes the social patterns of implementation and debugging of virtualisation tools at Ontario and the technological change at Wilkinson's (1983) Rubber Moulding Plant as co-ordinated implementation patterns. In both plants, management relied heavily on the skills of unionised shopfloor workers for the debugging of the new technologies. In Ontario, managers sought the input of assembly workers with high technical and manual skills when virtualisation tools failed to enable the smooth vertical disintegration of supply chains across North America and other continents.

Similarly, at Wilkinson's (1983) Rubber Moulding Plant, management integrated workers into the process of implementation and debugging and even conceded to removing piece rates during the process. Unions in both cases deployed highly developed strategies around technological change on the shopfloor. Both unions demanded training on the new equipment, simultaneously enforcing job controls on the shopfloor with shop stewards and workplace activists working to maintain control of the labour process at the point of production. Concurrently, both unions deployed more fostering strategies, encouraging members to integrate with management and engineers in the debugging process. While the interaction between management and workers resulted in a steady rollout—perhaps marginally slower than other patterns–both instances of co-ordinated implementation resulted in significant observable efficiency gains. The co-ordinated implementation pattern also resulted in high levels of generalised worker empowerment. At the Rubber Moulding Plant workers used this strength to resist the reintroduction of piece rates, while shop stewards at Laurier Ontario developed a concerted effort to concentrate control of more work processes on the shopfloor with unionised workers.

The early stages of implementation and debugging of technologies at Laurier Quebec and the spatial reorganisation of IKEA in Bilsland and Cumbers' (2018) study both adhered to a co-opted pattern of implementation. In these instances, there was nothing approaching a developed union strategy aimed at influencing how technology changed occurred. At IKEA, this reflected the fundamental weakness of the union. At Laurier, despite ostensibly strong union structures, shop stewards were unwilling or unable to influence how technologies were implemented, often appearing ignorant to the details of change. In both instances, management deployed fostering strategies, selectively integrating workers in the process of change. At IKEA this involved the token involvement of workers in the process of spatial reorganisation. At Laurier Quebec, management handpicked a small group of workers to be involved in the process of implementation and debugging. In terms of outcomes, worker involvement in the process of implementing technology change contributed to the smooth rollout of technology and contributed to observable efficiency gains. In other words, in the absence of an organised labour voice, in both cases worker "input was valued insofar as it contributed to business success" (Bilsland and Cumbers 2018, p. 139). But efficiency gains were limited by the tokenistic or restricted nature of worker empowerment. Outcomes for workers in both cases are classified in **Figure 4** as limited or selective empowerment. Worker empowerment was limited at IKEA by the tokenistic nature of their involvement while at Laurier Quebec worker involvement was highly selective and controlled exclusively by management.

CHAPTER TWELVE: Conclusion

> *The sad, horrible, heart-breaking way the vast majority of my fellow countrymen and women, as well as their counterparts in the rest of the world, are obliged to spend their working lives is seared into my consciousness in an excruciating and unforgettable way. And when I think of all the talent and energy which daily go into devising ways and means of making their torment worse […] If the same effort, or only half of it, were devoted to making work the joyous and creative activity it can be, what a wonderful world this could be.*
>
> *Sweezy 1974, p. xii—xiii*

To conclude my thesis I begin by summarising the project itself, including the study purpose, its design, findings, and the answers to my research question. Building on this summary, this chapter highlights the academic relevance of the project through its contributions to the labour process and industrial relations literatures. It then makes some final observations on the implications of this study's findings and sketches a further research agenda which could build off these findings to further investigate how the strategies of workplace actors interact on the shopfloor to influence not only technological change, but work organisation more broadly. Finally, it highlights that despite a high level of interest in questions of shopfloor technology change among trade unionists, both the extant literature and the empirical findings of this study suggest that many struggle to develop effective strategies to influence these social and political processes at the point of production. I conclude my thesis by arguing that this represents a space for practical engagement with the organised labour movement.

Summary of Theoretical Contribution

Out the outset of this study, I identified that despite numerous studies of the shopfloor politics of technological change, a framework grasping how the strategies of workplace actors shape patterns of implementation and debugging remained lacking. Notwithstanding limited empirical evidence on the use of the new technologies in production—ranging from internet enabled devices to additive manufacturing, advanced robotics to virtualisation tools—I noted that some observers claim we are on the precipice of a new industrial revolution. Other scholars are more circumspect, suggesting that recent technological changes are best understood as an incremental continuation of previous trends. I observed that while much had been written about the "new new technologies" (Holtgrewe

2014, p. 9), studies of their implementation and debugging remained relatively scarce (for exceptions see: Will-Zocholl 2017; Murphy and Cullinane 2021). Ultimately, I argued that the strategies of workplace actors, specifically trade unions and managers, shape different patterns of technological implementation, with implications for the efficiency of production and the autonomy of workers.

To address the research question—which asked how the strategies of unions and managers shape the implementation and debugging of technologies—I advanced a comparative case study research design to examine patterns of implementation on the shopfloor. Laurier Aerospace was selected as the research site for this study on the basis that it was in the process of adopting advanced technologies in its production processes. From a pragmatic perspective access was also relatively straightforward to arrange. Most importantly, the two plants to be studied were likely to vary in the two explanatory factors developed during the literature review phase. First, the distinctive institutional environments in Quebec and Ontario, and the gatekeepers' suggestion that the two Laurier plants maintained different management cultures, suggested they would present varying managerial approaches to technological change on the shopfloor. Second, the two plants were organised by different unions—the Machinists in Quebec and Unifor in Ontario—which, both the gatekeepers and the unions' histories suggested, would adopt observably different strategies towards technological change on the shopfloor.

To overcome a frequent criticism of labour process analysis—the failure to go beyond the shopfloor (Thompson and Smith 2010; Vidal and Hauptmeier 2015)—this study deployed a truncated version of Burawoy's (et al. 1991; 2009) extended case method. These extensions included the extension of the researcher into the world of the study participants through extensive participant and non-participant observation. Other empirical extensions included the spatial and temporal extensions in the process of data collection. The spatial extension was achieved by studying plants in different Canadian provinces. The temporal extensions were achieved first through a deep engagement with the history of Laurier, each of its plants studied, and of the unions at each plant; a version of Burawoy's (2009, p. 253) "archaeological" extension. And second, through a second tranche of follow-up semi-structured interviews in the vein of Burawoy's (2009, p. 253) "valedictory" revisit.

Additionally, this study has extended existing theory based on new empirical findings (Burawoy 2009). This includes extending our theoretical understanding of how management approaches questions of technological change on the shopfloor. Labour process studies of managerial strategies towards implementation and debugging new technologies have tended to emphasise control as a management concern. While this study belongs to the mainstream labour process tradition, it

accepts the criticism of Vidal (2019) that it has been too focused on control and should pay more attention to the tension between managerial concerns over control and efficiency. This study loosely follows Vidal's framework by examining the relationship between managerial fostering strategies—generally pursued to increase efficiency—and forcing strategies, deployed with a view to maintaining or extending managerial control of the work process.

In terms of labour, this thesis has argued that conceptualisations based on some variation of forcing and fostering are inadequate to capture trade union approaches to implementation and debugging. Instead, it draws on the findings of a body of studies examining the shop floor politics of implementation and debugging that unions can deploy developed strategies (encompassing either or both forcing and fostering strategies) or fail to deploy a meaningful strategy at all. Thus, labour strategies are conceptualised in the framework elaborated in this study in terms of the presence or absence of a timely, considered, and organised approach to the social and political processes of technological change on the shopfloor. Through this theoretical framework, this study draws on the empirical findings of my fieldwork and the observations of a range of studies of the shopfloor politics of technological change to extend our understanding of how unions can shape the process of technological implementation and debugging, and why they frequently fail to do so.

Finally, this study has extended our understanding of patterns of implementation and debugging on the shopfloor by developing a theoretical framework to grasp these patterns which until now has been lacking. These patterns represent the central theoretical contribution of this study. By cross classifying managerial and labour strategies this study produces four patterns of implementation and debugging: (1) contested implementation; (2) unilateral implementation; (3) co-ordinated implementation; and (4) co-opted implementation. Through extensive empirical research and, in the discussion chapter, applying this framework to other empirical studies, this study is able to demonstrate the value of these patterns in explaining variations in the speed and efficacy of rollout, the efficiency improvements, and worker outcomes resulting from technology change.

Final Observations and Future Research Agenda

Some of the patterns of implementation emerging from and elaborated in this study generate outcomes that may be considered 'better' across multiple metrics. Notably, the co-ordinated pattern generates significant efficiency improvements while empowering workers, though for the reasons discussed above it appears in only limited situations and cannot always be sustained. As detailed at length in the preceding chapters, capitalism places partially contradictory pressures on managers in the process of implementation and debugging. The pursuit of fostering approaches that upskill and empower workers for greater efficiency are limited by the need to maintain control of the

production process. In the case studies outlined above, managers and engineers alike expressed frustration at the failure of their firm to pursue greater efficiency goals in the process of implementation. And while the literature is peppered with examples of managers taking the 'high-road' of upskilling and empowering workers, capitalism places limits on the level of control employers can grant their employees while maintaining control of the means of production. Despite various waves of management led 'worker empowerment,' the evidence appears to support the assertion that the dramatic humanisation of work processes cannot and will not be driven by capital.

An occasional refrain in studies of implementation and debugging of new technologies is that once a technology reaches the stage of implementation and technology it is 'too late' for labour to effect much change over the technologies. This study strongly suggests otherwise. As Orlikowski (2007) points out, some technologies are subject to a high level of reconstitution in use. For example, the capacity to program the drill and fill robots existed at the point of production, as did retooling and maintenance functions. A small group of workers involved in the co-opted phase of implementation and debugging at the Quebec plant had high levels of responsibility in all these areas. These workers understood how to deal with over 100 error codes. Workers at the Ontario plant, where the robots had been implemented under a contested pattern had some control over these functions, including being taught how to handle several error codes and perform retooling. A large majority of workers at the Quebec plant had little or no capacity to operate the robots beyond their most basic functions, understanding how to deal with only a handful of error codes. In short, the large majority of workers experienced a highly degraded, alienated work process compared to what was possible, and likely most efficient.

In the context of these highly varied worker experiences, and the evidence that demonstrates that union strategies at the implementation stage can change the course of technological change, few of the reasons trade unions and trade union leaders use to justify not developing comprehensive strategies towards technological change on the shopfloor appear sustainable. Anybody with any sort of concern for the way that people spend their working lives ought to have such questions at the front of mind. Especially those elected and paid to represent the interests of those workers. Implied here is a criticism of mainstream labour process theory. Several scholars have argued—correctly in my view—that the core theory approach has frequently mirrored the agendas of management and proved incapable of generating any alternative debate (Spencer 2000; Martinez Lucio 2010). It does not necessarily follow that authors should attempt to develop theory as a revolutionary weapon, as some scholars have suggested (Braverman 1955; 1976; Spencer 2000). I do argue, however, that this tradition can develop an alternative debate in which there is some scope for the development of

novel political projects. The extended extract by Martinez Lucio (2010, p. 20) below is perhaps the best articulation of this critique:

> *This, presumably, requires a renewed discussion on not just the levels of participation and the relation between participants but on the principles and rights that underpin participation. This links back to our discussion of the way the alternatives discussed around industrial democracy and worker control in the 1970s marked a forgotten yet important moment in the discussion... If radical and critical debates do not do this we will remain encased in the agendas and practices that management set—critiquing in the absence of any alternative debate. In effect, we run the risk of our critiques mirroring the agendas of management.*

Martinez Lucio suggests that this can be countered by examining the labour process in non-capitalistic contexts. Here, he follows Hyman and Mason (1995) who point to studies of the labour process in notionally democratic workplaces in the former Yugoslavia and co-operative enterprises. Since the collapse of state communism in the 1990s, the opportunity to study in these contexts has receded, and studies of the labour process in China generally demonstrate that work organisation in that country are largely dictated by a capitalistic logic of accumulation (see Liu and Smith 2016). Similarly, most recent studies of the labour process in co-operative enterprises argue that the degree to which the division of labour can deviate from orthodox manager-worker employment relations when subject to the whip hand of the market in the broader economy is severely limited (see for example: Atzeni and Ghigliani 2007).

This thesis has argued that a third strand of analysis can help the labour process literature—especially the post-Marxist materialist strand—move beyond mirroring the agendas of management. This would analyse the strategies of trade unions in shaping how work is organised and reorganised, including technological change on the shopfloor (Taylor and Bain 2001; Danford 2005; Murphy and Cullinane 2021). There is a strong base of evidence to suggest high levels of trade union interest, at least at an abstract level, in technological change and work reorganisation. These issues were the central focus of no less than four presentations at the two union conferences I attended as part of participant observation. They were also subject of several union and union adjacent publications (see for example Stanford and Bennett 2021). However, as demonstrated in the findings chapters, this deep interest manifested in decidedly mixed ways on the shopfloor.

Having demonstrated that trade unions can play a demonstrable role in shaping the process of implementation and debugging new production technologies, I suggest this line of analysis as a potential future research agenda for labour process analysis. A potentially fruitful future research agenda could involve examining moments when unions have developed and pursued highly

ambitious programs to bargain over technology change. A historical examination of the CAW's Work Organisation Unit could be an illustrative case study here. Several research participants in this study pointed to this example, and there is some indication that significant documentary evidence exists, though it was beyond the scope of this study to access it. Similarly, some Australian unions developed wide-ranging strategies around technology change and upskilling during the era of the Prices and Incomes Accords in the 1980s and 90s in that country (Scott 2013). Most academic studies of the Accord concentrate on wages, social policy, and union structures (see for example Humphrys 2018). However, Ogden (2020) points towards the significant experiment undertaken by unions to influence technological change and work organisation. His account includes a discussion of how it was influenced by the labour process literature—especially Braverman.

Engagement with the Trade Union Movement

Another criticism of the post-Marxist materialist tradition of labour process analysis is that its theoretical underpinnings have 'boxed it in' to a degree that it cannot engage with policy makers and workplace actors in practical ways. As discussed above, some have argued that scholars associated with the post-Marxist materialist tradition (see Edwards 2014 for a discussion) have made limited contributions to public policy discussions because they have erected an "iron cage" that permits no escape from the determinist logic of capitalism (Ackers 2012: 79). As Edwards (2014) has demonstrated, this criticism is too strong. Nonetheless this study demonstrates a significant gap between substantial knowledge base generated by labour process scholars in this tradition and the underdeveloped strategies of trade unions around technological change on the shopfloor.

It should be stated as a guiding principle that the purpose here would be to offer union organisers and activists tools of analysis and not necessarily substantive answers. As Hyman (2012, p. 155) puts it, the task of the academic is not to produce "recipe books for workers" but the "elaboration of the right questions." The recent exchange on trade union strategies around the introduction of lean management principles between Vidal (2022a; 2022b) and Rosenfeld (2022) is an indicative example here. An increasing body of scholarship directly addresses the question of how researchers can fruitfully engage with trade unions through participatory and action research (Bronfenbrenner 2007; Juravich 2007; Stanford 2022; Turnbull 2022) or "partisan scholarship" (Thomas and Turnbull 2021, p.18). In his handbook entry on how social scientists can engage with social movements, Stanford (2022: 199) argues that one of the primary tasks is to "collaborate to identify priorities." This study has firmly established that the participant unions had—at least at an abstract level—a strong interest in how their organisations could extend their influence over technology change. Strong union activity in these processes has the potential to make the difference between meaningful,

challenging work, and meaningless, alienated toil. There is strong evidence to suggest that there is a role for researchers to play in articulating questions for the trade union movement in these areas.

REFERENCES

Ackers, P. 2014. Rethinking the employment relationship: a neo-pluralist critique of British industrial relations orthodoxy. *The International Journal of Human Resource Management*, 25 (18), pp. 2608-262

Ackroyd, S. and Thompson, P. 2016. Unruly Subjects: Misbehaviour in the Workplace. In: Edgell, S. et al. eds. *The SAGE Handbook of the Sociology of Work and Employment.* London: Sage Publications.

Adler, P. S. 2007. The Future of Critical Management Studies: A Paleo-Marxist Critique of Labour Process Theory. *Organization Studies*, 28(9), pp. 1313–1345

Adler, P. S. 2019. *The 99 Percent Economy. How democratic socialism can overcome the crises of capitalism.* New York: Oxford University Press.

Aéro Montréal. 2020. *Learn more about Aéro Montréal*. Aéro Montréal. Available at: https://www.aeromontreal.ca/aero-montreal-en.html (accessed: 19 September 2022)

Allinson, I. 2022. *Workers Can Win: A Guide to Organising at Work.* London: Pluto Books.

Analoui, F. 1992. Unconventional Practices at Work. *Journal of Managerial Psychology*, 7(5), pp. 3-31.

Archer, M. et al. 1998. *Critical Realism Essential Readings*. London, Routledge.

Archer, M. et al. 2016. What Is Critical Realism? *American Sociology Association,* [online], Available at: http://www.asatheory.org/current-newsletter-online/what-is-critical-realism (Accessed 23 May 2022)

Archibald, C. 1983. *Un Québec Corporatiste?* Hull: Éditions Asticou.

Arneson, E. 2007. *Encyclopedia of U.S. Labor and Working- Class* History (2nd. Vol.2. ed.). New York, NY: Taylor & Francis Group LLC

Armstrong, P. 1983. Class Relationships at the Point of Production: A Case Study. *Sociology*, 17(3), pp. 339–358.

Atzeni, M. and Ghigliani, P. 2007. Labour process and decision-making in factories under workers' self-management: empirical evidence from Argentina. *Work, Employment and Society*, 21(4), pp. 653–671.

Bar-Haim, A. 1984. Workers' Participation in Management: Integration versus Co-optation or Segregation. *Economic and Industrial Democracy*, 5(3), pp. 341–357.

Beaudry, C. and Solar-Pelletier, L. 2020. *The Superclusters Initiative: An Opportunity to Reinforce Innovation Ecosystems.* Institute for Research on Public Policy. Available at: https://irpp.org/wp-content/uploads/2020/10/The-Superclusters-Initiative-An-Opportunity-to-Reinforce-Innovation-Ecosystems.pdf (Accessed: 05 December 2021)

Bélanger, J. and Evans, S. 1988. Job Controls and Shop Steward Leadership Among Semi-Skilled Engineering Workers. In: Terry, M. and Edwards, P. K. eds. *Shopfloor Politics and Job Controls in the Post War Engineering Industry.* Oxford: Basil Blackwell.

Bélanger, J. 2006. Technology and Work. In: Korczynski, M. et al. eds. *Social Theory at Work.* London: Oxford University Press.

Bélanger, J. and Edwards, P. 2007. The Conditions Promoting Compromise in the Workplace. *British Journal of Industrial Relations*, December, Vol. 45(4), pp. 713-734

Bélanger, J. and Nadeau, R. 2009. *Le Comportement Électoral Québécois*. Montreal: La presse de l'Université de Montréal.

Benanav, A. 2019a. Automation and The Future of Work—1. *New Left Review,* 119 Sept/Oct 2019.

Benanav, A. 2019b. Automation and The Future of Work—2. *New Left Review,* 120 Nov/Dec 2019.

Beynon, H. 1974. *Working for Ford.* London, Allen Lane.

Blauner, R. 1964. *Alienation and freedom: The factory worker and his industry.* Chicago: Chicago University Press.

Bilsland, K. and Cumbers, A. 2018. Managerial control and the limits to employee participation in retail work spaces: evidence from a UK IKEA store. *New Technology, Work and Employment,* 33 (2), pp. 130-148.

Boes, A. and T. Kampf. 2007. The Nexus of Informatisation and Internationalisation—A New Stage in the Internationalised of Labour in Globalised Working Environments. *Work, Organisation, Labour and Globalisation,* 1 (2) pp. 361—68.

Bogdan, R. C. and Biklen, S. K. 2006. *Qualitative research in education: An introduction to theory and methods*. Boston: Allyn and Bacon.

Böhm, A. 2004. Theoretical Coding: Text Analysis in Grounded Theory. In: eds. Flick, U. et al. *A Companion to Qualitative Research.* London: Sage.

Bosch, G. and Schmitz-Kießler, J. 2020. Shaping Industry 4.0 – An Experimental Approach Developed by German Trade Unions. *Transfer: European Review of Labour and Research*, 26(2), 189–206.

Braverman, H. 1955. Automation: Promise and Menace. *American Socialist*, October 1955, pp. 7—12.

Braverman, H. 1974. *Labor and monopoly capital: the degradation of work in the twentieth century.* New York & London: Monthly Review Press, 1974.

Braverman, H. 1976. Two Comments. *Monthly Review,* 28 (3), pp. 120—122.

Brighton Labour Process Group. 1977. The Capitalist Labour Process. *Capital and Class* 1, 3-22.

Briken, K. et al. 2017. Labour Process Theory and the New Digital Workplace. In: Briken et al, eds. *The New Digital Workplace: How Technologies Revolutionise Work.* Basingstoke: Palgrave Macmillan. pp. 132—152.

Brodsky, A.E. 2008. Fieldnotes. In: Given, L. ed. *The SAGE Encyclopedia of Qualitative Research Methods.* Thousand Oaks: Sage.

Bronfenbrenner, K. ed. 2007. *Global Unions: Challenging Global Capital Through Cross-Border Campaigns*. Ithaca, NY: Cornell University Press.

Bruner, E. 1997. Ethnography as Narrative. In: Hinchman, L.P. and Hinchman, S. eds. *Memory, Identity, Community: The Idea of Narrative in the Human Sciences*. SUNY Press: New York.

Brynjolfsson, E. and McAfee, A. 2014. *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies.* Boston: MIT University Press.

Budnitz, H. and Tranos, E. 2022 Working from Home and Digital Divides: Resilience during the Pandemic. *Annals of the American Association of Geographers*, 112 (4)

Bulmer, M. 1978. Exploratory Data Analysis, *Sociology*, 12(3), pp. 605–605.

Burawoy, B. 1979. *Manufacturing Consent: Changes in the Labour Process under Monopoly Capitalism.* London: The University of Chicago Press.

Burawoy, M. 1998. The extended case study method. *Sociological Theory* 16 (1), pp. 4—33.

Burawoy, M. 2009. *The extended case method: four countries, four decades, four great transformations, and one theoretical tradition*. University of California Press: Berkeley.

Burawoy, M. et al. 1991. *Ethnography Unbound: Power and Resistance in the Modern Metropolis.* Berkeley, Los Angeles, London: University of California Press.

CEDC, 2020. *Opportunities in Aerospace Industries.* Community and Economic Development Commission. Available at: https://gotothunderbay.ca/key-sectors/aerospace/ (accessed: 13 March 2021)

Chang, H. J. 2014. *Economics: A User's Guide.* London: Pelican Books.

Clegg, H. A. 1951*. Industrial Democracy and Nationalisation: A Study Prepared for the Fabian Society*. Oxford: Blackwell.

Coe, N. 2015. Labour and Global Production Networks; Mapping Variegated Landscapes of Agency. In: Eds: Newsome, K. et al. *Putting Labour in its Place*. Palgrave MacMillan: Basingstoke, pp. 117—194.

Crowhurst, I. and Kennedy-MacFoy, M. 2013. Troubling gatekeepers: methodological considerations for social research. *International Journal of Social Research Methodology*, 16(6) pp. 457-462

Cruddas, J. and Pitts, F. H. 2018. Marxism Revisited. *Fabian Review*, Spring 2018, pp. 21-23.

DAIR, 2020. The Aerospace Hub. *Downsview Aerospace Innovation & Research.* Available at: https://www.dairhub.com/#hub (accessed 17 August 2021)

Danford, A. 1999. *Japanese Management Techniques and British Workers.* London: Routledge.

Danford, A. 2005. New Union Strategies and Forms of Work Organisation in UK Manufacturing. In: Harley, B. et al. eds. *Participation and Democracy at Work.* Basingstoke: Palgrave MacMillan.

Danford, A. et al. 2005. Employees' Experiences of Workplace Partnership in the Private and Public Sector. In: Stuart, M. and Martinez Lucio, M. eds. *Partnership and Modernisation in Employment Relations*. London: Routledge.

Dzedzickis, A. et al. 2022. Advanced Applications of Industrial Robotics: New Trends and Possibilities. *Applied Sciences,* 12 (1) pp. 135—148.

Delbridge, R. 2000. *Life on the Line in Contemporary Manufacturing: the workplace experience of lean production and the 'Japanese' model.* Oxford: Oxford University Press.

Delbridge, R. 2007. Explaining Conflicted Collaboration: A Critical Realist Approach to Hegemony. *Organization Studies*, 28(9), pp. 1347–1357.

de Laine, M. 2000. *Fieldwork, Participation and Practice: Ethics and Dilemmas in Qualitative Research*. London: Sage Publications.

Denis, R. and Denis, S. 2004. Quebec Unions in Politics. In: Gagnon, A. ed. *Quebec: State and Society*, Third Edition. Toronto: University of Toronto Press.

Diaz, J. 2019. Foreword. In: Wilson, F. *A New Kind of Union: Unifor and the birth of the modern Canadian union.* Toronto: Lorimer James and Company. pp. 7-11.

Ditton, J. 1977. Perks, pilferage and the fiddle: The Historical Structure of Invisible Wages. *Theory and Society,* 4(1), pp. 39–71.

Dunlop, T. 2016. *Why the Future is Workless.* Sydney: New South Books.

Dyer Jr, W. G. and Wilkins, A. L. 1991. Better stories, not better constructs, to generate better theory: A rejoinder to Eisenhardt. *Academy of management review*, 16 (3), pp. 613-619.

Economist, 2022. Joe Biden's Industrial Policy is Big, Bold and Fraught with Difficulty. *Economist,* September 13, 2022. Available at: https://www.economist.com/united-states/2022/09/13/joe-bidens-industrial-policy-is-big-bold-and-fraught-with-difficulty (last accessed 29 December 2022)

Edwards, R. 1979. *Contested Terrain: The Transformation of the Workplace in the Twentieth Century*. London: Heinemann.

Edwards, P. 1986. *Conflict at Work.* Oxford: Blackwell

Edwards, P. 2010. Developing Labour Process Analysis: Themes from Industrial Sociology and Future Directions. In: Thompson, P. and Smith, C. eds: *Working life: renewing labour process analysis*. Basingstoke: Palgrave Macmillan. pp.29—46.

Edwards, P. 2014. Were the 40 Years of 'Radical Pluralism' a Waste of Time? A Response to Peter Ackers and Patrick McGovern. *Warwick Papers in Industrial Relations,* Number 99.

Edwards, P. 2018. Conflict in the Workplace: The Concept of Structured Antagonism Reconsidered. *Warwick Papers in Industrial Relations,* Number 110.

Edwards, P. and Collinson, M. 2002. Empowerment and Managerial Labor Strategies: Pragmatism Regained. *Work and Occupations*, 29 (3) pp. 272–299.

Edwards, P. and Ramirez, P. 2016. When should workers embrace or resist new technology? *New Technology, Work and Employment* 31 (2) pp.99-113

Edwards, P. et al. 2006. The Bases of Compromise in the Workplace: A Theoretical Framework. *British Journal of Industrial Relations,* 44 (1) pp. 125—145.

Eisenhardt, K.M. and Graebner, M.E., 2007. Theory building from cases: Opportunities and challenges. The Academy of Management Journal, 50(1), pp.25-32.

Eldridge, J. E. T. et al. 1991. *Industrial Sociology and Economic Crisis*. Hemel Hempstead: Harvester Wheatsheaf.

Elections Ontario. 2022. Election Results. *Elections Ontario,* Available at: https://www.elections.on.ca/en/resource-centre/elections-results.html (accessed 01 January 2022)

Fairris, D. 1995. Control and Inefficiency in Capitalist Production: The Role of Institutions*. Review of Social Economy,* 53(1), 1–29.

Fetterman, D. M. 1998. *Ethnography: Step by step* (2nd ed.) Thousand Oaks, CA: Sage.

Felstead, A. 2022. *Remote Working: a research overview.* London, Routledge Focus.

Flyvberg, B. 2006. Five misunderstandings about case-study research. *Qualitative Inquiry*, 12 (2), pp. 219-245.

Ford, M. 2015. *Rise of the Robots: Technology and the Threat of a Jobless Future*. New York: Basic Books.

Forsyth, A. 2022. *The Future of Unions and Worker Representation: The Digital Picket Line*. Melbourne: Bloomsbury Publishing PLC.

Freeman, J. B. 2018. *Behemoth: A History of the Factory and the Making of the Modern World*. New York: W. W. Norton and Co.

Frenkel, S. 1988. The Australian Metalworkers' Union and Industrial Change: a Labour Movement Offensive. In: Eds: Hyman, R. and Streeck, W. *New Technology and Industrial Relations.* Oxford: Basil Blackwell.

Frey, C. B. 2019. *The Technology Trap: Capital, Labor, and Power in the Age of Automation.* Oxford: Princeton University Press.

Friedman, A. 1977. *Industry and Labour: Class Struggle at Work in Monopoly Capitalism.* London: Macmillan.

Frost, A. 2000. Explaining Variation in Workplace Restructuring: The Role of Local Union Capabilities. *Industrial Relations Review*, 53 (4), pp. 559-578.

Fry, S. and Mees, B. 2017. Two discursive frameworks concerning ideology in Australian industrial relations. *The Economic and Labour Relations Review*, 28(4), pp. 483–499.

Gahan, P. et al. 2017. Technology, the Digital Economy and the Challenge for Labour Market Regulation. In: Howe, J. et al. *The Evolving Project of Labour Law: Foundations, Development and Future Research Directions.* Melbourne: Federation Press.

Galletta, A. 2012. *Mastering the Semi-Structured Interview and Beyond: From Research Design to Analysis and Publication.* New York: New York University Press.

Geary, J. and Trif, A. 2011. Workplace Partnership and the Balance of Advantage: A Critical Case Analysis. *British Journal of Industrial Relations,* 49 (1) pp. 44—69.

Gindin, S. 1995. *The Canadian Auto Workers: The Birth and Transformation of a Union.* Toronto: James Lorimer & Company.

Given, L. M. 2008. *The sage encyclopedia of qualitative research methods* (vol. 1). Thousand Oak, California: SAGE Publications.

Gobo, G. 2004. Sampling, representativeness and generalizability. In: Seale, C. et al. Eds. *Qualitative Research Practice*. London: Sage, pp. 435-456.

Goldkuhl, G. and Cronholm, S. 2010. Adding Theoretical Grounding to Grounded Theory: Toward Multi-Grounded Theory. *International Journal of Qualitative Methods*, 9 (2) pp. 187–205.

Goodrick, D. 2014. Comparative Case Studies: Methodological Briefs. *Impact Evaluation*, 9 (754) Methodological Briefs.

Gouldner, A. W. 1954, *Patterns of Industrial Bureaucracy*. London: Routledge & Kegan Paul.

Grant, D. and Hall, R. 2005. *Power and Discourse in the Management and Organisation of ERPs.* Proceedings of the 4th Critical Management Studies Conference, Judge Institute of Management, University of Cambridge, 4—6 July 2005.

Grant, D. et al. 2006. The False Promise of Technological Determinism: The Case of Enterprise Resource Planning Systems. *New Technology, Work and Employment*, 20(1) pp. 2—24.

Green, K. 2020. Union Profile: A Look at the International Association of Machinists and Aerospace Workers. *Union Track,* available at: https://uniontrack.com/blog/international-association-of-machinists-and-aerospace-workers (accessed: 02 February 2022)

Greenhouse, S. 2011. Union Membership in U.S. Fell to a 70-Year Low Last Year. *The New York Times* (Jan. 21, 2011) Available at: https://www.nytimes.com/2011/01/22/business/22union.html (accessed 30 April 2022)

Gregolinska, E. et al. 2022. *Capturing the true value of Industry 4.0.* Reports: McKinsey and Company. Available at: https://www.mckinsey.com/capabilities/operations/our-insights/capturing-the-true-value-of-industry-four-point-zero (accessed: 17 July 2022)

Haddow, R. 2015. *Comparing Quebec and Ontario: Political Economy and Public Policy at the Turn of the Millennium*. Toronto: University of Toronto Press.

Hader, M. et al. 2018. Navigating complexity. Flying close to the wind: Aerospace and defence top management issues radar 2018. *Think: Act Magazine*. Roland Berger. Available at: https://www.rolandberger.com/publications/publication_pdf/roland_berger_aerospace_defense_radar.pdf (accessed: 30 October 2021)

Haidinger, B. 2014. Value Chains and Networks in Services – Crossing Borders, Crossing Sectors, Crossing Regimes? In: Vidal, M. Hauptmeier, M. eds.: *Comparative Political Economy of Work.* London: Palgrave.

Hall, R. 2005. The Integrating and Disciplining Tendencies of ERPs: Evidence from Australian Organisations. *Strategic Change,* 14(5) pp. 245—54.

Hall, R. 2010. Renewing and Revising the Engagement between Labour Process Theory and Technology. In: Thompson, P. and Smith, C. eds: *Working life: renewing labour process analysis*. Basingstoke: Palgrave Macmillan. pp. 159—182.

Hall, P. and Soskice, D. 2001. An Introduction to the Varieties of Capitalism. In: In: Hall, P. and Soskice, D. eds. *Varieties of Capitalism: The Institutional Foundations of Comparative Advantage*. Oxford: Oxford University Press. pp1—65.

Handcock, M. S. and Gile, K. J. 2011. Comment: On the Concept of Snowball Sampling, *Sociological Methodology*, 41 (1), pp. 367–371.

Harley, B. et al. 2005. The Paradoxes of Participation. In: eds. Harley, B. et al. *Participation and Democracy at Work.* Basingstoke: Palgrave MacMillan.

Harrisson, D. and Laplante, N. 1996. Trade Unions and Cooperation: Case Studies in Quebec Manufacturing Plants. *Economic and Industrial Democracy*, 17 (1), pp. 99–129.

Hartley, K. 2014. *The political economy of aerospace industries: A key driver of growth and international competitiveness?* Cheltenham: Edward Elgar Publishing.

He, Y. and Chen, S. 2018. Advances in sensing and processing methods for three-dimensional robot vision. *International Journal of Advanced Robotic Systems*, 15(2) pp. 1—19.

Healy, J. et al. 2017. *The future of work in Australia: Anticipating how new technologies will reshape labour markets, occupations and skill requirements*. Report: NSW Department of Education.

Hecht, J. 2018. How Technology Is Driving Change in Almost Every Major Industry. Forbes. Available at: https://www.forbes.com/sites/jaredhecht/2018/11/30/how-technology-is-driving-change-in-almost-every-major-industry/?sh=67f2225b2f6f (last accessed: 18 August 2022)

Hennebert, M. A. and Pérez-Lauzon, S. 2019. The Practice of Collective Bargaining in the Private Sector in Quebec (Canada): The Changing 'Rules of the Game'. *Industrial Relations Journal*, 50 (3) pp. 240-255.

Herrigal, G. 2010. *Manufacturing Possibilities: Creative Action and Industrial Recomposition in the United States, Germany, and Japan*. Oxford: Oxford University Press.

Hinton, J. 1973. *The First Shop Stewards' Movement*. Surrey: Unwin Brothers Limited.

Hobsbawm, Eric. 1968. *Labouring Men: Studies in the History of Labour*. London: Weidenfeld and Nicolson.

Holgate, J. 2021. *Arise: Power, Strategy, and Union Resurgence*. London: Pluto Press.

Holtgrewe, U. 2014. The future and present of work in ICT. *New Technology, Work and Employment*, 29 pp. 9-24.

Howe, I. and Widdick, B. J. 1949. *The UAW and Walter Reuther.* New York: Random House.

Hrnjica, B. and Softic, S. 2020. Explainable AI in Manufacturing: A Predictive Maintenance Case Study. In: Lalic, B. et al. eds. *Advances in Production Management Systems: Towards Smart and Digital Manufacturing*. New York: Springer.

Humphrys, E. 2018. *How Labour Built Neoliberalism Australia's Accord, the Labour Movement and the Neoliberal Project*. Sydney: Brill Publications.

Hyman, R. 1975. *Industrial Relations: A Marxist Introduction*. London: Palgrave Macmillan.

Hyman, R. 1981. Whatever Happened to Industrial Sociology? In: Dunkerley, D. and Salaman. G. eds. *The International Yearbook of Organization Studies 1981*. London: Routledge.

Hyman, R. 1987. Strategy or Structure? Capital, Labour and Control. *Work, Employment and Society*, 1 (1), pp. 25–55.

Hyman, R. 2007. How can trade unions act strategically? *Transfer: European Review of Labour and Research*, 13 (2), pp. 193–210.

Hyman, J. and Mason, B. 1995. *Managing Employee Involvement and Participation*. London: Sage.

IAM. 2021. International Association of Machinists and Aerospace Workers. *IAM Union Structures,* available at: https://www.goiam.org/about/ (accessed: 30 August 2021)

Innovation, Science and Economic Development Canada. 2018. *State of Canada's Aerospace Industry Report*. Innovation, Science and Economic Development Canada.

Invest Quebec. 2020. Aerospace: Touch Down in the Hear of the Action. Investissement Quebec, available at: https://www.investquebec.com/international/en/industries/aerospace/touch-down-in-the-heart-of-the-action.html (accessed: 26 March 2021)

Jenkins, J. 2007. Gambling partners? The risky outcomes of workplace partnerships. *Work Employment & Society,* 21 (4), pp. 635-652.

Jenkins, J. 2008. Pressurised partnership: a case of perishable compromise in contested terrain. *New Technology, Work and Employment,* 23 (3), pp. 167-180.

Juravich, T. 2007. Beating Global Capital: A Framework and Method for Union Strategic Corporate Research and Campaigns, in Bronfenbrenner, K. (ed.) *Global Unions: Challenging Global Capital Through Cross-Border Campaigns*. Ithaca, NY: Cornell University Press.

Kagermann, H. et al. 2013. *Recommendations for implementing the strategic initiative INDUSTRIE 4.0. Final report of the Industrie 4.0 working group*. Reprot: Plattform Frankfurt. Available at: http://www.acatech.de/fileadmin/user_upload/Baumstruktur_nach_Website/Acatech/root/de/Material_fuer_Sonderseiten/Industrie_4.0/Final_report__Industrie_4.0_accessible.pdf. (accessed: 03 May 2021)

Karppinen. K. and Moe H. 2019. Texts as Data I: Document Analysis. In: Van den Bulck H. et al. eds. *The Palgrave Handbook of Methods for Media Policy Research.* London: Palgrave Macmillan.

Katz, H. 1988. Policy Debates over Work Reorganisation in North American Unions. In: Hyman, R. and Streeck, W. eds. *New Technology and Industrial Relations.* Oxford: Basil Blackwell.

Klosowski, T. 2022. There's (Probably) Nothing You Can Do About the New Bossware That's Spying on You. NYTimes 06-06-2022. Available at: https://www.nytimes.com/wirecutter/blog/what-to-do-about-bossware-employee-monitoring/ (accessed: 21 September 2022)

Kozhaya, N. 2015. The consequences of a strong union presence in Quebec. *Montreal Economic Institute: Economic Note*. Available from: https://www.iedm.org/files/sept05_en.pdf (accessed: 29 October 2021)

Knights D. 1990. Subjectivity, Power and the Labour Process. In: Knights D., Willmott H. eds. *Labour Process Theory. Studies in the Labour Process,* pp297—335. Palgrave Macmillan, London.

Knights, D. and Willmott, H. 1988. *New Technology and the Labour Process*. Palgrave Macmillan, London.

Kraus, H. 1985. *The Many and the Few: A Chronicle of the Dynamic Auto Workers.* Urbana, Illinois: University of Illinois Press.

Kvale, S. 1996. *Interviews: An introduction to qualitative research interviewing*. Thousand Oaks, CA: Sage.

Lee, T. 2017. Artificial intelligence is getting more powerful, and it's about to be everywhere. *Vox*. Available at: www.vox.com/new-money/2017/5/18/15655274/google-io-aieverywhere (accessed 01 February 2022).

Lévesque, C. et al. 2021. *Industry 4.0, the Future of Work, and Skills Building Collective Resources for the Canadian Aerospace Industry*. Government of Canada's Future Skills Program: Ottawa. Volume I. London: CSE Books.

Lévesque, C. and Murray, G. 2010. Understanding Union Power: Resources and Capabilities for Renewing Union Capacity. *Transfer: European Review of Labour and Research*, 16, pp. 333-350.

Levidow, L. and Young, B. 1981. *Science, Technology and the Labour Process: Marxist Studies, Volume I.* London: CSE Books.

Levidow, L. and Young, B. 1983. *Science, Technology and the Labour Process: Marxist Studies, Volume 2*. London: CSE Books.

Liang, M. 2021. A study of the labor process from a technology transformation perspective: the case of internet virtual teams. *Chinese Sociology*, 8 (22).

Lipton, C. 1967. *The Trade Union Movement of Canada 1827-1959.* Toronto: NC Press.

Littler, C.R. and Salaman, G. 1982. Bravermania and Beyond: Recent Theories of the Labour Process. *Sociology,* 16(2) pp. 251-269.

Lupton, T.1963. *On the Shop Floor*. Oxford: Pergamon

Lüthje, B. and Butollo, F. 2017. Why the Foxconn Model Does Not Die: Production Networks and Labour Relations in the IT Industry in South China. *Globalizations*, 14:2, 216-23

Mandel, E. 1976. Introduction: Results of the Immediate Process of Production. In: Marx, K. 1916. *Capital Volume I*. London: Penguin. pp. 942—947.

Mason, P. 2015. *Post Capitalism: a guide to our future*. London: Allen Lane.

Marchington, M. 2005. Employee Involvement: Patterns and Explanations. In: Harley, B. et al. eds. *Participation and Democracy at Work.* London: Palgrave MacMillan.

Marglin, S. A. 1974. What Do Bosses Do? The Origins and Functions of Hierarchy in Capitalist Production. *Review of Radical Political Economics*, 6 (2), pp. 60–112

Marshall, R. C. and Merlo, A. 2004. Pattern Bargaining. *International Economic Review*, 45 pp. 239-255.

Martin, S. 2021. Cars, trains and ships: Albanese pledges $15bn fund for Australian manufacturing jobs. *The Guardian,* 30-03-2021. Available at: https://www.theguardian.com/australia-news/2021/mar/30/cars-trains-and-ships-albanese-pledges-15bn-fund-for-australian-manufacturing-jobs (accessed 23 November 2022)

Martinez Lucio, M. 2010. Labour Process and Marxist Perspectives on Employee Participation. In: Wilkinson et al. eds. *The Oxford Handbook of Participation in Organizations*, pp. 105—130.

Martinez Lucio, M. et al. 2021. New technology, trade unions and the future: not quite the end of organised labour. *Revista Española de Sociología*, 30 (3).

Martinez Lucio, M. and Stewart, P. 1997. The Paradox of Contemporary Labour Process Theory: The Rediscovery of Labour and the Disappearance of Collectivism. *Capital & Class*, 21 (2) pp. 49–77.

Martinez Lucio, M. and Stuart, M. 2005. 'Partnership' and new industrial relations in a risk society: an age of shotgun weddings and marriages of convenience? *Work, Employment and Society*, 19(4) pp. 797–817.

Martinez Lucio, M. and Weston, S. 1992. The Politics and Complexity of Trade Union Responses to New Management Practices. *Human Resource Management Journal*, 2 pp. 77-91.

Marx, K. 1976. *Capital Volume I.* London: Penguin.

Marx, K. and Engels, F. 1974. *The German Ideology,* 2nd edn. Arthur, C. J. ed. London: Lawrence and Wishart

Mars, G. 1973. Chance, Punters and the Fiddle: Institutionalised Pilferage in a Hotel Dining Room. In Warner, M. ed. *The Sociology of the Workplace*. London: Allen and Unwin

Mayring, P. 2014. *Qualitative content analysis: theoretical foundation, basic procedures and software solution*. Klagenfurt. Available at: https://nbn-resolving.org/urn:nbn:de:0168-ssoar-395173 (accessed 13 December 2022).

McCann et al. 2010. Restructuring Managerial Labour in the USA, the UK and Japan: Challenging the Salience of 'Varieties of Capitalism.' *British Journal of Industrial Relations,* 48 (2) pp. 347-374

McKinlay, A. and Taylor, P. 1994. Privatisation and industrial relations in British shipbuilding. *Industrial Relations Journal*, 25 (4) pp. 293.

Meaney, T. 2022. Fortunes of the Green New Deal. *New Left Review,* 138 Nov/Dec 2022 pp. 79—122

Meiksins, P. 1994 'Labor and Monopoly Capital for the 1990's: A Review and Critique of the Labor Process Debate.' *Monthly Review*, 46 pp. 45–59.

Milkman, R. 1997. *Farewell to the Factory: Auto workers in the late twentieth century.* Berkeley: University of California Press.

Mills, C. W. 1999. *The Sociological Imagination.* London, Oxford University Press.

Moeuf, A. et al. 2018. The industrial management of SMEs in the era of Industry 4.0. *International Journal of Production Research,* 56 (3), pp. 1118–1136.

Morgan, G., and Hauptmeier, M. 2021. The Social Organization of Ideas in Employment Relations. *ILR Review*, 74 (3) pp. 773–797.

Morissette, L. and Charest, J. 2010. Variétés de capitalisme ou entrepreneurs institutionnels. [Varieties of capitalism or contractors institutional? An application to the cases of subcontracting and formation of the hand work in Quebec]. *Canadian Sociological Review* 47 (3) pp. 225—45

Morton, D. 1998. *Working People: An Illustrated History of the Canadian Labour Movement.* 4th Edition. Montreal and Kingston: McGill-Queen's University Press.

Movitz, F. and Allvin, M. 2017. Changing Systems, Creating Conflicts: IT-related Changes in Swedish Banking. In: Eds: Briken et al: *The New Digital Workplace: How Technologies Revolutionise Work.* Basingstoke: Palgrave Macmillan. pp. 132—151.

Murolo, P. and Chitty, A. B. 2001. *From the Folks Who Brought You the Weekend: A Short, Illustrated History of Labor in the United States*. New York: The New Press.

Murphy, G., and Cullinane, N. 2021. Performance management technologies and trade union responses: A case study from banking. *New Technology, Work and Employment*, 36 (3) pp. 285-306.

Murray, G. et al. 2013. Workplace representatives: strategic actors of union renewal? *Industrial Relations Journal*, 44 (4) p. 340-354.

Musante, K. and DeWalt, B.R. 2011. *Participant Observation: A Guide for Fieldworkers*. Plymouth: AltaMira Press.

Newsome, K. 2015. Value in Motion: Labour, Logistics and the Contemporary Political Economy. In: Newsome, K. et al. eds. *Putting Labour in its Place*. Palgrave MacMillan: Basingstoke.

Nichols, T. and Beynon, H. 1977. *Living with Capitalism: Class Relations and the Modern Factory.* London: Routledge & Kegan Paul.

Nicholson, et al. 2017. Unions and collective bargaining in Australia in 2016. *Journal of Industrial Relations,* 59 (3) pp. 305–322

Noble, D. 1984. *Forces of Production: A Social History of Automation.* New Jersey: Transaction Publications.

O'Mahoney, J. 2016. Putting Critical Realism into Practice. *Critical Realism Network*, http://criticalrealismnetwork.org/2016/01/11/putting-critical-realism-into-practice/ (last accessed: 21 September 2022)

OECD. 2017. Employment Outlook 2017. Report: The Organisation for Economic Co-operation and Development, Paris.

OECD. 2021. *What happened to jobs at high risk of automation?* Report: The Organisation for Economic Co-operation and Development, Paris.

Oliver, D. and Walpole, K. 2018. Subject to qualification: Weakening links between job roles and qualifications in Australian manufacturing enterprise agreements. *Journal of Industrial Relations*, 60 (4), pp. 517–537.

Oltmann, S. 2016. Qualitative Interviews: A Methodological Discussion of the Interviewer and Respondent Contexts. *Forum: Qualitative Social Research,* 17 (2).

Ontario Aerospace Council. 2019. *Ontario Aerospace, Space, Defence, UAV And MRO: 2019 Capabilities Directory.* Toronto: Ontario Aerospace Council.

Orlikowski, W. J. 2007. Sociomaterial Practices: Exploring Technology at Work. *Organization Studies* 28, pp. 1435–1448

Palmer, B. D. 1999. Before Braverman: Harry Frankel and the American workers' movement. *Monthly Review*. 50 (8) pp. 33–46.

Pardi, T. et al. 2020. Digital manufacturing revolutions as political projects and hypes: evidence from the auto sector. *ILO Working Paper 3*. Geneva, International Labour Organisation.

Parker, M. 2008. Are Industrial Unions Better than Craft? Not Always. *Labor Notes,* August 25, 2008. Available at: https://labornotes.org/2008/08/are-industrial-unions-better-craft-not-always (last accessed 09 January 2023)

Patton, M. Q. 1999. Enhancing the quality and credibility of qualitative analysis. *Health Services Research*, 34 (5 pt 2) pp. 1189–1208

Penn, B. and Diaz, J. 2019. New NAFTA's Labor Terms Sway AFL-CIO, But Not All Unions on Board. *Bloomberg Law*. Available at: https://news.bloomberglaw.com/daily-labor-report/new-naftas-labor-terms-sway-afl-cio-but-not-all-unions-on-board (accessed: 07 April 2021)

Perline, M.M. Union views of managerial prerogatives revisited: The prospects for labor-management cooperation. *Journal of Labor Research,* 20 pp. 147–154

Perlman, M. 1961. *The Machinists: A New Study in American Trade Unionism.* Cambridge, Massachusetts: Harvard University Press.

Pfiefer, S. 2017. Industry 4.0 in the Making—Discourse Patterns and the Rise of Digital Despotism. In: Eds: Briken et al: *The New Digital Workplace: How Technologies Revolutionise Work.* Basingstoke: Palgrave Macmillan. pp. 62—88.

Phillippi, J. and Lauderdale, J. 2018. A Guide to Field Notes for Qualitative Research: Context and Conversation, *Qualitative Health Research*, 28 (3), pp. 381–388.

Pitts, F. H. and Dinnerstein, A. 2021. *A World Beyond Work? Labour, Money and the Capitalist State Between Crisis and Utopia.* London: Emerald.

Porter, M. E. and Heppelmann, J. E. 2015. How Smart, Connected Products Are Transforming Companies. *Harvard Business Review*. Available at: https://hbr.org/2015/10/how-smart-connected-products-are-transforming-companies (accessed: 28 October 2023)

Rainnie, A. 2021. Technology and Deglobalisation: A Sceptical View. *Future of Work,* available at: https://futuresofwork.co.uk/2021/03/16/industry-4-0-3d-printing-and-deglobalisation-a-sceptical-view/ (accessed: 14 November 2021)

Rainnie, A. and Dean, D. 2020. Industry 4.0 and the Future of Quality Work in the Global Digital Economy. *Labour & Industry: A Journal of the Social and Economic Relations of Work*, 30 (1).

Ramsay, H. 1977 Cycles of Control: Worker Participation in Sociological and Historical Perspective, *Sociology*, 11 (3) pp. 481–506.

Reeves, C.L., 2010. A difficult negotiation: Fieldwork relations with gatekeepers. *Qualitative Research*, 10 (3), pp.315-331.

Rinehart, J. et al. 1997. *Just Another Car Factory? Lean production and its discontents.* Ithaca: IRR Press.

Rodden, R. G. 1984. *The Fighting Machinists: A Century of Struggle.* Washington D.C.: Kelly Press Inc.

Rosenfeld, H. 2022. Lean Production Is Not a Solution. *Catalyst Journal,* 6 (1) Spring 2022.

Ross, L. 2020. *Stuff the Accord! Pay Up! Workers' Resistance to the ALP-ACTU Accord*. Melbourne: Interventions Inc.

Roy, D. 1952. Quota restriction and goldbricking in a machine shop. *American Journal of Sociology*, 57 pp. 427–442.

Russell, R., et al. 2019. Qualification and certification of metal additive manufactured hardware for aerospace applications. In: Froes, F. and Boyer, R. eds., *Additive manufacturing for the aerospace industry.* Sydney: Elsevier Publishing. Pp. 33-66.

Rutherford, T. and Frangi, L. 2020. Is Industry 4.0 a Good Fit for High Performance Work Systems? Trade Unions and Workplace Change in the Southern Ontario Automotive Assembly Sector. *Relations Industrielles/Industrial Relations* 75(4) pp. 751-773

Saldana, J. 2013. *The coding manual for qualitative researchers*. London: SAGE.

Salpukas, A. 1990. Labor Overcame Differences to Hammer Out a UAL Bid. *The New York Times,* April 9th 1990, available at: https://www.nytimes.com/1990/04/09/business/labor-overcame-differences-to-hammer-out-a-ual-bid.html (accessed: 01 July 2022)

Savage, L. 2021. The NDP turns 60: It's never truly been the political arm of organized labour. *The Conversation,* 27 June 2021. Available at: https://theconversation.com/the-ndp-turns-60-its-never-truly-been-the-political-arm-of-organized-labour-161964 (accessed: 11 November 2021)

Sayer, A., 1992. *Method in social science: A realist approach*. Psychology Press.

Scott, A. 2013. Australia Reconstructed. In: Reeves, A. and Dettmer, A. eds. *Organise, educate, control: the AMWU in Australia, 1852 – 2012*. Melbourne: University of Melbourne Press.

Schorpf, P. et al. 2017. On Call for One's Online Reputation—Control and Time in Creative Crowdwork. In: Briken et al. eds. *The New Digital Workplace: How Technologies Revolutionise Work.* Basingstoke: Palgrave Macmillan. pp. 89—112.

Schwab, K. 2016. *The Fourth Industrial Revolution.* Genova: World Economic Forum.

Scullion, H. and Edwards, P. K. 1988. *The Social Organization of Industrial Conflict. Control And Resistance in The Workplace.* Oxford, Basil Blackwell.

Seale, C. 1999. Quality in Qualitative Research, *Qualitative Inquiry*, 5(4), pp. 465–478.

Seligman, B. 1966. *Most Notorious Victory: Man in an Age of Automation*. New York: Free Press.

Snell, D. et al. 2022. Militarising Australian Industrial Policy: A Dead End? *Futures of Work,* Issue 21. Available at: https://futuresofwork.co.uk/2022/02/10/militarising-australian-industrial-policy-a-dead-end/ (last accessed: 18 June 2022)

Sniderman, B. et al. 2016. Industry 4.0 and manufacturing ecosystems. *Deloitte,* Report. Available at: https://www2.deloitte.com/tr/en/pages/manufacturing/articles/industry-4-0-manufacturing-ecosystems-exploring-world-connected-enterprises.html (accessed 17 December 2021)

Sochor, Z. A. 1981. Soviet Taylorism Revisited. *Soviet Studies*, 33 (2) pp. 246-264.

Spencer, D. A. 2000. Braverman and the Contribution of Labour Process Analysis to the Critique of Capitalist Production - Twenty-Five Years on. *Work, Employment and Society*, 14 (2), pp. 223–243.

Stanford, J. 1999. Labour-Sponsored Funds; An Orwellian Charade*. Canadian Dimension Publication*. Available at: https://www.thefreelibrary.com/Labour-Sponsored+Funds%3B+An+Orwellian+Charade-a056750805 (accessed: 04 February 2023)

Stanford, J. 2015. Towards an activist pedagogy in heterodox economics: The case of trade union economics training. *Journal of Australian Political Economy*, 75 (1) pp. 233-55.

Stanford, J. 2019. Looking Back on a Moment of Truth. In: Wilson, F. *A New Kind of Union: Unifor and the birth of the modern Canadian union.* Toronto: Lorimer James and Company Ltd.

Stanford, J. 2020. The Robots are NOT Coming (And why that's a bad thing…). Report: *Centre for Future of Work,* available at: https://www.futurework.org.au/the_robots_are_not_coming (accessed: 06 February 2022)

Stanford, J. 2022. Ideas into Motion: Progressive Economics and Social Change Movements. In: Stilwell, F. et al. eds. *Handbook of Alternative Theories of Political Economy*. Edward Elgar Publishing.

Stanford, J. and Bennett, K. 2021. Bargaining Tech: Shaping New Technologies to Improve Work, not Devalue It. *Centre for Future Work,* available at: https://centreforfuturework.ca/2021/06/15/bargaining-tech/ (accessed 13 October 2022)

Stewart, P. and Martínez Lucio, M. 1998. Renewal and tradition in the politics of production. In: Thompson, P. and Warhurst, C. eds. *Workplaces of the Future*. London: Macmillan. pp. 65–83.

Statistics Canada. 2017. Table 27-10-0367-01 Use of advanced or emerging technologies by industry and enterprise size. *Statistics Canada*. Available at: https://doi.org/10.25318/2710036701-eng (accessed: 23 August 2021)

Statistics Canada. 2022. Table: 14-10-0129-01 Union status by geography. *Statistics Canada*. Available at: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1410012901 (accessed 20 January 2022)

Steigerwald, D. 2010. Walter Reuther, the UAW, and the dilemmas of automation. *Labor History*, 51 (3) pp. 429-453.

Streeck, W. 2009. *Re-Forming Capitalism: Institutional Change in the German Political Economy.* Oxford: Oxford University Press.

Streeck, W. 2012. How to Study Contemporary Capitalism? *European Journal of Sociology*, 53(1), 1-28.

Sunyaev, A. 2020. *Internet Computing*. New York: Springer Publisher.

Sweezy, P. 1974. Foreword by M. Sweezy. In: Braverman, H. 1974. *Labor and monopoly capital: the degradation of work in the twentieth century.* New York & London: Monthly Review Press, 1974.

Tanguay, B. 1984. Concerted action in Quebec, 1976–1983: Dialogue of the deaf. In: A.G. Gagnon ed. *Quebec. State and Society*. New York, NY: Methuen. pp. 365–385.

Tao, F. et al. 2019. Digital Twins and Cyber–Physical Systems toward Smart Manufacturing and Industry 4.0: Correlation and Comparison. *Engineering,* 5(4) pp. 653-661.

Taylor, P. and Bain, P. 2001. Trade Unions, Workers' Rights and the Frontier of Control in UK Call Centres. *Economic and Industrial Democracy*, 22 (1), pp. 39–66.

Taylor, S. and Land, C. 2014. Organizational anonymity and the negotiation of research access. *Qualitative Research in Organizations and Management*, 9 (2), pp. 98-109

Touraine, A. 1955. *L'évolution du travail ouvrier aux usines Renault*. Paris: CNRS.

Thomas, R. and Davies, R. 2005. What Have the Feminists Done for Us? Feminist Theory and Organisational Resistance. *Organization,* 12 pp. 711—40

Thomas, H., & Turnbull, P. 2021. Navigating the Perilous Waters of Partisan Scholarship: Participatory Action Research (PAR) with the European Transport Workers' Federation (ETF). *Work, Employment and Society, 1 (2).*

Thompson, D. 2015. A World Without Work. *The Atlantic,* July/August 2015 Issue. Available at: https://www.theatlantic.com/magazine/archive/2015/07/world-without-work/395294/ (accessed: 20 December 2022)

Thompson, P. 1983. *The Nature of Work: An introduction to debates on the labour process*. London: Palgrave.

Thompson, P. 1990. Crawling from the Wreckage: The Labour Process and the Politics of Production. In: Knights D., Willmott H. eds. *Labour Process Theory. Studies in the Labour Process*. Pp.95—124. London: Palgrave Macmillan.

Thompson, P. 2003. Disconnected Capitalism: Or Why Employers Can't Keep Their Side of the Bargain. *Work, Employment and Society*, 17(2), pp. 359–378.

Thompson, P. 2007. Adler's Theory of the Capitalist Labour Process: A Pale(o) Imitation. *Organization Studies,* 28 (9) pp. 1359-1368.

Thompson, P. 2013. Financialization and the workplace: extending and applying the disconnected capitalism thesis. *Work, Employment and Society*, 27(3), 472–488.

Thompson, P. and Ackroyd, S. 1995. All Quiet on the Workplace Front? A Critique of Recent Trends in British Industrial Sociology. *Sociology*, 29 (4) pp. 615–633.

Thompson, P. and Bannon, E. 1985. *Working the System: the Shopfloor and New Technology.* London: Pluto Books.

Thompson, P. and Laaser, K. 2021. Beyond technological determinism: revitalising labour process analyses of technology, capital and labour. *Work in the Global Economy*, 1 (1-2) pp. 139-159.

Thompson, P. and Smith, C. 2010. Debating Labour Process Theory and the Sociology of Work. In: Eds: Thompson, P. and Smith, C. *Working Life: Renewing Labour Process Analysis*. London: Palgrave Macmillan.

Thompson, P. and Vincent, S. 2010. Labour Process and Critical Realism. In: Eds: Thompson, P. and Smith, C.: *Working life: renewing labour process analysis*. Basingstoke: Palgrave Macmillan. pp. 47-69.

Turnbull, P. 2022. Slow, slow, quick, quick, slow: The 'thick and thin' of comparative (statactivist) research with a European trade union federation. *European Journal of Industrial Relations*, 28 (4) pp. 427–449.

Turner, I. 1967. *Sydney's Burning.* Sydney: Alpha Books.

Turner, L. 1991. *Democracy at Work: Changing World Markets and the Future of Labor Unions.* New York: Cornell University Press.

Unifor, 2018. *The Future of Work Is Ours: Confronting risks and seizing opportunities of technological change.* Toronto: Unifor. Available at: unfor.org/futureofwork (accessed: 06 June 2021)

Unifor, 2019. *Unifor Aerospace Bylaws*. Toronto: Unifor.

Veen, A. et al. 2020. Platform-Capital's 'App-etite' for Control: A Labour Process Analysis of Food-Delivery Work in Australia. *Work, Employment and Society*, 34 (3), pp. 388–406.

Vidal, M. 2007. Manufacturing empowerment? 'Employee involvement' in the labour process after Fordism. *Socio-Economic Review*, 5 (2) pp. 197–232.

Vidal, M. 2014. Incoherence and Dysfunctionality in the Institutional Regulation of Capitalism. In: Eds. Vidal, M. Hauptmeier, M.: *Comparative Political Economy of Work.* London: Palgrave. pp. 73-97.

Vidal, M. 2017. Lean Enough: Institutional Logics of Best Practice and Managerial Satisficing in American Manufacturing. *Socius*, 3.

Vidal, M. 2019: Contradictions of the labour process, worker empowerment and capitalist inefficiency. *Historical Materialism,* 28 (2) pp. 170—204.

Vidal, M. 2022a. The Politics of Lean Production. *Catalyst Journal,* 5 (4).

Vidal, M. 2022b. Which Way Forward Labour? *Catalyst Journal,* 6 (4) pp. 137—155.

Vidal, M. and Hauptmeier, M. 2014. Comparative Political Economy and Labour Process Theory: Toward a Synthesis. In: Vidal, M. & Hauptmeier, M. eds.: *Comparative Political Economy of Work.* London, Palgrave. pp. 1—32.

Walton, R. E. et al. 2000. *Strategic Negotiations: A Theory of Change in Labor-Management Relations.* New York: Cornell University Press.

Walton, R. E. and McKersie, B. 1965. *A Behavioral Theory of Labor Negotiations: An Analysis of a Social Interaction System*. New York: McGraw-Hill.

Wells, D. 1997. When push comes to shove: Competitiveness, job insecurity and labour-management co-operation in Canada. *Economic and Industrial Democracy*, 18 pp. 167-200.

Wiles, R. et al. 2008. The Management of Confidentiality and Anonymity in Social Research, *International Journal of Social Research Methodology*, 11 (5) pp. 417-428

Wilkinson, B. 1983. *The Shopfloor Politics of New Technology*. London: Heinemann Educational.

Will-Zocholl, M. 2017. Virtual Temptations: Reorganising Work under Conditions of Digitisation, Virtualisation and Informationisation. In: Briken et al. eds.*: The New Digital Workplace: How Technologies Revolutionise Work.* Basingstoke: Palgrave Macmillan. pp.62—88.

Willis, E. 1988. *Technology and the labour process: Australasian case studies*. Sydney: Allen & Unwin.

Willmott H. 1990. Subjectivity and the Dialectics of Praxis: Opening up the Core of Labour Process Analysis. In: Knights D., Willmott H. eds.: *Labour Process Theory. Studies in the Labour Process.* Macmillan, London. pp. 336-378. Palgrave

Wilson, H. J. et al. 2016. How Companies Are Using Machine Learning to Get Faster and More Efficient. *Harvard Business Review,* May 03 2016, Available at: https://hbr.org/2016/05/how-companies-are-using-machine-learning-to-get-faster-and-more-efficient (accessed 20 December 2021)

Wilson, F. 2019. *A New Kind of Union: Unifor and the birth of the modern Canadian union*. Toronto: James Lorimer & Company.

Womack, J.P. et al. 1990. *The Machine that Changed the World.* New York: Macmillan.

Woodward, J. 1965. *Industrial organization theory and practice*. Oxford: Oxford University Press

Yeginsu, K. 2018. If Workers Slack Off, The Wristband Will Know (and Amazon has a patent on it.) *The New York Times,* July 18 2018. Available at: https://www.nytimes.com/2018/02/01/technology/amazon-wristband-tracking-privacy.html (Accessed 09 April 2022)

Yin, R. 2009. *Case study research: design and methods*. 4th Edition. London: Sage Publishers.

APPENDICES

Appendix 1: Request for Access

Research Summary:
EXPLORING THE MANAGERIAL AND EMPLOYMENT CONSEQUENCES OF TECHNOLOGICAL CHANGE IN THE MANUFACTURING INDUSTRY.

Research:
Recent rapid technological change has caused widespread speculation about how these changes might impact the world of work. In the manufacturing sector new technologies represent both a significant opportunity for improved productivity and better jobs, and a potential threat to incumbent market leaders and workers. The **objectives of my research** are to better understand:

1. **how technological change is reshaping the production process** in the aerospace sector;
2. how it is reshaping the roles of **managers and workers**; and
3. **how changes are being navigated** by managers, workers and trade unions.

This research will generate valuable insights for managers, workers and their organisations, including opportunities to improve workplace performance, organisational competitiveness and contribute to the broader discussion of technological change and the future of work.

Access Requested:
To achieve the objectives identified above, this research will involve two main types of data collection:

- First, this research will involve **interviews with a selection of managers, engineers and workers** to discuss how technology is changing the production process and work organisation. Ideally, this will involve **around 25-30 interviews with staff from your factory** each lasting **around 45 minutes.**
- Second, **I hope to observe the factory floor (perhaps through a guided factory tour)** in order to view the production process in person.

Voluntary and Anonymous Participation:
No managers or employees would be obliged to participate in this research, and participants would be free to withdraw at any time without explanation. When permission is given, interviews will be recorded and transcribed. Reasonable steps will be taken to anonymise the information collected so that individuals cannot be identified. Information gathered through interviews and observation are for the purposes of this research only and will not be shared with anybody besides the undersigned researchers.

Outcomes of the Research:

This research is part of my doctoral research and will be used as the main data source for my thesis. In addition to my thesis, information gathered will be used to inform academic publications and presentations. In addition to academic publications, **I will also write research reports summarising my findings for research participants**. This will include a report for managers summarising my findings, outlining how workers and managers are experiencing technological change and how they feel it can be best managed by the organisation. Please do not hesitate to contact me if us if you have any questions.

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Appendix 2: Sample Interview Guide

Indicative List of Interview Questions for Participants in PhD Project:

THE IMPACT OF TECHNOLOGICAL CHANGE ON JOBS IN THE MANUFACTURING SECTOR

INTERVIEW PHASE 1: CONTEXT

What is your position here at Laurier?

How long have you held the position?

Could you describe a normal day of work for you here? What tasks do you perform? Who else do you interact with?

INTERVIEW PHASE 2: PRODUCTION TECHNOLOGIES

Tell me about the key technologies involved in the production process here?

How have these technologies changed during your time working at Laurier?

How have the changes you have described impacted how production workers do their jobs? The skills you need to do their jobs? And the tasks they perform?

What changes are occurring at the moment to the technologies that shape how work is done here at Laurier?

INTERVIEW PHASE 3: THE PROCESS OF CHANGE

What is the process for deciding and implementing new production technologies here at Laurier?

Who oversees the decisions around what new technologies are adopted and the impact they have on jobs? What other people or groups of people are involved?

Do you feel you have much say over how technology changes in the factory?

What guides you in your approach to technological change in the workplace?

What do you think guides other people's decision making in these areas? (Workers; unions; engineers; other managers)

Is there sometimes reluctance or resistance to change? How do you manage this?

INTERVIEW PHASE 4: LOOKING FORWARD

Do you think aerospace can will ever transition to 'lights out' manufacturing as some industries have?

What do you think is the future of technological change in aerospace sector? (Industry 4.0?)

Appendix 3: Interviewee Consent Form

CONSENT FORM:

Technological change and job change in the manufacturing industry

This research examines how technological changes in the manufacturing industry are impacting management and jobs. More specifically, this research aims to examine how technological change in manufacturing industry is negotiated between management and employees and how it is reshaping the roles of managers and workers. This research will generate valuable insights for managers and workers including opportunities to improve workplace performance as well as contribute to the academic discussion of technological change and the future of work.

By signing this form, you agree to the following:

I understand that my participation in this project will involve an interview which will likely take between 30 and 60 minutes, and if I agree the interview will be recorded. You will be asked about your job, how your job has changed in recent years, how technology has changed your workplace, and how you see it developing in the future.

I understand that participation in this study is entirely voluntary and that I can withdraw from the study at any time without giving a reason.

I understand that I am free to ask any questions at any time. If for any reason I have second thoughts about my participation in this project, I am free to withdraw or discuss my concerns with Professor Marco Hauptmeier hauptmeierm@cardiff.ac.uk

I understand that the information provided by me will be held confidentially and securely. The information will be retained for up to 1 year and will then be anonymised, deleted or destroyed. I understand that if I withdraw my consent I can ask for the information I have provided to be anonymised/deleted/destroyed in accordance with the General Data Protection Regulation 2016.

I, _____(*NAME*) consent to participate in the study conducted by Daniel Nicholson, PhD Candidate (nicholsonda@cardiff.ac.uk) of Cardiff Business School, Cardiff University, under the supervision of Professor Marco Hauptmeier.

Signed:

Date: