Capitalism without Workers?

Technological and Economic Imperatives of Automation, Displacement and Efficiency in the Automotive Industry

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Abstract

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Parallel to the increasing use of nominally labour-saving technologies such as robots and AI, employment in the OECD automotive industry has increased steadily since the financial crisis. Such persistence of manufacturing employment in high-wage economies is only seldomly engaged in the ongoing "automation debate". In order to explain this persistence, this dissertation seeks to understand why firms make the automation decisions they do; hence, which factors determine the automation of a labour-process. Based on this understanding, it can in turn be answered why increasing automation does not appear to have resulted in the displacement of workers in the Austrian automotive industry over the past 15 years. To this end, a multi-method case study is conducted. The study, focusing on the period of 2009 to 2024, consists of a quantitative estimation of the effects of automation on productivity in the OECD automotive industry, and a qualitative analysis of the rationalities underlying automation decisions in Austrian automotive firms. Its results show that persistent manufacturing employment is explained by a "partiality of automation". This partiality rests on: output and productivity differentials, the production location and technology-use decisions of global manufacturing firms, the characteristics of the commodity to be manufactured, and class compromise on technology-use between workers and management. Furthermore, the analysis also shows, that the standard narratives on how these factors shape automation and work are incorrect or incomplete. Thus, in contrast to common narratives, in particular in mainstream economics and public debate, the accounts presented here extend a "socio-economic theory of automation and work", which is tentatively related to a recent literature on stagnation and inefficiency in the conclusion. The findings of this dissertation thus not only contribute to recent debates on automation and work and their socio-economic critique, but also an economic sociology of the antinomies of contemporary capitalism.

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Finally, I dedicate this work to my grandparents. My late grandmother, Amalia Krenn, who despite attending only primary school, like all my grandparents, utterly believed in the sanctity of learning. My late grandfather, Josef Fleischacker, who wished to be a shoemaker but was a farmer, however shrewd, all his life. Finally, my grandmother, Paula Karlovics, who did not have the opportunity to even consider a vocation, education or get a driver's license, but made a good life without either. I name my remaining late grandfather, Karl Ferschli, here as a reminder of times and convictions antithetical to life and progress, which appear to have once again arrived in full. The lives of all four are intimately wrapped up in my primary academic interest in work and its societal organisation, and consequently the interest of this dissertation.

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Hic Rhodus, hic salta

Benjamin Ferschli 25.4.2025

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1. Research interest

Recent developments in the fields of robotics and artificial intelligence have brought the social and economic causes and consequences of automation back to the fore of scientific and public debates. The primary interest in this "*Automation discourse*" (Benanav, 2020) derives from the potential effects such new technologies may have on work and employment, and in particular the fear of a de-stabilisation of wage-based societies based on technological unemployment (Mokyr et al., 2015, Frey 2020; Brynjolfsson and McAfee 2014; Ford 2015). Yet, even only considering the case of manufacturing, after two and half centuries of automation, more people are subsumed under industrial production processes globally than ever before in history (Pfeiffer, 2021). Today it is neither a world of massive technological unemployment nor exceeding leisure which we inhabit, but one of labour-intensive cobalt mines in the Global South and highly automated electric car factories, next to ruins of de-industrialisation, in the Global North. Worsening labour-shortages in the manufacturing sectors of the latter suggest that the prevalent crisis of work may lie in not having enough workers, rather than too few jobs (Butollo, 2024). To complicate matters further, the most recently discussed technological change, AI applications, appears to be applicable primarily in the displacement of creative tasks rather than the reduction of toil. Why then does work, and manufacturing work specifically, persist, despite the constant development of the productive forces, and why does this work continue to be intense, toilsome and tedious in many instances? Why does work not get *lighter* (Spencer, 2022)?

Since the 1990s, the "knowledge worker" was seen as the assured future of work in developed economies. Increasing globalisation and automation was thought to render the main task of "work" as the handling of information in the course of "immaterial" and "cognitive labour" (Hardt and Negri, 2000). The applicability of AI in precisely such fields of formerly assumed "hard to automate" knowledge work, such as text creation, editing and programming, rather than manufacturing or reproductive work, appears as an ironic twist to these visions. However, there was good reason to expect an end of manufacturing work, as it occupies a singular position in the socio-economic change associated with increasing automation.

Compared to agriculture, where employment was decimated in the course of its industrialisation in the 19th and 20th century, and the service sector, significant segments of which offer less possibility for displacement sui generis such as care work, the structured production- and labour-processes and increasing returns to scale of manufacturing[1] are predestined for automation. And clearly, a well-established history of de-industrialisation of the Global North has shown that based on already accomplished automation, interwoven with bouts of offshoring, the relative need for industrial work as share of total employment in high-wage countries has significantly fallen in comparison to its historical high-points. Despite this, however, many of the countries and sectors which show the highest degrees of automation today, are often also those which retain the relatively highest shares of manufacturing employment (Figure 12 to 17 in the appendix). Less than the displacement of workers and the reduction of wage-costs, it is unmet demand, worsening labour-shortages, and exogenous shocks such as the COVID

[1] Standard economic theory posits agriculture to have negative returns to scale due to increased burden on the soil, manufacturing to have increasing returns to scale and the service sector neutral returns, as prima facie more output requires more employees (two hairdressers rather than one etc.)

pandemic, which are increasingly given as causes for the automation decisions of firms, drawing into question basic supposition of a continued technological de-industrialisation of developed economies (Tita, 2022; O'Brien et al., 2021, Molina, 2021; Reiley, 2022).

Among manufacturing sub-sectors, the question of automation and employment is especially topical in the automotive industry for two reasons. First, since it is usually considered the technological frontier of manufacturing, the extent and effects of automation are likely especially pronounced (Jürgens et al., 1993; Boyer and Freyssenet, 2000). Secondly, due to the ambiguous consequences of its ongoing "*twin transition*" of digitalisation/automation and electrification/decarbonisation. Based on the first leg, workers are speculated to potentially be displaced in the course of labour-saving technological change and changing production methods, or re-instated due to re-shored production based on higher productivity (Cetrulo, 2023; Butollo and Staritz, 2022). Equally, the transition to the production of electric vehicles may increase employment in the course of re-shoring, or decrease it in the course of simpler production processes (Jetin, 2020).

The prospects of employment in the OECD automotive industry in particular, are further complicated by several parallel trends. The secular stagnation of productivity and growth (Copley, 2023; Benanav, 2020, Smith 2020, Goldin et al. 2022; OECD 2019) means a likely reduction of employment due to decreased output quantities. New tendencies of technological monopolisation (Rikap, 2021, Conyon et al., 2022, Summers, 2015; 2016) may equally limit the diffusion of productivity and thus employment. Finally, the pressures for industrial policies to address ecological breakdown (e.g. EU Net Zero Industrial Act, Mattioli et al., 2022) create contradictory desires of both decreasing resource-use while simultaneously maintaining production and employment.

Again, however, amidst these turbulent transformations and uncertainties, the average of total hours worked across the largest OECD automotive sectors has increased significantly between 2009 and 2019 (Figure 1). While one half of this increase shows the recovery to pre- financial crisis levels, the other half exceeds them. Figure 18 in the appendix illustrates the same for the general manufacturing sectors of these countries, which show a flatter trajectory of recovery leading up to a strong drop in 2019. Albeit turbulent, both figures appear more marked by drops during the financial crisis followed by different trajectories of recovery, rather than revolutionary or even tendential changes of labour-displacement associated with automation.

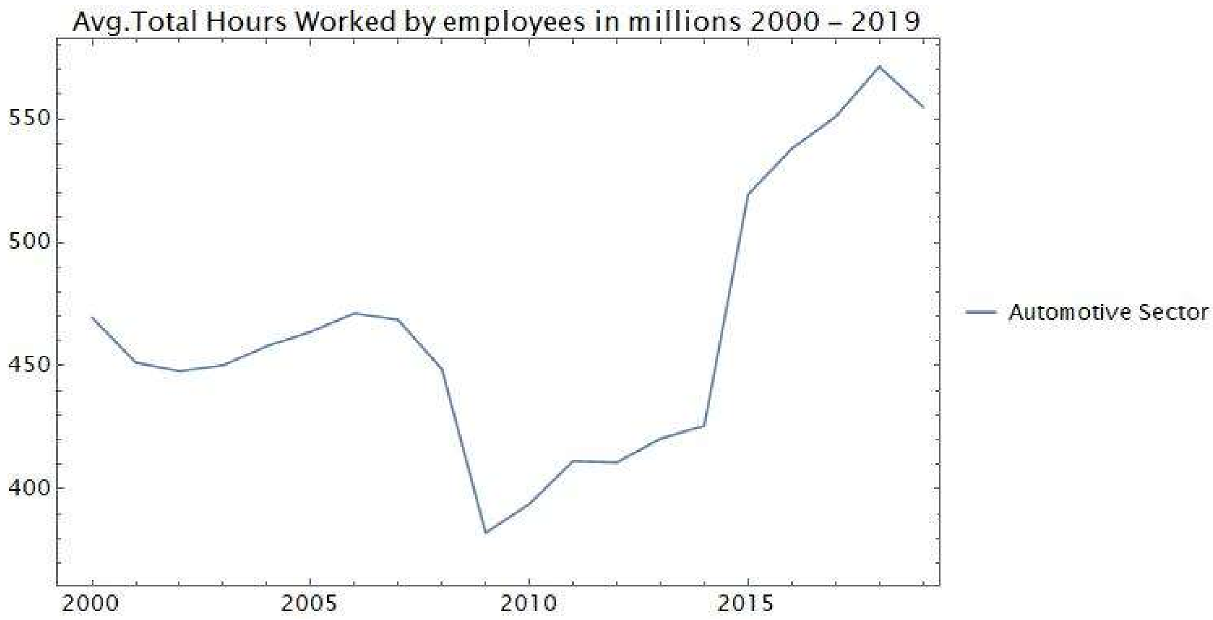

Figure 1: Average Hours Worked between 2000-2019 in the Automotive sectors of: Canada, Mexico, US, Japan, Austria, Germany, Spain, France, Italy, Netherlands, Portugal, UK, Sweden, CZ, Hungary, Poland, Romania, Slovakia, Slovenia, South-Korea, Turkey, Finland. Source: WIOD, OECD Stan and The Conference Board; own calculation.

In many of these OECD countries, automotive production has been a crucial motor of economic development in the 20th century (classically and most significantly: Germany, Japan, US). It is, however, precisely these countries which are now under pressure due to shifting core-periphery dynamics such as China's industrial development and production of electric vehicles. Within the OECD, the Central and Eastern European economies (CEE) show a similar shift. Relegated for a long time as the manufacturing "workbench" of the European core, this designation does not neatly apply anymore. Wage increases, upskilling and technological convergence have brought the automotive sectors of the Czech Republic, Slovakia, Slovenia and Poland much closer to the core of Europe, rendering their status as "(semi-) periphery" unclear (Olejniczak et al., 2020).

Within the CEE, Austria has a curious position, starting with the fact that it is sometimes considered part of this economic block and other times not. The Austrian automotive industry is similar to those of the CEE in that it is a supplier industry dependent on the larger home countries of OEMs[2], but is set apart in its more symbiotic relation to the German automotive industry, and production for the global premium segment. In this sense, the case of Austria represents an interesting avenue to study the effects of automation and employment as it faces both simultaneously: the pressures associated with being a peripheral supplier of parts and components, such as little leverage against large conglomerates and countries, as well as the pressures of technologically intensive premium segment exporters of the core.

The Austrian automotive industry also shows the same puzzle formulated above for the OECD: high wage levels, increasing automation, all next to relatively high manufacturing

[2] Original Equipment Manufacturers, in the automotive industry meaning the large brand names: BMW, Audi, Renault etc.

employment. As seen in Figure 2 below, between 2008 and 2021 employment in the manufacturing sector of Austria has increased by around 6%[3], and around 15%[4] in the automotive sector (figures 19 and 20 in the appendix show the sectors in separation). This period was marked by increasing dissemination of industrial robots (see chapter 4) and continued discussions on the necessity of European manufacturing to defend its „competitiveness“ (chapter 5). Austria's position as "high wage" country, and thus high likelihood of the continued offshoring of production capacities, next to its specialisation in parts production (chapter 6) and its simultaneously worsening labour-shortages (chapter 7)[5], reflect strangely on the persistence and increase of its automotive employment. A term to capture these contradictory tendencies is as a *„de-industrialisation paradox***"** (Kowall, 2021)**,** meaning the persistence of industrial employment in supposedly de-industrialised sectors and countries.

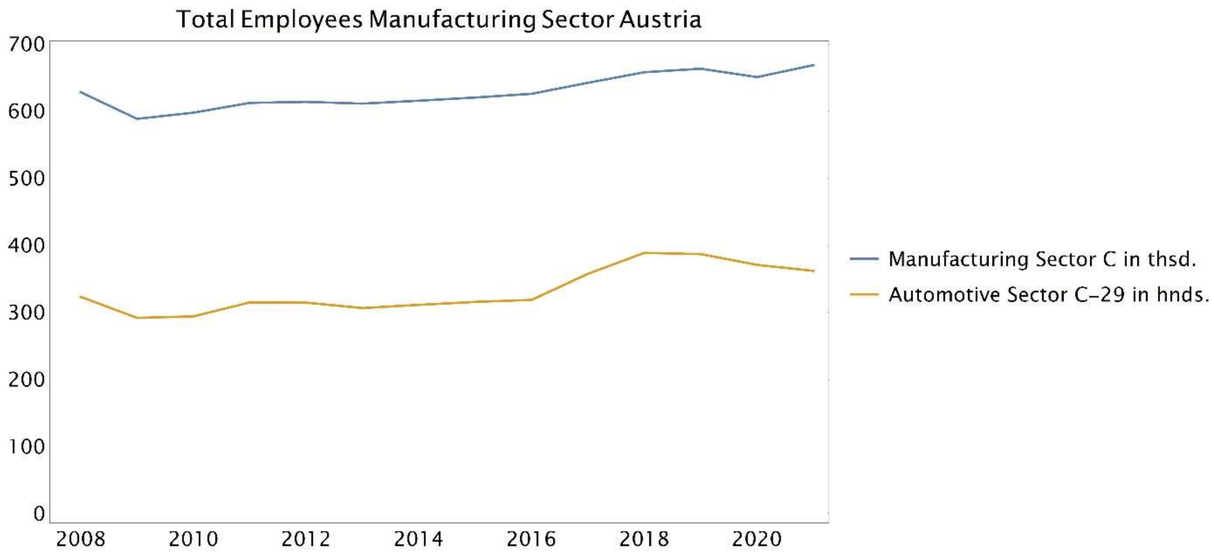

Figure 2: Employment in Austrian manufacturing 2008 to 2021, thsds in manufacturing, hnds in automotive. Source: Business Cycle Statistics of Manufacturing, Austrian Statistics Agency.

[3] NACE rev. 2- C, about 40.000 jobs
[4] NACE rev. 2-C-29, about 4.000 jobs
[5] https://ec.europa.eu/commission/presscorner/detail/en/ip_23_3704

It would be close at hand to conclude that this persistence of manufacturing employment is actually an uninspired problem and quite easily explained: rather than blue-collar workers on production lines, an increasing part of "manufacturing employment" simply consists of engineering and product development, or, less clear in terms of what type of work it actually is, the maintenance and repair of machinery. As figure 21 in the appendix shows, the ratio of those classified as undertaking manual manufacturing work (workers) and those performing clerical service work in manufacturing (employees) is indeed shifting in favour of the later in Austria. In the average Austrian manufacturing sub-sector, the ratio has changed from 1.6:1 in 2008, to 1.3:1 in 2021. In the Austrian automotive sector, it has decreased from 2:1 in 2008 to 1.6:1 in 2021. As shown in table 11 in the appendix, while total employment in the Austrian automotive industry has increased by 14,8% between 2008 and 2021, the number of workers has increased by 5,6%, whereas employees have increased by 38%. Hence, the increasing importance of clerical work in manufacturing cannot be denied. However, this does not mean that the interest of this dissertation is inconsequential. It is, after all, the 2/3 of total employment still made up of manual manufacturing workers, which are of interest here, as it is their work that prevalent theories consider most expendable. If automation is displacing manual work and reinstating service work, the former should decrease relative, if not in proportion at least in tendency, to the latter's increase, which it is not.

In addition, while the overall service content of industrial production may have increased (Fort et al., 2018), concepts such as "manufacturing footprint" (Scott, 2015) and "manufacturing adjacent service work" make clear that without material production and its associated jobs, the service jobs of administering said production would also not exist. Service activities in manufacturing are in this sense presently still an appendage to persistent manual work, rather than its replacement. Finally, it could also be claimed that the change of employment itself is rather small and thus insignificant, rendering the interest in it mute. The reply here is that really the question mark lies in *any* employment increase or persistence or any situation which does not constitute a sharp and continuous decline in manual manufacturing work.

The above two points also allow a clarification of the chosen title of this dissertation. The term “worker” used in the title, follows the German definition of “*Arbeiter*Innen*”, meaning those engaged in material, and manual work in manufacturing, as opposed to employees performing immaterial service activities (“*Angestellt*Innen*”). While the English distinction between “worker” and “employee” is related, it does not have the same theoretical boundaries and legal consequences. The notion of “capitalism without workers”, thus denotes the feasibility of material industrial production without manual labour. The persistence of manufacturing employment is only a puzzle if one considers such a notion of capitalist societies without work, or in the very least without manual manufacturing work, feasible in the first place. “Capitalism without workers” and the “persistence of manufacturing employment” are in this sense two sides of the same coin, or inverse formulations of each other.

2. Recent Debates and Research Questions

The causes of automation and its consequences for work and employment have been a traditional subject of research in Economic Sociology and Political Economy since their inception (Spencer, 2017). While automation has undoubtedly increased productivity and shrunk the relative share, if not absolute global number, of workers required in manufacturing over the past two-hundred-fifty years, the "de-industrialisation paradox" shows that recent developments appear less linear in how they affect the extent and content of industrial work. Several contributions over the past years have noted this general conundrum in different ways. Among the best-known is Autor (2015:5) who put it in the technical terms of economics: „*Why doesn't automation necessarily reduce aggregate employment, even as it demonstrably reduces labour requirements per unit of output produced*?".

The presently dominant theoretical approach in economics, to explain why a job is automated or not, and thus why, which kind of, manufacturing employment persists, is routine-biased technological change (RBTC). RBTC places the explanatory burden of automation on the routine-intensity of tasks, hence the more routine a job entails, the higher the likelihood and technological feasibility of its automation (Autor et al., 2001; Frey and Osborne, 2013). While intuitive, this view neglects many and competing reasons for automation on the shop-floors of manufacturing firms which cannot merely be surmised under the "routineness" of jobs. However, it is ultimately firms and how they weigh the relative importance of such reasons in making automation decisions which are the lynchpin for employment outcomes. The goal of this dissertation then is to understand why firms make the automation decisions they do, hence why some labour-processes come to be automated and others not. The guiding research question to focus this interest is: *If we really are currently living in an age of rapid automation, why is there still a high level of manufacturing employment in the automotive industry of a high-wage country like Austria?*

This dissertation answers this question in four parts, corresponding to four substantive chapters and four hypotheses focused on the causes of automation decisions in firms (productivity, competitiveness, routine-biased technological change, and control over workers and labour-processes). Each hypothesis, in turn, is discussed in relation to different controversies in the ongoing debate on automation and its effects on manufacturing work (productivity-paradox, re-shoring and the behaviour of global conglomerates, critiques of RBTC, low worker resistance to automation).

Before outlining the different potential answers to the overall research question, however, an exceedingly simple answer must be considered. It can be argued that firms simply make the automation decisions they do, and thus manufacturing employment persists, because that is what is most profitable. While this is very likely truthful to say in most cases and in the aggregate, as profits are a, if not the, defining motive of capitalist firms and unprofitable firms usually do not survive indefinitely, the assertion tells us nothing about how the motive itself is fulfilled or not, and why this affects automation decisions and employment outcomes in which way. Finding answers to precisely these questions, however, is what is of interest here. Much like the statement "everyone dies" is certainly correct, it does make a difference for individuals, groups and societies to understand how, when, why and for whom such death may occur or not, hence the study of population health and demographics.

2.1. Automation and Productivity Growth Stagnation

A first potential explanation for the persistence of manufacturing employment lies in labour-productivity. If recent automation has not led to increasing labour-productivity, as a recent literature on the "productivity paradox" argues, then it also may not have had a displacing effect on workers.

Generally speaking, increasing automation should mean more output with less work input, either saving costs on the latter or simply increasing the former. Both cases should result in higher productivity. If the output of production remains equal while productivity increases this must logically mean a reduction of employment, as (P)roductivity, (E)mployment and (O)utput form an accounting identity: P=O/E. If output is sufficiently increased alongside higher automation, meaning production is extended for whatever reason, employment may persist or even increase. In both cases, however, automation must be followed by an increase of labour-productivity.

A recent debate on a (new) "productivity paradox"[6] casts doubt on such productivity increasing effects of recent automation (Goldin et al. 2022; OECD 2019; Brynjolfsson et al. 2019/2021; Gordon 2015 and 2016). According to the paradox, labour productivity growth stagnated in OECD economies over the past two decades, precisely when, based on supposedly great technological strides[7] it should have sped up. This means, the

[6] The original Solow-Paradox stemming from the 1980s

[7] To name a few buzzwords: robots, Industry 4.0, digitalization, AI etc.- for a demarcation of these terms see chapter 3.

persistence of employment in OECD automotive sectors could be explained by stagnating productivity in connection with steady output. On the other hand, rising productivity could have safeguarded employment in highly automated sectors through lower unit-labour costs and thus higher output, which however, would cast doubt on the notion of productivity growth stagnation. Both propositions cannot be true at the same time.

Some contributions have argued that jobs persist in high-wage countries despite automation, precisely because resulting output have led to an increasing demand for work (Autor, 2015; Bessen, 2019). In its inverse, Benanav (2020) has argued that the de-industrialisation of the Global North is better understood as reduction of output, rather than an increase of productivity and automation.

The literature on productivity growth stagnation has several open questions, however. First and foremost is a continued debate on the causes of the slowdown, in particular the effects of new technologies and increasing monopolisation. It also remains unclear to what degree the identified stagnation applies on the sub-sectoral level, and how it developed following the financial crisis, a period which has seen significant employment increases in the OECD automotive industry, as shown earlier. In order to address these gaps, the first substantive analysis of this dissertation asks: *What effects did automation have on labour-productivity, output and hours worked in the largest OECD automotive sectors between 2010 and 2019?*

2.2. Automation and the Production Location Decisions of Firms

In a variation of firms' desire to increase productivity, the literature on "competitiveness" explains automation and employment outcomes based on the competitive dynamics between regions. Due to intense and increasing global manufacturing competition, for example, regions such as Austria, are argued to *have to* be more highly-automated than others, as labour-costs are exceptionally high. Hence, employment may persist because firms in the Austrian automotive industry are "competitive" and thus successful in the zero-sum game over global market shares, increasing automation, output and employment simultaneously. This would explain the persistence of manufacturing employment, as prolific economic performance.

On the other hand, also here firm-level strategies must be considered. It is likely that based on global functional specialisation and division of labour, Austrian firms occupy specialised functions in global commodity chains, such as innovation activities, product development and testing, which could allow employment to persist despite automation and high wages. A "lead plant" theory (Krzywdzinski, 2017; 2019 a,b) argues in this vein, that there is an advantage of global firms of retaining manufacturing plants near their origin country headquarters. One, due to the availability of high-skilled blue-collar workers, and two, due to the synergy effects of a close proximity of development and design departments. At such "lead plants" new products and technologies are tried and tested, thus requiring persistent employment.

In both cases, high and increasing degrees of automation should paradoxically safeguard employment in high-wage countries. However, in distinction to productivity, the competitiveness approach also considers that in particular in the automotive industry, sector-wide changes depend on the production location decisions of large global conglomerates. Despite many quantitative estimations in this literature, there is little research on how these firms practically navigate requirements of "competitiveness" in the course of automation, and how they fit into turbulent global production location decisions. The second substantive chapter therefore asks: *how do requirements of "competitiveness" determine automation and production location decisions in the Austrian automotive supplier industry?*

2.3. Automation and the Routine-Intensity of Tasks

Another possible explanation for persistent employment is the focus of the Austrian automotive industry on high-value added, complex activities and products, which cannot be automated. According to the dominant theory of routine-biased technology change (RBTC), firms automate routine-activities, hence, persistent manufacturing employment might simply consist of non-routine activities which are not technologically feasible to automate. A wider "polarisation thesis" based on this assertion argues precisely that the manufacturing work which persists in developed economies is split into diverging high-skill and low-skill poles, as the two ends of the spectrum show the highest share of non-routine activities (Goos, Manning and Solomons, 2014). Such non-routine activities may also include new jobs that automation itself reinstates, such as the maintenance, repair or engineering of machinery (Acemoglu and Restrepo, 2020)[8]. While economics largely subscribes to the notion of RBTC, contributions in sociology have critiqued it extensively (Krzywdzinski, 2022). Instead, sociological contributions have shown that there are many competing and divergent reasons for automation, and the weighing of cost and benefit between machine and worker is not as straightforward as assumed by micro-economic modelling (Krzywdzinski 2022; Pfeiffer, 2016; Butollo and Paiva, 2020). In what has been described as "rebound-effects of automation" (Butollo, 2024), for example, the

[8] It is, however, unlikely that an equal number of maintainers would be hired in exchange for the automation of a production line.

persistence of employment next to increasing automation is explained by factors such as the distinction between technological feasibility and actual use, and the increasing complexity of products and production.

Few contributions in the recent debate on the effects of automation, consider the ins and outs of the automation decisions at the firm level, with notable exceptions (Koepp, 2023; Butollo and Paiva, 2020; Butollo, 2024). In contrast to the maximally broad approach of these exceptions, however, the empirical focus of chapter 6 lies on the equally underrepresented perspective of engineers who have a privileged point of access as producers, implementers and consumers of new technologies (Gnisa 2025; Krzywdzinski et al., 2025, Steinhoff 2021). Ultimately, it is their labour-process of automating other labour-processes, and of mediating between technological feasibility and economic imperative, which is at stake in automation decisions. The analysis below is therefore guided by the research question: *Which factors do engineers consider decisive in the automation of labour-processes in the Austrian automotive industry?*

2.4. Automation and Worker Resistance

A final potential explanation for persistent employment investigated in this dissertation, is the role of worker consent and compromise in the use of new technologies. A large part of the literature in industrial sociology and industrial relations, most famously Labour-Process Theory, has traditionally focused on the function of automation to increase managerial control. This control allows the extraction of a maximum of labour-power from workers, and to discipline those who are in opposition to the goals or methods of management. Negative consequences of recent automation technologies for workers ,in line with this assumption, have been established, ranging from displacement to increased surveillance, intensification and deskilling (Butollo, et al., 2018, Carbonell, 2020, Pfeiffer, 2017). Historically, such negative consequences were the primary cause for opposition and sabotage (Hobsbawm, 1952). While recent contributions in economics argue, on the contrary, that strong unions and worker opposition to managerial goals are the main reason for automation (Acemoglu and Restrepo, 2024), there presently appears little opposition by workers and unions to begin with.

This raises the question whether and why workers and unions consent to technological changes, despite their negative consequences. Such consent in turn has significant bearing on the question of persistent manufacturing employment, in particular in Austria, as a country often designated as corporatist, with a strong social partnership in particular in manufacturing.

This hypothesis is intimately connected to the literature on how different social actors can shape the outcome of the implementation of new technologies (Thompson and Laaser, 2021, Hall 2010, Noble 1984), which ultimately boils down to the power relations in firms (Dosi et al., 2021). Management, for example may show conflicting priorities and prove internally divided on how to increase efficiency (Vidal, 2022), or unions and workers may have more or fewer resources to resist changes detrimental to them (Krzywdzinski, 2022). In order to shed light on the role of this hypothesis in persistent manufacturing employment, the final substantive chapter asks: *why do workers and unions in the Austrian automotive industry appear to not resist automation?*

3. Goal and Contributions

The goal of this dissertation is to extend our understanding of why firms make the automation decisions they do, the relative importance of different reasons in these decisions as well as their relevance for a downstream understanding of persistent employment in high-wage manufacturing sectors. In order to achieve this goal, this dissertation answers its proposed research question in four parts, corresponding to four substantive chapters and four hypotheses on the causes of automation decisions in firms (productivity, competitiveness, routine-biased technological change, and control over workers and labour-processes). Each hypothesis, in turn, is discussed in relation to different controversies in the ongoing debate on automation and its effects on manufacturing work (productivity-paradox, re-shoring and the behaviour of global conglomerates, critiques of RBTC, low worker resistance to automation).

The dissertation follows a multi-method research design and conducts a case study of the Austrian automotive supplier industry between 2009 to 2024. Addressing the research question through firm decisions is useful, because it is they who organise production by using technology and deciding on type and quantity of employed work, hence the engines of aggregate outcomes. Understanding the reasons for automation at the level of the firm thus supplies a seldomly engaged, compared to macro-economic estimations, but crucial perspective on how automation is changing work. The dissertation thereby contributes to the literature on the causes of automation and its consequences for work and employment in manufacturing, as well as the socio-economic critique of standard economic narratives of: productivity, competitiveness, routine, and trade-union opposition. Finally, it contributes to the sociology of work literature by discussing changes in an OECD automotive industry through shop-floor perspectives of workers and engineers.

4. Structure of Dissertation and Overview of Chapters

The goal of this chapter was to set out the research interest of this dissertation in the social and economic effects of recent automation. It has outlined a puzzle of a persistence of manufacturing employment in high-wage economies despite increasing automation. It has formulated an overarching research question based on this puzzle, focussing on the reasons for automation from the perspective of firms.

The following chapter 2 provides a more in-depth discussion of the already outlined theoretical propositions and literatures, and more formally derives hypotheses from these debates for persistent manufacturing employment.

Chapter 3 operationalises automation, and describes the multiple-method research design as well as the underlying case in greater depth. The data used in the empirical analysis are described in the corresponding substantive chapters, as well as the fieldwork and the methods for their analysis. The chapter concludes with a discussion of the limitations to this research based on data and method.

Chapter 4, the first empirical chapter, assess the relationship between automation (measured as number of robots per 10.000 workers) and labour-productivity (as output per hours worked), controlled by sectoral concentration (revenue share of the largest firms in a sector), in the largest automotive sectors of the OECD between 2010 and 2019. The estimated fixed-effects model shows that automation has increased labour-productivity in the manufacturing sector, but reduced it in the automotive sector. Explaining this counterintuitive result, the chapter shows that the results depend on the relative strength of "output" and "employment"-effects which in turn vary between countries of the "core" and "periphery" of the sample.

Chapter 5 presents the first part of the qualitative case study of the Austrian automotive supplier industry, while still focused on the "external" conditions of firm behaviour. The chapter begins by drilling down into the case of the Austrian automotive industry, specifying its industrial structure. It then discusses the role of "competitiveness" in automation and production location decisions. It starts from a definition of competitiveness, derived from the literature and affirmed by the statements of respondents, and proceeds with showing how this view is relativized by automation rationalities in three points: 1. the regional "parallelism" of automation strategies of Austrian automotive firms, 2. the dependence of automation possibility on firm size and 3. the hierarchy and dependence on automation decisions between different types of manufacturing firms.

Chapter 6 shows that firms do not behave as supposed by the theory of routine-biased technological change. On the technical side this is shown in three points: 1. that technological feasibility is not a central concern in automation decisions, 2. that "new" technologies such as artificial intelligence and collaborative robots are insignificant as extension of the technological feasibility of automating "routine" tasks, 3. that maximal automation strategies are found to not be desirable, even where feasible, due to their increased susceptibility to breakdown. On the economic side, this is equally shown based on three points: 1. that relative factor cost calculations are not as neat as assumed in micro-economic theory and the routine-content of tasks is too crude for understanding automation decisions, 2. that automation decisions are based to the largest extent on a "product imperative", meaning: what type of product is manufactured, how much of it, and with which type of process and 3. that financial pressures increasingly place significant limits on what is feasible to automate.

Chapter 7 discusses the role of worker and union resistance in automation decisions. The chapter finds that workers, their unions and works councils, concur with management on the need to automate. Representations of labour do oppose management on distributional policies, however without demands on how and what technology is implemented. The chapter explains the absence of opposition to automation based on 1. a reduced need for resistance based on the relative labour market strength of (some) automotive workers in Austria, 2. a reduced possibility of opposition of other automotive workers in Austria due to fragmentation.

Finally, chapter 8 concludes the dissertation by summarising the results and discussing their theoretical and empirical merit in advancing our understanding of the causes of automation and their employment outcomes. It underlines the contributions of the dissertation, spells out limits, and outlines avenues to further develop the arguments presented.

Chapter 2 - Causes of Automation and their Consequences for Manufacturing Employment

0. Summary

This chapter discusses the current state of the literature on the causes and consequences of automation in greater depth. Based on four current controversies, it derives four hypotheses for explaining persistent manufacturing employment in high-wage economies. The first section thereby discusses the role of productivity in explaining persistent employment, its complications through a recent productivity-paradox, as well as its potential causes. The second section, specifies this view to the criteria influencing the automation and production location decisions of global manufacturing firms, in particular the role of "competitiveness". Section three moves the analysis into a micro-level of production processes in firms, discussing routine-biased technological change, as well as its socio-economic critiques. Finally, section four discusses worker and union resistance to automation and its consequences for persistent manufacturing employment. While it is beyond the scope of this chapter to demarcate a complete and comprehensive theoretical framework which connects these four dimensions rigorously, the chapter concludes with interrelating the theoretical positions and hypotheses on its crucial points, thereby confirming and extending an existing "socio-economic theory of automation and work".

1. The Productivity Paradox and its Potential Causes

Debates on the development of manufacturing employment in the Global-North have been ongoing since the 1980s, most notably in analyses of "de-industrialisation**"** (Kollmeyer, 2009; Blackaby, 1979; Rawthorn and Ramaswamy, 1997; 1998). One of the most prominent theories in these debates argues, that it is the disproportionate labour-productivity growth of manufacturing, compared to the service sector, which explains the formers progressive decline in relative employment shares (Rowthorn and Ramaswamy, 1997; 1998; Baumol, 1967; Baumol et al., 1985). This theory of "*Unbalanced Productivity Growth*" (Kollmeyer, 2009)[9] has served as basis for a large number of empirical studies (Baumol et al., 1985; Rowthorn and Ramaswamy 1997, 1998; Rowthorn and Coutts 2004; Boulhol, 2004, Tregena 2014). However, most them rest on assumptions of steady output. If output were to increase next to labour-productivity, say due to decreasing prices of manufactured goods or increasing exports, this might *increase* manufacturing employment or allow it to persist. For de-industrialisation to take place, therefore, a "productivity effect" of technological changes must be stronger than their "output effect" (see Škuflić and Družić 2016).

Hence, while automation naturally substitutes for human labour, this must not necessarily decrease employment, provided output increases sufficiently. Conversely, several contributions have explained the counter-intuitive persistence of manufacturing employment in the Global North over the past decades, as the result of a relatively stronger output effect, compared to productivity increases (Autor, 2015; Autor and Solomons, 2018; Bessen, 2019). Notably, Benanav (2020;2019) has also identified an

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[9] Next to theories of changing consumption patterns (Gershuny, 1978 and Gershuny and Miles, 1983) and offshoring approaches (Bluestone and Harrison 1982; Bluestone 1984; Ross and Trachte 1990; Wood 1999; Saeger 1997; Brady and Denniston 2006).

output effect as primary driver of the de-industrialisation of developed economies, however, with the additional specification that output-growth has decreased due to the stagnation of global manufacturing stagnation and its overcapacity. Hence, between the 1950s and 2018, output-growth has increased less steeply than productivity, at a logical expense of manufacturing employment (Benanav, 2020:20). De-industrialisation in the Global North is thus better understood as reduction of output, rather than an increase of productivity and automation.

A recent literature on a “productivity paradox” further complicates this view by arguing that labour-productivity growth has stagnated in OECD economies over the past two decades, precisely when, based on supposedly great technological strides and increasing automation, it should have sped up (Goldin et al. 2022; OECD 2019; Brynjolfsson et al. 2019;2021; Gordon 2015 and 2016; Gordon and Sayed, 2019). This stagnation began around the early 2000’s, is primarily identified for high-income economies, with manufacturing as a key contributor (Goldin et al. 2022:4, Christofzik et al., 2021). If productivity growth has been stagnating, or increasing automation has not translated into productivity gains, given increasing or steady output, then this could explain the persistence of employment in OECD automotive sectors. While empirically, the “productivity paradox” appears relatively well established (Brynjolfsson et al. 2019; Goldin et al., 2022, OECD 2019), its causes, and thus explanation for persistent employment, are still debated (Ilzetzki, 2020). Possible explanations vary widely (Brynjolfsson et al., 2019; Goldin et al., 2022), but two central factors are 1. the potentially stagnating effects of increasing concentration and 2. the potentially lacking productivity effects of new technologies. These two causes will therefore be discussed in the context of two more specific literatures, namely on the productivity effects of competition, and the productivity and employment effects of industrial robot-use.

The central issue of contention in the lacking productivity effects of new technologies such as robots and AI, lie in the question whether they are less transformative than the technological changes of previous periods (Moniz et al., 2022; Antonialli et al., 2022, Autor and Solomons, 2017). After the exceptional technological leaps of the 20th century, the world may thus have returned to the long-term "normal" of (productivity-) stagnation (Gordon and Sayed 2019; Gordon 2016). Proponents of this view suggest that the "low hanging fruit" of technological progress have been picked, and now ever greater investments yield ever smaller results. Alternatively, the productivity benefits of new technologies may not be overestimated, they just take time or additional conditions to materialize (Dosi and Virgilito 2019). Such lags may, for example, result from a need for more complementary investments, auxiliary innovations or organizational or institutional changes required for the productive use of new technologies in firms (Brynjolfsson et al.'s (2021). The argument has been made that the first productivity paradox of the 1980s was mainly the result of such insufficient organizational change (David, 1990; Goodridge et al., 2018).

Rather than such a wide stance on "technology", however, it is helpful to focus on a concrete and established example: industrial robots. In the relatively recent literature on the effects of robots on productivity and employment, the standard view is straightforward: robots are developed and used in order to save labour-input and its associated costs, thus increasing labour-productivity (Graetz and Michaels, 2018[2015]; Acemoglu and Restrepo, 2017; Dauth et al. 2017, Kleinert et al., 2022 Autor, 2015; Frank et al., 2019; IFR, 2017). While the literature seems clear on the productivity-increasing effects of industrial robots, their employment effects are thoroughly ambiguous. In their initial jump-start of this literature, Graetz and Michaels (2018/[2015]) found that higher robot-use has increased labour-productivity and wages, while not reducing overall employment[10]. Acemoglu and Restrepo (2020) find a negative effect of industrial robots on manufacturing employment and wages in the US, and Dauth et al. (2021) find the same for the case of Germany. Dauth et al. (2017), corroborate the results of Graetz and Michaels for German manufacturing, with robots increasing labour-productivity, without a negative employment effect. Bekhtiar et al. (2021) find for Austria that a positive productivity effect can be maintained, however, without a positive wage effect and skill-biased direction of displacement. Klump et al. (2021) show that contributions using IFR data mostly find negative manufacturing employment effects, while Fernandez-Macias et al. (2020) argue that the largest employment impact robots was already achieved long ago. Correspondingly, Antón et al. (2020) find that the time period chosen affects the outcomes: between 1995 and 2005 robots are ambiguous, 2005 to 2015 robots were employment increasing, and without evidence of a "polarisation thesis" (see below). However, Fernández-Macías et al. (2021) find that robots reduce low-skill employment in the European context. Kleinert et al. (2022) find that robot use in the EU manufacturing, increases aggregate employment and does not reduce the share of low skilled workers. They also find that the effect of robotization is small compared to time and country fixed effects, and that most variation in employment is driven by other factors such as secular contraction of the manufacturing sector in Europe over the last decades (time fixed effects) and shifts in automotive manufacturing from western to eastern European

[10] For methodological critiques of these results see Bekhtiar et al. (2021) as well as Kleinert et al., (2022).

countries (country-sector specific effects). They are also among the few publications which pay greater attention to the skewed distribution of industrial robot-use. While the empirical literature on robot-use thus seems very clear on their productivity-increasing effects, results are very contradictory for employment.

Overall, there are three significant shortcomings in this literature which may explain the large variation of its findings: 1. The view, most often deriving from routine-biased technological change theory, is a very limited view on how, where and why automation takes place (see also section three in this chapter). 2. Industrial robots are only a relatively small part of the technological capital stock of highly automated factories, serving the specific function of grabbing, handling and placing. In industrial processes which do not require such tasks, the number of robots does not say anything about the degree of automation (see the results in chapter 6). As shown by Jürgens (2023) for example, even in the automotive industry, robots are mainly used to support and increase the quality and flexibility of production, meaning that their use does not necessarily have a direct translation in productivity figures. Employment and productivity effects are therefore difficult to directly and unequivocally link to the increased use of robots, which ultimately is a bad measure of automation. 3. The literature hardly accounts for heterogeneity and the skewed distribution of robots in countries, sectors and time periods. Correspondingly aggregate and general accounts of the changes in manufacturing due to automation as industrial robot use are misleading (Krzywdzinski, 2021). Despite these critiques, however, the analysis of robots and their diffusion is not without meaning, if one is wary of their limitations. The debates on the employment effects on automation *have* been dominated by econometric studies in this literature. Robots *do* represent an important functional piece of automation technology, which has seen several great proliferations over the past decade. While the measure of robot-density tells us very little about the specific state of automation and its employment outcomes, their diffusion does tell us something about trends in both. This means there is a reason to follow and engage with it, given an understanding of its limits.

The second potential driver of productivity-growth stagnation lies in the effects of increasing monopolisation. Such monopolisation has recently become a focus in socio-economic research once more, not just in explaining productivity- (Goldin et al., 2022) but the general "secular stagnation" of developed economies (Dosi and Virgilito, 2019; Summers, 2016), coinciding with the rising dominance of technological monopolies such as Google, Facebook, Apple etc. Compared to the economic mainstream (Summers, 2013; Stiglitz, 2016; Rikap, 2021), which had to "recover" such interest, other schools of thought have maintained it as foundational element of their research program, which is continued uninterrupted (Conyon et al., 2022; Sawyer, 2022).

The theoretical effects of firm size, and the competitive dynamics firms are exposed to, on productivity are among the most fundamental and thus contentious topics in socio-economic research. The central question is of course whether higher monopolization/lower competitive pressures fetter or spur technological development and labour productivity, and whether large firms are thereby a "useful" or "detrimental" social formation. The neoclassical theory of competition, predicts that monopolistic sectors should grow less in productivity, since production factors are allocated inefficiently. The behaviour of monopolies should further restrict investments and the increased prevention of spill- overs by larger firms should reduce aggregate productivity.

With higher concentration one thus expects technological change and productivity growth to stagnate (Varian, 2017). A twist to this view has recently been proposed by Autor et al. (2020) through their "superstar firm hypothesis". Very productive (technology) firms are argued to have gained ever larger market shares, increasing their own productivity while lowering it in the aggregate, and at the same time reducing the wage-share (for empirical results on the hypothesis see Ferschli et al., 2021; Stiebale et al., 2020; Ponattu et al., 2018). Andrews et al. (2019) corroborate this finding by showing that a significant part of productivity slowdown can be traced to the increasing productivity gap between firms within sectors. Haskel and Westlake (2018) argue in this context that due to the increasing importance of intangible capital, especially of technology firms, and its scalability at low to no marginal costs, spill-overs can be avoided successfully and efficiently (for a similar argument see Rikap, 2021). The result is increasing productivity for the largest firms while others fall behind. Consequently, large and growing firms are increasingly extracting rent from intangibles and restricting market access (Philippon 2019), thereby decreasing aggregate productivity growth.

Based on a Schumpeterian line of thought, on the other hand, monopolies can also be viewed as productivity increasing due to the greater organizational efficiency of large firms (having entire departments dedicated to tasks rather than individuals) and economies of scale (Verdoorn-Kaldor effects). Large firms may also drive technological progress and productivity by being the only ones (next to the state, Mazzucato, 2013) able to bankroll investments large enough to implement and develop new technology at a meaningful scale. Galbraith (1959:103) has pointed out that such large firms, especially in sectors in which a high concentration is traditional, such as automotive, chemicals and heavy engineering, usually dedicate significant resources to research and development.

In the opposite case, of many small firms, as in construction and the textile industry, such investment is negligible. Consequently, smaller firms can simply not afford any serious investment in research (see chapter 5).

In contrast to these views, Shaikh (2016) puts forward a fundamentally different conception of "real competition", showing that all firms are under constant competitive pressure. Independent of a firm's size, the threat of market entry or market share capture of other firms, forces them to invest independently of their relative market dominance. Fettering or spurring of productivity should thus not a function of firm size or market position at all. In the end, this theoretical overdetermination renders the effects of concentration on productivity an open empirical question (Moen et al., 2018).

Empirical findings here are again ambiguous, however. While increases in concentration are more clearly documented for the United States (Autor et al., 2020), results for Europe are much less clear-cut (Döttling et al. 2017, DeLoecker and Eckhout, 2017; Valetti, 2017; Barkai, 2016, Bourguignon, 2017; Weche and Wambach, 2018; Stiebale et al., 2020). Bighelli et al. (2020), for instance, find rising market concentration in Europe and trace its cause to the most productive firms, arguing a link between productivity and concentration. Overall, despite ambiguity on productivity, evidence on increasing sectoral concentration appears to be mounting (Calvino and Criscuolo, 2018, Calligaris, Criscuolo and Marcolin, 2018; Bajgar et al., 2019). On average it appears that larger firms are more productive (Van Bieseboreck, 2005; Leung, Meh, & Terajima, 2008), hence a confirmation of the Schumpeterian view. For the concentration of sectors, however, as proxy for competition, the productivity decreasing effects are more prevalent (Dune, Klimek, & Schmitz, 2008; De Loecker, 2009; Syverson, 2004). Ferschli et al. (2021) find that, in the case of Germany, increasing digitalization is not related to increasing concentration. There are highly concentrated sectors in the German economy, as well as highly digitized ones, and they do not necessarily overlap. However, they do find that both digitalization and concentration both affect labour-productivity positively and independently form one another.

In addition to the role of competition in productivity, it is helpful to extend considerations here briefly to other "countervailing" pressures to automation and productivity. Ultimately, what is also evident in the discussion of firm size and competitive pressure, is that every automation decision is in the first instance an investment decision. Theories of stagnation have argued that high-market concentration and large firms' size would reduce such investments due to rent-seeking (Steindl, 1952; Baran and Sweezy, 1970; Hilferding, 1919, Magdoff and Sweezy, 1980; Summers, 2013; Stiglitz, 2014; Stiglitz, 2016). This would mean a convergence of high-profits, low investments and stagnation (Orhangazi 2008; Stockhammer, 2006 ; Haskel and Westlake, 2018; Favero and Galasso, 2016). In addition, where firms restrict investment in favour of increasing financial assets, dividend payments or generally shareholder value, the condition for "financialisaton" is fulfilled. "Financialization" thus means the short-term realization of financial goals (Lazonick, 2011). Such goals likely make long-term and large investments in productivity increases unattractive for boards and owners (Ferschli et al. 2019a,b; Spencer 2017; Spencer and Slater 2020). Consequently, short-term profit goals and financial performance are prioritised over concerns over new technologies (Lapavitsas, 2011; Thompson, 2013; Mazzucato, 2013). A consequence of financialisaton is that its profitability requirements force a combination of skills and costs in production, which are optimal for profits, but spatially disperse production, making use of lower labour-costs and labour-standards to circumvent the need to invest in automation (Thompson, 2013). In this vein, Moody (2018) has also argued that theoretical productivity and automatability don't matter much for implementation if there is no perceived need or willingness for investment. Together with the suppression of wages, labour-saving automation thus did not occur in the US over the past 30 years based on favourable wage-productivity differentials. Hence, the "function of robots" could be fulfilled by workers without any costs of investment. Where technological change has taken place, rather than the displacement of workers, it has focused on the intensification of work, which is in most cases the cheaper application (Moody, 2018: 141). Financialization thus represents an additional important "countervailing pressure" of relevance for shaping automation and productivity.

The emphasis on the productivity-output differential, is still one of the more underrepresented perspectives in recent contributions on automation and work. Within the literature on productivity-growth stagnation, contributions are mounting which aim to substantiate its causes. However, the overall debate lacks empirical specificity regarding: 1. the heterogeneity between different technologies and their uses, 2. the variation of sub-sectors and different time periods and 3. a higher degree of complexity on how relevant variables interact in different time periods. The empirical analysis of chapter 4 seeks to address these gaps by presenting results on the specific technology of industrial robots and the specific sector of the automotive industry and the under-researched time period of the wake of the financial crisis. Not just the crisis itself may have thereby affected productivity by reducing demand, but also reduced technological development by constraining investment (Agostino et al., 2022; Levine and Warusawitharana, 2021), inefficient input combinations (Mendoza-Velazquez and Benita, 2019), and generally declining innovation (Adler et al., 2017; Oulton, 2018). Based on these results, inferences are made about the relation of labour productivity stagnation and output to employment in increasingly automated manufacturing sectors. This will test the limits of generalisability of the productivity paradox for different aggregation levels, and how the OECD automotive industry has maintained employment within a wider context of de-industrialisation in the Global North. The paper thus seeks to address the above gaps by asking: *What were the effects of automation on employment and productivity in the automotive sectors of OECD countries between 2010 and 2018*?

2. The Role of Competitiveness in the Automation and Production Location Decisions of Firms

One of the standard narratives of the development of global manufacturing employment,[11] namely the progressive offshoring of industrial capacities to low-wage regions, has recently been challenged by claims of "re-shoring" amidst new technological capabilities (Butollo and Staritz, 2022). New technologies would increase productivity, reduce labour-unit costs and thereby reduce the relevance of wages in production location decisions, bringing industrial production back to the core (Debacker et al., 2018; Carbonero et al 2018; Faber, 2020; Krentz and Sturllik, 2021; Kinkel et al. 2022). There is thus an additional way to look at the question of productivity in addition to the one presented in the previous section. High and increasing degrees of automation could have increased productivity, paradoxically safeguarding industrial employment in high-wage countries, or increase it in the course of re-shoring, which however, would cast doubt on

[11] Next to unequal productivity growth and changing consumption patterns, as described above.

the notion of productivity growth stagnation. While the persistence of automotive employment of the Global North, could thus be explained by both stagnating or increasing productivity, both propositions cannot be true at the same time.

The literature on the development of global manufacturing most frequently explains existing differences in technological intensity between countries and regions through competitive dynamics. In the course of the second half of the 20th century, global manufacturing competition has thereby significantly intensified leading to "locational competition" wherein countries have come compete over attracting capital, technical knowledge and skilled workers. In other words, the immobile factors of production in countries compete over mobile global factors of firms (Sieber, 1996). As the successful outcome in such competition means the accumulation of exports, employment and profits, concerns over "competitiveness", *as ability to succeed in this competition,* has come to dominate industrial policy debates in almost all economies. For some this meant defending dominant positions in global commodity chains, for others to improve their position within them. The resulting global division of labour and functional specialisation of industrial production[12] is also well known: the "core" focuses on high-value added products and activities drawing on high-skilled workers and high technological intensity, while low-value added and labour-intensive tasks are outsourced to "periphery countries", overall, leading to progressive loss of manufacturing employment in the former. The manufacturing employment which remains in high-wage countries is thus argued generally produce under technologically intensive, high-automation strategies, in order to mitigate relatively higher labour-costs. This section therefore discusses how

[12] Or rather underlying since earliest forms of capitalist trade and unequal exchange.

“competitiveness”, as umbrella term to capture the desire of „technologically advanced“ economies to further increase and solidify manufacturing output and employment, affects the production location and automation decisions of firms.

Definitions of competitiveness today are most often distinguished by their origin of advantage: input-oriented (price and technological competitiveness) or output oriented (GDP, employment etc.) (Aiginger et al., 2013; Aiginger 2018). Most frequently input-oriented approaches are invoked, with narratives corresponding to what was described earlier: firms in high-wage sectors and regions either outsource or sub-contract production to low-wage regions (price competitiveness) or pursue high-automation production strategies in the countries of the core (technological competitiveness). Hence, to either move production location, or automate. Ultimately, both strategies amount to achieving favourable unit-labour costs (labour cost by output), and thus of labour productivity. While competitiveness on price has seen some disrepute as a “dangerous obsession” (Krugman, 1994), it is still strategy of many global manufacturers, in particular the periphery. “Technological competitiveness”, on the other hand, has a continued strong presence in both manufacturing policy as well as strategy (Dosi et al., 1996).
The European Union, for example, periodically emphasises “competitiveness” as policy goal for its manufacturing sector, mostly meaning the need to drive its technological development. The importance of competitiveness in global markets for employment was first articulated in the 1993 EU white paper on growth, competitiveness and employment. Following on from this, the Lisbon strategy (2000) made this relationship more explicit by suggesting policies to focus on technological advances, innovation and research. Europa 2020 (2010) updated the Lisbon strategy but added considerations on sustainability and a

renewed relevance of price-competitiveness. In its „Communication on industrial Policy“ in 2014 the EU called for “modernisation and re-industrialisation of the EU’s industrial base, focusing on “highly adaptive, technologically advanced and productive Industries“ (Škuflić and Družić, 2016). Most recently, the so called “Draghi report” (European Commission, 2024) on European competitiveness reiterates the same, as does the recent ratification of European industrial policy for the green transition in the course of the European Green New Deal (Commission Competitiveness Compass, 2025).

However, such a simple “competitiveness”-narrative, be it based in technology or price, is insufficient in explaining the automation and production decisions (and successes) of firms. This point has perhaps been most notably made Porter (1990). Describing why some firms succeeded on the world market and not others, the „*Porter diamond model*“ (1990) shows the interdependence of a variety of „favourable conditions“ which must actively be established, in contrast to the laissez-fair policy of standard economics. Still, also Porter largely reduces the question of national wealth and “competitiveness” to a question of high and increasing productivity, which in turn means that labour-productivity is the “only meaningful concept of competitiveness” and determining of a “long run standard of living” (Porter, 1990: 76). Similarly, Kowall (2021;2015) based on notably rare qualitative research on the role of “competitiveness” in firm behaviour, finds that the export success of Austrian firms for the largest majority lies in their “technology” according to themselves, with a very secondary role played by price. Correspondingly, conventional wisdom and economic policy which reduce firm performance to competitiveness, and competitiveness to relative prices, and prices to high wages misrepresent the situation, at least in Austria.

Furthermore, the pursuit of competitiveness itself may have several negative consequences, often eschewed in debates. Kacmarczyk (2022), for example, has shown that the nominal drive for competitiveness has in fact *prevented* innovation and technological development in the European automotive industry. The German automotive industry, for example, has thereby avoided labour-productivity increases usually purported through "innovation competition", in favour of relocating production to the eastern-European periphery stabilising profits due to lower wage costs. On the other side, "left-behind places", both of the core and periphery, are also a logical consequence of achieved competitiveness. In such "losing" regions, industrial production has ceased after concentrating it successfully for, however long a time (e.g. the Rust-Belt in the US, North and Mid-England, or the Ruhrgebiet in Germany). It is also in these places which are now among the most important hotbeds for right-wing populist agendas (Essletzbichler et al.,2018). The point being that the pursuit of competitiveness itself not necessarily beneficial for a region. If the jobs to be created were only of low wages, for example, the "success" of a firm would mean little, and can in fact actively undermine economic prosperity (Reich, 1990).

Perhaps the most substantial critique of a simple competitiveness narratives, however, is that the analytical level of "region" or "country" are unhelpful for truly understanding aggregate production outcomes. These outcomes depend on the production location and technology-use decisions of firms, which in manufacturing are most often large, and globally active conglomerates. It is thus them which must be researched. Put differently, production does not happen "in manufacturing" or "Austria", but is organised through firms who in turn organise workers and implement technology. Especially, in the automotive industry, these firms are not local, national producers as Riccardian comparative advantage has it, but globally connected conglomerates. Understanding the behaviour of such large global manufacturing firms is therefore decisive, in particular for analyses of the automotive industry.

What then are the relevant dimensions of how international firms make production location and technology-use decisions? Among the most circumspect and fruitful recent approaches, , and in view of the question of persistent manufacturing employment, is a “lead plant” theory (Krzywdzinski, 2017; 2019 a,b). Its proponents argue that it is advantageous for global firms to retain manufacturing plants in core countries, despite high wages. Such plants test and produce new products and technologies, using highly skilled blue-collar workers in close cooperation with local engineering departments. The distinction between lead-plants and other production sites within the same conglomerate is, for one, reported by Krzywdzinski (2019), finding this difference conform to different degrees of automation between plants in Germany and the CEE, with the higher innovation degree of a plant corresponding to a higher skill level of its workers. Krzywdzinski further finds, however, this result is differentiated between supplier activities and final car assemblers, whereas the latter have remained in Germany to a larger degree despite requiring higher degrees of manual labour (Krzywdzinski, 2019). Within the commodity chain structure of the global automotive industry, being a lead plant and lead firm also implies a certain standing in the power-hierarchy. Lead plants of OEMs in core countries thus stand in opposition to supplier plants in in periphery countries. Leads plants and firms can leverage their hierarchical position to minimise their own risks and uncertainty, for example by cancelling orders or forcing excessive pressure on the prices and agreements of suppliers.

It can thus be hypothesised that high and increasing automation of “lead plants” in high-wage countries has increased the “technological competitiveness” of certain countries in certain sectors, which has safeguarded global market shares, thus production locations, thus output, thus employment. Discussions surrounding new possibilities of re-shoring manufacturing production based on new technologies could have further strengthened this channel. However, global production decisions are not made by countries or regions, but international manufacturing firms, whose economic reasoning may not be as straightforward as seeking the cheapest possible labour-costs, as formulated, for example, by the “lead plant” hypothesis. More than anything, recent debates on competitiveness show a gap in empirical engagements with how precisely firms practically navigate “competitiveness requirements” in the course automation decisions and how they fit into the turbulent decisions of global production locations. This paper therefore asks: *How have requirements of “competitiveness” determined automation and production location decisions in the Austrian automotive supplier industry, during a recent period of supposed re-shoring?*

3. Routine-Biased Technological Change and its Discontents

The following section moves into the rationalities of production, and how firms make production decisions on the micro-level, which form the basis of macro-outcomes. The goal of this section is thus twofold: to describe the dominant view of economics on the automation of labour-processes, and to further develop a socio-economic critique of this view.

The presently dominant framework for understanding why firms automate labour-processes or not, "Routine-Biased Technological Change" (RBTC), posits that the deciding factor lies in the routine-intensity of tasks (Goos et al., 2021; Autor et al., 2001; Frey and Osborne, 2013, Autor, 2015). "Routine" thereby means a task which follows a precise and understood procedure, and which can be fully codified and thus automated (Levy and Murnane 2004, Autor et al., 2003, Autor, 2015:11). RBTC derives from earlier contributions in economics, dating back to the 1990s and early 2000s, which also sought to understand the effects of new technologies on work through a "skill-bias" (SBTC). The idea then was that increasing wage inequality could be explained by new technologies favouring highly skilled workers, while displacing "low skilled" ones. Automation was thereby thought to replace the lower parts of the skill spectrum, in particular in manufacturing (Bermann et al., 1998, Autor et al., 1998; Antonietti, 2007; Brynjolfsson and McAfee, 2014; Katz and Margo, 2014). However, SBTC was incapable of explaining the growth of "low-skilled" jobs in both manufacturing and the service sector (Leigh et al., 2020) and had difficulty in connecting skill-requirements to technological changes more generally (Handel, 2025). In response, RBTC formulated an alternative theoretical proposition and empirical hypothesis.

Theoretically, the claim was made that the technical feasibility of automation of a task actually depends on its routine-content. Compared to SBTC, non-routine activities can, however, now be found both in the "abstract", "high skilled" jobs of professions which require "*problem-solving capabilities, intuition, creativity and persuasion*", as well as the low-skilled "manual" jobs of serving, cleaning and maintenance and care work which require "*situational adaptability, visual and language recognition and in-person interactions*", which must be completed in person and on site and where "*the potential* *supply of workers who can perform these jobs is very large.*" (Autor, 2015:12; Autor et al., 2001). Based on its highly routinised nature, manufacturing work was still thought to be greatly reduced in a however immediate future. The resulting empirical claim of RBTC is that the development of employment structures in developed economies conforms to a "polarisation thesis": increasingly diverging high-skill and low-skill poles of non-routine (Autor et al., 2001, Goos and Manning 2007;[14] Autor and Dorn 2013, Autor, Dorn and Hanson, 2015; Goos, Manning and Solomons, 2014, Aghion, Jones and Jones, 2017; Bessen, 2017; Caselli and Manning, 2017).

While economists largely subscribe to RBTC in some form (Biagi and Sebastian, 2018), mostly debating empirical applications and measurement issues, socio-economic contributions, have critiqued it extensively as an inadequate theory of automation and work (Krzywdzinski, 2022, Koepp, 2023, Carbonell, 2024, Pfeiffer, 2018). A first common critique which can be synthesised is RBTCs emphasise on routine. Automation decisions have been shown to depend on many additional or alternative factors such as desired quality, precision requirements or simply the expansion of output which would otherwise be impossible. This means, that such decisions are much more contingent than a comparison between the cost of worker with that of a machine (Adler, 1989; Jürgens et al., 1993; Freyssenet, 1999 Pfeiffer, 2016; Butollo and Paiva, 2020).
A second type of common critique relates to the differentiation of technological potentials and their application. As Butollo (2024) shows, not being precise in this distinction leads to a general overestimation of the effects of new technologies on work and employment. Which jobs then persist or not, is not a function of their routine-content, but rather depends on the production conditions in each firm and sector (Pfeiffer, 2019).

A third common critique focuses not just on the emphasis, but the methodological operationalisation of “routine” (Fernández-Macías and Hurley, 2017; Haslberger, 2021; Lewandowski et al., 2022). Krzywdzinski (2022) for example finds that the concept is hardly ever described in the first place, and Pfeiffer (2016; 2018) shows that what are considered “repetitive”, “unskilled” and “routine” jobs in manufacturing, in fact require considerable experience and spontaneous problem solving. More generally, it can also be doubted whether there is any “job” in existence, which does not conform to some notion of “routine”. Also, the work of a tenured economics professor is ultimately a series of very routine tasks and behaviours, casting doubt on the usefulness of “routine” as analytical category for distinguishing possibilities of automation. Consequently, whether a polarisation thesis can be supported or not, depends largely on the definition and classification of “routine” (Hunt and Nunn, 2019).

A final, and most common, type of critique concerns the empirical conclusions of polarisation suggested by RBTC. While the expected polarisation of skills is a noticeable finding in older technology debates (Gallie, 1991; Milkman and Pullman, 1991), it cannot be reproduced in the same clarity in recent debates (Briken et al., 2017; Gallie, 2017). Rather, regionally specific and heterogenous occupational trends of skills are emphasised (Vera-Toscano et al., 2022; Fernandez-Macias 2012; Fernandez-Macias et al. 2017, Hurley et al., 2019, Perez et al., 2023). At points this seems to originate in either a reversal of demand for cognitive tasks (Kurer and Gallego, 2019), the dependence of polarisation on business cycles (Audry et al., 2016) or it is specified that polarisation only applies under certain conditions (Haslberger, 2021; Jerbashian, 2019), for specific firm (Heyman, 2016) or occupational group (Cortes et al., 2017). Among this heterogeneity of findings are also those which insist on an overall upskilling of workers in developed economies (Oesch and

Rodríguez Menés, 2011; Picciotto and Oesch, 2020; Oesch and Picciotto, 2019; Ferreira, 2022). More convincingly, however, especially given ongoing labour-shortages, others simply find an increasing demand for workers over the entire skill spectrum (Vona et al., 2019, Muench et al, 2022, Blasmeier et al., 2019; Styzhal, 2023; Gersenberger et al., 2023; Basso et al., 2023), which, however stands in contrast to prevalent theories of chronic labour under-demand (Benanav, 2020).

Given these substantial critiques, it is necessary to consider alternative frameworks for explaining automaton decisions. The presently most circumspect of such frameworks is Krzywdzinski's (2022) "Socio-Economic Firm-level theory of automation at the firm level". Building on specialised literatures in sociology, management and engineering, Krzywdzinski proposes that the causes of automation and its consequences for work and employment can be formulated along three dimensions of contingency: socio-material conditions, social choice of technology and social outcomes.

Whereas RBTC has a very limited view on what is feasible to automate and why, namely routine-intensity, Krzywdzinski argues that the feasibility of automation significantly depends on the complexity and variety of product and process. Simply put, the more complex a production process is, the harder it is to automate. This complexity rests on the variety of parts which must be assembled, the conditions under which they are assembled, the available physical outlay of the production site as well as the requirement production speed. Occupations which are thus assumed as highly automatable by RBTC, are in fact not. In the case of the automotive industry this is most evident in the case of assembly. While overall the labour-process is very routine and repetitive, it is difficult to automate due to the variability of which part is put into which car, where and in which form. The physical characteristics of parts (soft or hard etc.) by themselves mean great difficulty for consistent automation, for example through robots (2022:8). As put by Krzywdzinski: "*In industries such as the automotive industry, the first "race" is not between humans and machines, but between the development of product diversity and product architectures*". (2022:11) Where diversity increases more quickly than simplification and modularisation, opportunities for automation are reduced. Conversely, changes in products are often more important than changes in technologies. Rather than continuously advancing automation steps, failed strategies and dead ends are entirely possible, and well recorded. Therefore, a first crucial point of the socio-economic theory of the firm is a strong influence of the product on the conditions of its automation (Krzywdzinski, 2022:10), which will be extended by the dimension of output in the analysis below (see chapter 6).

Within the constraints of the product and process, there is still a social choice of which technology to use in which way. According to Krzywdzinski, these choices will depend not on the characteristics of technologies themselves, such as in RBTC, but on firms' manufacturing and profit strategies as well as power relations within companies, sectors and countries (2022:12). For example, in the automotive industry, manufacturing strategies are differentiated between highly standardised products, diversity of models, production flexibility or quality. Based on these strategies, profit strategies are then pursued (Boyer and Freyssenet, 2002). Correspondingly, a choice can be made between "high-tech automation", driven by a focus on highest possible technological application to achieve quality and productivity, or "low-cost automation" using reliable machine systems in long-term use, supplemented by manual activities, and foregoing complex automation procedures in favour of flexibility. In the automotive industry these different strategies manifest on the country and not just firm level, explaining differences in the size and composition of employment (Krzywdzinski, 2021). Robots may still be used in both approaches, but they will have decidedly different functions and effects.

The second social choice of technology depends on the power relations between labour and capital in the workplace. Simply put, the possibility of different automation and work outcomes depends on the relative strength of the actors involved. If labour-representations are in strong positions and combative, opposition to technology is feasible. If they are weak and/or cooperative, technological implementation not face great obstacles (see chapter 7). For example, the striking non-opposition of worker representations to automation and Germany and Austria captured by the term of "productivity coalition", which have led to automation approaches which proved contentious in other countries (2022:16). This mean, whereas RBTC would suppose an objective and clear path to automation, the socio-economic theory of automation shows wider array of potential choices. Profit strategies, for one, crucially define which automation step is reasonable and power relations determine the which is possible to implement (2022:18). There is thus not one objective optimal path to automation choices, as in most economic modelling and RBTC, but rather variety of different ends and purposes for different technologies and firms.

The final dimension of Krzywdzinski's framework concerns the "social outcomes of automation", meaning the consequences of automation decisions for work and employment. In contrast to RBTC, where the outcome is clear and linear in that automation reduces routine jobs causing polarisation, in the socio-economic theory outcomes can thus vary even where the same technology, such as industrial robots, is used (2022:18). In Germany, for example, vocational training and labour laws incentivise investing in skills retain strategies of blue-collar workers, thus reskilling etc. a "high skill equilibrium" (Finegold and Soskice 1988). This hampers the polarisation of employment structures and persistence of blue-collar manufacturing employment despite automation (2022:18). In contrast in Korea, Krzywdzinski argues that companies have invested in engineers while minimising skills and the roles of blue-collar workers, which he refers to as "engineer-led automation". The bottom line being that there is no clear and uniform trend for the polarisation of employment structures. The choice of low-tech or high-tech automation depends on the institutional setting consisting of vocational training systems, employment protections, unions strength etc. which in turn influence managerial strategies which may either rely on skilled blue-collar work (Germany and Austria) or not (Korea, US).

As a third hypothesis, the presently dominant theory of routine-biased technological suggests that the manufacturing employment which persists in high-wage economies is work which simply cannot be automated. Few contributions, however, deal with the question whether firms behave according to the principles of RBTC. Chapter six will do so by focusing the equally underrepresented perspective of engineers, how are ultimately the professional arbitrators between technological feasibility and economic imperative at stake in automation decisions. The analysis in chapter six is therefore guided by the research question: *Which factors do engineers consider decisive in the automation of labour-processes in the Austrian automotive industry?*

4. Worker Resistance to Automation

Noble (1984) showed in his seminal study on the implementation of Computer-Numerical Controlled (CNC) in US manufacturing, that management was more interested in developing the technology in a way which allows it to discipline workers and to decrease its reliance on workers' skills and knowledge, rather than making technologically efficient choices. Rather than being driven by "technologically necessary" developmental steps therefore, CNC automation was guided to best serve a "control function" (Ferschli, 2017). If control is the central concern in automation, the opposition or consent of workers to it may be an important explanatory factor in the persistence manufacturing employment in high-wage countries. Connecting to power relations between labour and capital, as also briefly addressed in the previous section, this final section discusses the role of managerial and worker interests in automation decisions of firms in greater detail.

Recent contributions in economics have argued that it is worker dissent and the power of unions to resist managerial desires which drive ongoing automation efforts in developed economies (Acemoglu and Restrepo, 2024). While historical studies find the opposite, of dissent being a consequence of technological changes detrimental to workers (Hobsbawm, 1952; Thompson, 2013; Dubois, 1976; Zabala, 1989), there presently appears strikingly little opposition to begin with. This is not to say there is no worker malcontent and protest *in toto*. In fact, Erne and Nowak (2025) find that socio-economic worker protests in the European Union have doubled from the turn of the century to before the COVID pandemic, a time when unions largely appeared to be in retreat. However, these protests were largely disconnected from the technological characteristics of production, in particular in manufacturing industries. This prompts the question how and why workers may or may not consent to changes in the productive forces. In the debates over the effects of new technologies on manufacturing workers, this question has been pursued relatively little. Most contributions over the past years have asked whether new technologies "empower" and "upskill" workers or not (Dupuis and Masciotte, 2024;2025; Butollo et al., 2018). While the degree of "empowerment" of workers through technologies is certainly related to consent, and may constitute a sufficient condition for it, it is not a necessary one, meaning additional causes must be considered.

Workers' consent to technological change can be conceptualized correspondingly on two primary levels: 1. the consent of workers to their concrete daily labour-processes and 2. the collective bargaining compromises between management and the representations of workers in sectors and on the national level. While the first is most notably identified as concern in the literature of labour-process theory (LPT), the second is a traditional subject of industrial relations (IR). Both dimensions have important consequences for how workers position themselves towards technological change.

Without practical consent in the everyday of labour-processes, production would not take place. LPT scholars have traditionally taken an interest in explaining and describing the underlying dialectic of control and consent (Burawoy, 1985). Workplaces are thereby understood as "contested terrain" in which workers' effort is continuously negotiated and imposed through various control mechanisms that develop precisely in response to workers' resistance (Edwards, 1979; Edwards and Scullion, 1982). Rather than such politics of technological change, however, later contributions to LPT have focused mostly on the consequences of new technologies in the workplace, most frequently through the lens of new and different forms of control (Thompson, 1989; Hall, 2010, Ferschli, 2017). This emphasis of LPT, however, runs the risk of obscuring important elements determining consent and compromise in workplaces (Petrosino, 2024), most notably collective bargaining. Corresponding research emphasizes that the outcome of technological implementation is precisely the result of institutional struggles between worker representations and management, in which workers may also have an upper hand and consent to changes as they conform to their interests (Vereycken et al., 2021). In line with parts of the literature in LPT, this stream of research thereby shows above all that workers and their representatives are not passive in the face of technological change and that the technological structure of workplaces is the product of a "negotiated order" (Dupuis et al., 2022). Consequently, how this order is negotiated depends on the industrial relations system of country and sector. However, in seclusion, also this view is insufficient. To only consider the dimension of institutional representation abstracts from crucial elements of technical and economic production structures and requirements which affect technological changes and workers' position to them. While contributions within LPT and IR thus converge in emphasising the conflictual production of a technological order (Pulignano, Franke, 2022), there are few attempts to theoretically integrate both dimensions and literatures.

One such framework, however, was proposed by Belanger, Edwards and Wright (2006) and Belanger and Edwards (2007). In order to answer why different patterns of conflict, consent and compromise between workers and management emerge in workplaces, they formulate a matrix of possible outcomes. Underlying these outcomes are the most basic concerns of capital to ensure the extension and profitability of production as well as the application of labour power, and of labour to achieve higher wages, and better working conditions through greater autonomy. They summarise these concerns as either falling into the category of "development" or "control". Whereas "control concerns" represent day to day relations and power over labour-process and the application of labour-power (see LPT described above), "developmental concerns" designate objectives such as the "wellbeing" of the firm to ensure profits for capital and wages for labour (see IR). Developmental concerns also include the efficiency of production, organisation of work, skills, and organisational structures, as well as, and most relevant for the purposes of this paper, overall development of the productive forces and technological changes (2006:129). Although, as evident from the LPT, technology also figures centrally in control concerns.

In general, both capital and workers can be argued to have an interest in each concern, to different degrees at different times (2006:129). Patterns of workplace compromise and conflict originate in the varying strengths of concern over "developmental" issues of the productive forces or "control" issues at the point of production (Belanger, Edwards and Wright, 2006). Crucially, this means that the interests of capital and labour do not necessarily need to always be opposed (Burawoy and Wright, 1990). However, rather than the reduction often found in the managerial literature, that workers and management have shared goals allowing for obvious "win-win" situations, this just means that there are contradictory pressures faced by both capital as well as labour (as also described by Vidal (2022) regarding worker empowerment). In the case of technological changes, there nonetheless may exist a "positive sum" possibility of overall production surpluses increasing next to a reduction of effort and/or increase of worker pay (Lazonick, 1990). Understanding such outcomes, even if they are rare and far from likely, requires a more in-depth understanding than only a focus on control over workers to ensure accumulation, or the institutional strength of national collective wage bargaining. The point being that labour relations can be co-operative while still remaining conflictual (2006:131), and that positive sum outcomes are indeed possible, even if they are likely very rare or temporary in practice as the fundamental antagonism most likely will always re-emerge (Tomšic, 2015). Put in the words of Wright (2000): a position of extreme capitalist weakness is analytically impossible under capitalism.

In order to provide an additional layer of causal effects, which determine the varying strength of developmental and control concerns, Belanger and Edwards (2007) suggest "key structuring conditions". The conditions they deem to function as most important drivers of variation between workplace regimes of conflict and consent are: technology, product markets and institutional regulation (2007:714).

Technology means all forms of machinery and equipment, both hardware and software, with the central question being whether said technology increases or decreases the discretion of workers over their labour-process (2007:717). Although not specifically differentiated by Belanger and Edwards, this dimension also depends on the type of product and production processes used in firms, which significantly determine the extent and type of technology-use (Krzywdzinski, 2022; Ferschli 2025 Forthcoming). Belanger and Edwards do make the distinction between continuous and discrete production processes, the former allowing more favourable conditions for job autonomy than the latter, which, however, remains at a very general level. Krzywdzinski (2022), as also noted in the previous section, differentiates technology-use according to the manufacturing and profit strategies of firms and crucially the product to be produced. Focusing on manufacturing firms, this means that if a product is complex, of low batch size, manual activities are likely to persist and only a certain type of technology feasible to implement. Workers in such a scenario likely have greater discretion over their tasks and new technologies may even lead to their upskilling. However, also in this case there are potentially diverging paths. Whereas "high tech" automation solution would likely increase the participation and skill of workers, "low-tech" automation solutions reduce them. Which of these paths is chosen, crucially depends on the product and thus the manufacturing strategies of firms.

The second set of conditions, "product markets", is essentially synonymous with the form of competitive pressures a firm faces, see also section one of this chapter. For the most part, Belanger and Edwards find firms in monopolistic or oligopolistic competition to be able to afford greater worker autonomy, allowing both capital and labour to focus on developmental rather than control concerns, while more intense competition forces the reduction of worker autonomy (see again the similar argument in Vidal, 2022). Meaning, the more insulated a firm would be of competition and downturns, the more they would "accommodate" workers, making compromise and consent feasible. Here again the type of product plays a crucial role, as some "markets" are likely stable and predictable, allowing a focus of both capital and labour on developmental concerns. While the basic notion is intuitive, it has also been critiqued elsewhere, for example by Shaikh (2016), who argued that just because firms are large or operate in oligopolistic conditions, does not mean that the competitive pressures they face are lower. However, the point of the importance of product markets and competitive pressures as structuring features of technology-use and consent remain valid.

Drawing on Belanger and Edwards (2007), Dupuis and Masciotte (2024) explain differences in the empowering effect of recent technologies also based on worker power and product markets. They suggest the organisational models of “empowered digital lean” and “taylorised digital lean” to capture this difference. “Empowered digital lean” leaves tasks and skills unaffected, perhaps even increasing them given new technologies, while “taylorised digital lean” rests on labour-displacement, deskilling and reduced participation of workers, suggesting reasons for opposition. The central distinguishing criterion between both are again the competitive pressures firms face. In highly-competitive “markets” where labour costs account for the majority of production costs, control over the workforce will play a more significant role than in capital-intensive sectors. The latter thus represent conditions under which technologies may have positive effects and workers and assuming that this is enough to do so, warrants their consent to their use. However, this emphasis of Dupuis and Masciotte suggests that all difference in conflict and cooperation can be reduced to a difference between types or industries, sectors and production processes. For example, if a plant is the lower end of a commodity chain in a declining or restructuring industry, or where OEMs put large pressures on suppliers, there is likely little room for compromise. In turn, an OEM plant using highly skilled labour with complex machinery in quasi oligopolistic niche markets, with relatively well-paid workers and little control over the labour processes, a compromise and/or productivity coalition regarding developmental goals seems feasible.

The third set of conditions to determine the prevalence of different concerns are the institutional regulations of workplaces: labour law, trade unions and collective bargaining, hence the traditional subjects of IR. While Belanger and Edwards (2007) and Dupuis and Masciotte (2024;2025) both suggest an important role, other contributions (Lloyd and Payne 2023;2025, Doellgast and Wagner, 2022), place almost the entire explanatory burden of the shape of technological changes and worker consent to them on such institutions. However, the same kind of institution does not necessarily have the same function in different countries, which is why Belanger and Edwards (2007:719) argue that the effect of regulations must be determined at the workplace level. Nonetheless, differences in conflict and cooperation and developmental and control concerns certainly do find articulation within national institutional systems. For example, the notorious concern over issues of control in the Anglo-American context, by both management and labour, has historically left little room for developmental concerns and originates in lax labour laws and weak worker protection. In European welfare states such as Sweden, an opposite focus with limited interest in control is characteristic, excluding issues of health and safety. Correspondingly, Belanger, Edwards and Wright describe the corporatist case, notably Germany and Austria, as an exclusive focus on developmental concerns without any control interests. In their specific mention of Austria, they even describe it as a case where unions have almost no shop floor involvement and all compromises are negotiated on the industry and national levels (see analysis in chapter 7). In this vein, Krzywdzinski (2022) specifies the framework of Belanger and Edwards regarding the possibility of high-tech automation, already briefly mentioned. A high-tech automation solution then requires a productivity coalition or a weak position of workers and unions. If labour has a stronger position shop floor battles likely arise, making high-tech automation solutions difficult. Based on these differences of high- and low-tech automation strategies different skill-regimes emerge which then in turn ossify again the type of technology to be used, and in all likelihood, worker consent to them. Notably with strong labour laws, such as in Germany, long-term investment in the skill development of a workforce is attractive. In reference to Finegold and Soskice (1988), Krzywdzinski calls this a “high skill equilibrium”, whereas in a "low-skill equilibrium" management will not seek to invest in the skills of workers but rather pursue displacement or to hire new workers with new equipment. Technology use and its consent is thus intimately connected to the vocational systems and investment strategies of firms in which the same level of automation can have very different consequences for work and employment and thus illicit different worker responses.

Overall, however, it is an open question to which extend heterogeneity of industrial relations actually persist. Cetrullo et al. (2023), for example, argue that neoliberal convergence has greatly reduced the variation of industrial relations systems and strategies. In particular globally mobile capital has successively reduced the leeway of national governments to influence the conditions of production, which are in turn more significantly shaped by the developments within industries rather than countries (Bachter et al., 2012). This is particularly true for sectors which are very globally interconnected and consist of few and very large firms connected through extensive commodity chains, such as the automotive industry. Correspondingly, Cetrullo et al. (2023) have found that for most part, trade unions in the European automotive industry do not have significant leeway on consenting or opposing technological changes in the first place.

The framework of Belanger, Edwards and Wright is of significant merit, in particular for empirical analysis of the relative comparison of similar situations and for comparative analysis (2007:730). The core theoretical argument, moving forward, is that rather than an overestimation of the importance of industrial relations systems, or the control concerns of management, the economic production conditions at workplaces interact with the capacity of workers and unions so as to motivate compromises or consent to technological changes. How this interaction unfolds is an empirical matter.

A final hypothesis thus locates the reason for persistent manufacturing employment in the consent or opposition to automation by workers and unions in high-wage economies. While workers would have many reasons to resist such technological changes in their labour-processes, and have done so in the past, this is does not appear to be the case presently. This may mean that automation is not serving control functions, or worker concerns over developmental issues are more significant. The view of worker consent to technological changes, in general, is seldomly engaged, however, which is why the final substantive chapter asks: *why do workers and unions in the Austrian automotive industry appear to not resist automation?*

5. Conclusion: A Socio-Economic Theory of Automation and its Meaning for Persistent Manufacturing Employment

This chapter discussed the current state of the literature on the causes and consequences of automation, and how they relate to persistent manufacturing employment in high-wage economies. This discussion was centred on four current controversies: productivity growth stagnation, competitiveness and global firm behaviour, routine-biased technological change and worker resistance to automation. The hypotheses drawn from them, correspond to two levels of analysis: macro and micro. While the review of the literature covered different disciplinary approaches, the goal was to structure the discussions around relevant channels of cause and effect on these two levels. Whereas the macro level discussed how conditions of production in the automotive industry affect the causes of automation and consequences for employment, the micro-level, addressed the rationalities of production in concrete firms, as well as the politics of production between workers and management.

Correspondingly, the first section has argued that the relation of automation to productivity and output is crucial for employment outcomes. If output increases in parallel to automation and productivity, employment can be maintained despite labour-saving technological change. Alternatively, output may remain steady or slightly increasing, if productivity is stagnating. Contributions on the "productivity paradox" suggest such an interpretation, and that manufacturing employment persist, due to the lacking productivity effects of recent automation steps. However, if, as suggested by Benanav, increasing global competition and export-led growth strategies have led to international manufacturing overcapacity, then it is more a question of securing markets for the outputs of countries, in which high degrees of automation may prove advantageous. This view would allow the integration of several contradictory stylised facts, such as that the countries with the highest degree of automation today are not the ones which have deindustrialized the most (2020:28). However, current mainstream accounts underestimate countervailing factors and often misjudge the relative importance of output in employment outcomes. Output is also relevant in other places. It connects to the analysis of chapter five through the production location decisions of firms, and perhaps most importantly in chapter six, as one third of the "productivity imperative". The role of output is thereby contradictory: on the one hand, it drives employment by extending production, on the other hand, it makes employment reducing automation feasible in the first place. The low output quantities of smaller manufacturing firms in Austria, due to their specialised products, thereby also suggests a hard limit of reshoring.

While persistent employment could be a result of stagnating productivity, section two has argued that rising productivity could have also safeguarded employment in highly automated sectors through lower unit-labour costs and increased “competitiveness”, which however, would cast doubt on the notion of productivity growth stagnation. The explanation of “competitiveness” was also shown to crucially rely on the production and technology-use decisions of large global firms. These, in turn, depend to a very large degree on their product and profit-strategies. Ultimately, the decisions of globally active manufacturing firms are the central determinant of all hypotheses: where to produce which product, in which quantities, and based on which labour-use strategies.

Moving from the conditions of production to the rationalities of production, the first micro section has critiqued the dominant views of dominant mainstream economics on the automation of labour-processes, siding with economic-sociological and socio-economic approaches. The section has also shown that automation decisions crucially depend on the characteristics a manufactured product, such as its complexity and required processes. Rather than routine-intensity and relative factor costs, suggesting that remaining manufacturing employment is simply not technologically feasible to automate, it was argued that automation and employment outcomes are the consequences of trade-off between technical capabilities and economic imperatives. The type of product produced in the Austrian automotive industry not only connects to output quantities and decisions of global firms, but also how labour is organised in its production.

Finally, section four has shown that these trade-offs are not just relevant in production rationalities, but also the “politics of production” between workers and management. There may be significant reasons for workers and unions to consider the “development” of the productive forces at their production site as in their interests. The corresponding cooperation allows different and higher automation strategies to be pursued. Global firms may make conscious investment decisions in regions with highly-skilled labour-forces which do not oppose automation and technological intensity, thus explaining persistent manufacturing employment in high-wage sectors and regions. Worker availability, their skill and cooperation in technologically intensive production is equally of relevance in all other chapters, in particular five, six and seven.

It is not feasible to establish a comprehensive, theoretical framework here or to rigorously connect the discussed demarcations between levels of analyses and disciplines. However, the arguments are, for all intents and purposes, already circumscribed well in what Krzywdzinski has pursued as a ”socio-economic theory of automation” (2022). In particular firm-level production rationalities, the emphasis of product architectures, manufacturing and profit strategies as well as conflicts and compromise between workers and management are captured fairly conclusively. Mostly, therefore, the above discussion adds to this by including macro-production contexts, in particular the role of stagnation, as well as recent theories on the behaviour of large international firms. What first and foremost remains to be seen, therefore, is how the discussed theoretical propositions and hypotheses fair empirically for understanding why firms make the automation decisions they do and why manufacturing employment persists in high-wage economies. Before that, however, the methodology of applying theory to data must be discussed.

Chapter 3 - Methodology

0. Summary

This chapter describes the empirical methodology for answering the research questions delineated in the previous chapter. The first section operationalises the term of "automation", by presenting a definition which diverges from common conceptions. The second section elaborates on the usefulness of a multiple-method case study design for researching questions of automation and work. A third section argues that manufacturing, the Austrian automotive industry, engineers and industrial robots are useful cases for such a study. The fourth section outlines ethical concerns, as well as limits of data and method.

1. Which is it - Automation, Digitalisation, Industry 4.0, Artificial intelligence or Robots?

Automation, the Archimedean point of this dissertation, is not as easily defined as colloquial and academic use of the concept would suggest. While in the first instance, it is indeed quite easily grasped as "machines doing things", what *precisely* this means becomes slippery quickly[13]. As one of the automation engineers has put it during fieldwork:

> "*Type "automation" into Google. Automation is everything. Its process automation, its discrete automation. At this level you have no idea who does what. Say you are looking for an integrator doing robot automation. Simply typing in automation, you also get people who are doing process automation in a garbage disposal plant or in a steel mill. And those are completely different worlds.*" (E6-30:06)

[13] The appendix section 1 contains a rather lengthy description by a professor of robotics describing the socio-economic complications which go into estimating the degree of automation of a plant correctly.

Most definitions of automation (Nof, 2009) do build on a relative lack of human intervention in production processes: "[Automation is a] *technique, method, or system of operating or controlling a process by highly automatic means, as by electronic devices, reducing human intervention to a minimum*" (British Academy, 2018). The transition from using terms such as "mechanisation", more prevalent in the previous two centuries, to automation, is often hinged on the extent of the remaining human effort and inversely the autonomy of machinery (Wallén, 2008). Whereas mechanisation thus implied a substitution for human labour, automation implies its outright displacement.

Benanav for one (2020:6) suggests that automation can only be identified if an entire category of job disappears, but not when human productivity is merely increased. While an interesting rebuke of opaque definitions of automation and their inflationary use, the separation between different types of labour-saving technological change creates other problems of understanding. As Benanav rightly points out, much on the debate on automation and the future of work turns on the question whether recent technologies are mostly labour substituting or augmenting, thus whether automation is taking place or not. However, the distinction is unhelpful, firstly, because empirically it is exceedingly difficult to disentangle substitution and augmentation (e.g. the augmentation of one worker leads to the substitution of another; the augmentation in one task substitutes parts of this task etc.). Secondly, and more importantly, it puts the cart before the horse. Rather than asking which type of technology serves which labour-saving function, it is more useful to ask which desired labour-saving function leads to the use of which technology. The latter obviously puts the emphasis on how and why technologies are used, rather than which effects some technologies necessarily will have. The later view also already makes clear that automation is not just a simple technical principle, but that, for example, the organisational of labour is a constitutive part of it.

Another misunderstanding arising from the view that “automation” only applies to the displacement of entire professions is that it precludes it from being applicable outside a very narrow list of instances (as also conceded by Benanav). In a grand scheme of the history of human civilisation, this list may still not be short by any means, but it is nonetheless dwarfed by technological changes which reduce the need for the application of labour power, however marginal the degree. For example, the end of the Bronze age saw the end of the need of craftsmen specialised in the smelting and working of bronze. Three thousand years later, metal working as a profession is still crucial in modern societies. However, the required type and extent of labour-power in these professions has changed drastically. The comical view of growth accounting in economics, that there “has always been “capital”” , is correct in this sense: even the simplest tool has a labour-saving function[14]. Conversely, every tool must be understood as some form of automation, even if it is only a stone in the hands of some ancient human, which removes the necessity of applying resistance to objects by human hands. Rather than considering automation an esoteric, other-worldly and singularly rare phenomenon, I would therefore argue that it is actually ubiquitous and constant. Defining automation in such a way, as the function of virtually any tool, not only makes it applicable in many more instances, it also makes its use in those cases better understandable. More than anything it also redirects the most important question to be asked from whether automation is happening, to what type of automation is happening and why. In other words, describing machinery as its function as

[14] It is still non-sensical of course to consider such labour-saving functions to be equal to what we understand under „capital“ today, meaning wealth with the capacity to control and produce further wealth.

a “social artefact” rather than merely by its technical specifications (Braverman 1998[1976]:127). For example, whereas the conveyor belt is a technologically completely uninteresting innovation, its effect on the organisation of the labour-process was incredibly profound in that it dictated the pace of production and how it is sequentially organised.

I will clarify with an example. Let’s imagine the machinery used in the labour-process of flattening gravel in road construction. This used to be done, some time ago, with a shovel. Then an engine-powered machine was used, now a type of flattening robot is remote-controlled. In other definitions, this change would not be counted as automation, as the category of „gravel flattener“ would persist. However, clearly a part of the labour-process is removed from the necessity of the human exertion of toil and intervention, if not human discretion. I therefore propose to view automation as a process after which the required inputs to a production process, in particular labour but not exclusively, change. They further likely change in such a way, that less time, effort or material is required for the completion of a tasks, or its result is of higher quality. This broader, yet clearly demarcated approach has the simple advantage of understanding automation in relation to the outcome of the production process, rather than merely human intervention. This also means that what “automation” means will depend entirely on the industrial sector, part of the production process and desired outcome. Even assuming a very narrow view on the driver of automation as reducing costs then produces a variety of difference: is cost saved by replacing humans with machinery, by increasing the quality of output or simply by increasing the overall size of output? These specifics must be worked out in concrete empirical instances. However, all tools and machinery which automates even the smallest part of a labour-process to achieve said goals, must be considered automation. Consequently, automation must be extended to the use of new materials, products etc. as well, all of which may have equally significant consequences for professions and which have at points been more distinctively disruptive in human history than the removal of human intervention from production (Christensen, 1997). Such a view of automation is also supported by the way robots are used in manufacturing. As a professor of robotics describes, they never substitute for 100% of manual worker activities, and it appears hardly reasonable to assume that the use of robots is not automation:

> „*We know a robot does not to take over 100% of activities from workers. Maybe 70-80%. That means, if I buy a robot, the worker still has to do things. I buy robots for 4 processes and one worker does the missing 20%.*". (R1-54:08)

Having thus operationalised automation, the question becomes how this definition relates to other concepts of technological change, often used interchangeably with automation in the literature. Contributions in economics usually avoid the question of definition altogether: "*We measure automation as industry-level movements in total factor productivity that are common across countries*." (Autor and Solomons, 2018:1). In more circumspect approaches, such as the evolutionary/institutionalist tradition, (Dosi 1982 and Dosi and Nelson, 2010) technology is viewed as path-dependent "recipe" of combining codified and tacit knowledge (Cetrullo et al., 2023), with a special focus on the Schumpeterian distinction between "product" and "process" innovations. The first being a new piece of technology which changes how a process is done (die-casting etc.) while the other is a new conception of an end-product which may be realised with given technology (a smart-phone etc.). Product innovation generally is associated with positive sectoral employment, due to market expansion (which is why Schumpeter classified it as "friendly to workers"), while process innovation is likely labour-saving. Hence, sectoral unemployment effects based on productivity increases are mostly associated with process innovation, while product innovations are often associated with firm level and sectoral employment increases.

The problem with this distinction is that the empirical world hardly applies to them, much like the distinction between displacing and augmenting technological change. Every new product in some way likely includes a new process for its production, as every new process allows for the production of different and new products. If not within a sector, then between them. Both a new product as well as process can entail new automation steps, and thus the distinction does not represent the essence of the process usefully.

More often than this distinction, however, the terms “digitalization” and “Industry 4.0”, are used as substitutes for automation, in particular in German speaking debates. To keep the discussion here to a minimum, I follow Pardi et al. (2020) and Krzywdzinski (2021): “*Although the current discussion about the future of work often confuses the terms digitalization and automation, it must be clearly emphasized that both denote different processes, even if they overlap in part*.”

Digitalization may thus at points serve the purpose of automation, but automation does not need to recur on digital processes, separating the effects of both into different sets questions. Pfeiffer (2021) for example has emphasised that digitalisation as process mostly concerns the sphere of the circulation and distribution of commodities, rather than their production. Where applicable in production, “digitalisation” mostly concerns the monitoring, control and optimisation through software systems, most expressly in digital assistance systems (tablets, data glasses, smart watches). Whereas digitalisation is aimed at the optimisation of production processes, therefore, automation may be such a form of optimization, but is not sufficiently accounted for as such (Butollo et al., 2019). In line with the earlier definition of automation, this means that to determine when and if digitalisation is automating, can only be answered in concrete empirical instances and considering the desired output, but not ipso facto. However, it must also be considered that a very narrow function of control may equally fall under the definition of automation presented above.

Industry 4.0 on the other hand does not merit an extensive discussion at this point. It has been shown to be mostly a politically enforced discourse (Pfeiffer, 2017), which did not contain anything substantially new in terms of economic propositions or technological descriptions, in particular not in the automotive industry (Krzywdzinski, 2021). As the head of the Austrian Industry 4.0 Platform has put it during fieldwork:

> "*I want to stress that [Industry 4.0] on the one hand is a very good term and on the other hardly helpful. It is hardly helpful because it evokes nothing [no specific technologies]. […] The aspect in which it is very helpful is that as term, coined and promoted in Germany, it allowed for the "old industry" to come to fore again, and this term achieved that 13 years after the dotcom bubble manufacturing was presented as innovative and also to connect this innovation to the notion of quality which worldwide is associated with Germany. The term has also freed a lot of subsidies […]. So politically it was an extremely successful term*." (R2-26:01)

Finally, the question remains, in particular in recourse to the definition of automation, is how specific technologies fit into it, and thus into this dissertation. It is neither sufficient nor expedient in empirical research to only take recourse to abstract concepts. The natural conclusion in this case, is to select individual technologies of relevance. The primary empirical entry point for the analysis in the substantive chapters is therefore the use of robots. However, since the interest of the qualitative part lies in automation rationalities more broadly, other technologies such as artificial intelligence and new forms of light-weight robots will also be discussed.

2. Multiple-Method Case Study

The empirical analysis in this dissertation follows a case study design (Yin, 2018), meaning an in-depth analysis, based on the contextualisation of a phenomenon and a triangulation of multiple sources of evidence (Yin, 2009:18). In acquiring these multiple sources, the study uses quantitative as well as qualitative methods. The combination of these different types of evidence follows Downward and Mearman's "mixed method triangulation" (2007). Such a combination is noteworthy as traditionally the qualitative program of much of the sociology of work does not intersect with the quantitative estimations of labour economics (Lee and Cronin, 2016). As Baosle and Ramnarain (2016) point out, however, it is quite curious that economic research has become divorced from qualitative research, as after all, the discipline itself arguably began with a factory visit (Smith's pin manufacture).

The advantage of case-study is the possibility for great empirical depth, in particular regarding "*small group behaviour, organizational and managerial processes […]*" (Yin, 2009:4). The traditional critiques of this method, on the other hand, are lack of rigor, lack of systematicity, bias of findings and un-generalizability. These are largely critiques levelled against qualitative research generally, as the results of qualitative interviews naturally depend on who is being spoken to and how. While great care was taken to mitigate these distortions in the research, by selecting a maximally representative sample, aiming for maximum saturation and a wide spread of different respondents, the issue can never be fully resolved. While quantitative evidence was included wherever reasonable, the issue of the generalizability of the results of a case study thereby remain. However, in reference to Burawoy's (2009) "extended case method", we can specify that the goal of a case study is in fact not a generalisation of populations, but rather theoretical positions. Put differently, the goal is to conduct a "generalising" and not a "particularizing" analysis. Hence, also the study of a particular case is a significant test of theory.

There are several additional advantages to using a multiple method research design for addressing questions of automation and employment specifically. First, automation and technological displacement play out differently on different levels of analysis (see chapter 2). The behaviour of single firms must not be the same as that of overall national sectors, or even global sectors. Focusing only on macro- aggregates risks getting lost in abstraction, while limiting the analysis only to individual instances loses the bigger picture. A mixed method case study, in the best case, mitigates both dangers. Such case studies are also hardly used in the study of technological displacement and economic research more generally, despite there being great need for them (Leigh et al., 2020). Secondly, the question of technological displacement is inherently very complex as it interrelates different dimensions of economic and social activity. Considering as much variation in evidence as possible gives the best chance of unravelling this complexity.

The multiple method study of this dissertation is conducted sequentially, meaning the results, data and analysis of each stage lead into those of the next. The stages are:

1. Beginning at a high level of sectoral aggregation, a fixed-effects model of the effects of robot-use on productivity, output and employment in the OECD automotive industry is estimated.

2. Drilling down into the results for Austria, the specific case study of the Austrian automotive industry described.
3. These aggregate results frame the analysis of specific automation rationalities of engineers, managers and workers.

A final point on the research design is in order here, as it does not just use multiple methods, but also draws on multiple disciplines. During presentations of this project and its results over the years, one of most common feedbacks was of disciplinary confusion. When presenting to sociologists, it was commented that this was in fact not sociology, but clearly an economics project. When presenting to economists, it was commented that this is clearly sociology and has nothing to do with economics. I therefore find it expedient to dedicate the final part of this section to come to a clear understanding why this dissertation can be submitted at a sociology department, even though researching economic subjects. I do so with two arguments both of which show that economic phenomena are amenable to sociological study,[15] and both of which are applicable to the present research.

The first point is that a logically consistent distinction between “economy” and “society" is in fact not possible, and thus equally, the disciplines of economics and sociology (Albert, 2014). Therefore, even where theories and variables are presented in economistic and technical jargon, their argumentative content is a description of social behaviour and thus representative of societal structures. The violent opposition of most economists in the “central tradition”, to use Galbraith’s term, to this point is unfortunately not in itself a

[15] The opposite has been practised extensively by Economics, also summarised as „economics-imperialism“. (Fine, 2023).

valid rebuttal. If a reasonable distinction between „economic“ and social“ behaviour cannot be made, questions of how automation affects employment are questions how societies organise their material production, rather technical questions of a quasi-natural kind. As this production is a social relationship between individuals and groups, however, it is accessible to sociological analysis. The history of social and economic thought is full with arguments to support this position, or conversely, which critique the distinction of economy and society, or the economic and non-economic. More recently, Streek (2016) and Fraser (2023) for example outright suggest that capitalism is best understood not as a type of economy but as a form of society, where processes deemed „economic“ fundamentally rely on process which are deemed „non-economic“. Williams (2010) has argued that the production of economic ideas itself is a social process, and thus amenable to non-economic social study. Hall (2021) has argued that the economic is determined by its relation to the non-economic, and Polanyi that the non-economic is a prerequisite for the economic, whereas Lukacs has found the economic to merely be a veneer to cover the non-economic at the core. Perhaps most famous, of course, is the rejection of Marx of a distinction between the economy and society (Mau, 2023:5). Rather, the ambition of Marxian theory is to show the social relations hidden within seemingly technical economic categories. In many ways, the reverse ambition of much work in economics (Meiksins-Wood, 2016). Hence, even when in this dissertation economist variables are discussed, such as labour-productivity (social input and social output) and sectoral concentration (the social relations between producers), it is quite clear that these variables represent the relations between people, rather than between things.

A second and equally well-defended argument is that the entire enterprise of the analysis of the development of industry, technology and work is a fundamentally sociological question. Obviously, there is a long tradition within sociology to study industrial society, manufacturing employment, technology and work in the factory. The existence of the sub-discipline of Industrial Sociology alone and in particular its emphasis on automation as a question therein (Mills, 1951; Bright, 1958; Caplow, 1954) speaks to this, even if it is more relevant in the German-speaking tradition than elsewhere. However, in all sociological traditions an inherent interest in the comprehensive and detailed study of work and technology is found, and in a very different way than in economics. This difference is illustrated sharply by Heilbronner: „*The actual social process of production- the flesh and blood act of work, the relationships of sub-and super-ordination by which work is organised and controlled- are almost strangers to the conventional economist*.“ (1975:6). If this flesh and blood of the hidden abode of production is not understood, however, more aggregate analysis will remain mystifications. While Heilbronner makes sociology appear as reigning supreme on questions of production, this is also not necessarily the case, as Foster has shown: “*[S]ociology, like economics, has usually been divorced from any real understanding of the way in which working life is objectively organized around the division of labour and profitability*.” (Foster in Braverman 1998:x). It is for this reason, that Adorno has defined Political Economy as the field of what is missing, both in economics as well as sociology (2000). Meaning, both disciplinary approaches cannot account for all the facts, unless they are combined. To consider how labour-processes are organised socially, also must include what this means for profit strategies etc. The goal must therefore be to understand the interrelation and limits of all types of factors, economic and social, even where they cannot be neatly separated. Hence not that economics determines technology, or society determines technology, but rather a web of elements which cannot be reduced to either. Consequently, if we do not conceive of "the economy" as congruent with "society", we understood little to nothing of either.

Naturally, this insight has been achieved within disciplinary boundaries. Institutional economics, for example, even though it relies on more economistic terms and language, has the main interest in the study of intuitions and thus social relations, akin to sociology. However, it is critically focused on their economic dimensions, meaning almost automatically, institutional economics creates the web suggested above, as does economic sociology. It is therefore no coincidence that the concepts of countervailing power and conventional wisdom, of one of the most famous institutional economists, figure heavily throughout this dissertation.

Economic behaviour is therefore decidedly social behaviour and the stability of all economic facts, empirical as they may be, is a function of social beliefs (rather than immutable laws of supply and demand etc.). It is in this sense that Albert, in his definition of economics, wondered about the very strange way, in which it attempts to give non-sociological answers to what are clearly sociological questions (Ferschli and Kappeller, 2018).

3. Industrial Robots in the Austrian Automotive Supplier Industry

The empirical core of the case study just laid out is the Austrian automotive supplier industry, with a focus on automation engineers and the use of robots. This choice, like any empirical operationalisation is not self-explanatory, which is why this section discusses it in greater detail.

Manufacturing is a theoretically and empirically interesting avenue for studying the causes and consequences of automation, firstly, since it is disproportionately affected by progressive robot-use in comparison to other sectors such as agriculture or services (Hill, 2019). Secondly, the "footprint" of manufacturing, when considering the costs of intermediate inputs, is much larger than value-added indicates (Scott, 2015), meaning also nominally "service economies" continue to rely on manufacturing. Manufacturing thus has structural characteristics which render it and its employment crucial to (most) developed economies: its products and its jobs. Material societal affluence, as we understand it today, continues to be matter of the size of manufactured commodities. Manufactured commodities, in turn, are also the only commodities which allow for significant jumps in value-added in different productions stages, meaning it is possible to import parts as lower-value added and export them as higher-value added. While much agriculture produce continues to be exported and traded, it cannot achieve anywhere near the trade surplus of exporting advanced machinery, e.g. which is why Germany does not specialize (at least not exclusively) in the export of potatoes, but of industrial machinery. This also means, in economistic terms, that manufactured goods having a higher international elasticity of demand, as domestic demand is seldomly sufficient for firms to grow (except perhaps for the US and China). As argued by Kaldor, neither economies of scale (Kaldor-Verdoorn law[16] :Kaldor, 1966) nor export driven multipliers can be created with any other product or sector. It is for this reason "industrialisation" continues to be the primary development strategy of economies (Chang, 2003). Manufacturing is a singular, perhaps the only significant, engine of growth (Benanav, 2020; Brenner, 2006). As pointed out by Škuflić and Družić (2016), before the financial

[16] Meaning the increase of productivity by virtue of increasing output

crisis in 2008/9, the prevailing notion was that de-industrialization amounts to successful economic development. It was only in the wake of the crisis that industrial policy was proclaimed as crucial path to re-establishing industrial production as a base of societal wealth (Rodrik, 2009). The second specific characteristic of manufacturing is its jobs. Manufacturing jobs are often of higher skill content and have higher wages than average service jobs (Felipe et al., 2019). Hence, the higher the share of manufacturing employment, the higher societal job quality in many cases. Furthermore, many jobs counted among service employment structurally depend on manufacturing (Scott, 2015). Both points make clear why the retaining of manufacturing employment is such an important industrial policy goal. Even more fundamentally, entirely digitally produced services have a material base which must be manufactured (Huws, 2015), making "chips wars" and national confrontations on AI infrastructure, for example, equally unsurprising. Service jobs, in turn, are prone to what Benanav (2020:60) calls super-exploitation or what has been referred to as "bullshit jobs" (Graber, 2018) which represent an "immiseration of the wage bill" (Autor, 2015). This is the case where wages increase slower than value-added, referred to as the productivity-wage gap (Bivens and Mishel, 2015), which has been a central feature of high-wage economies over the past decades (Dosi and Virgillito, 2019). Finally, productivity increasing technology is usually first developed in industry (Leigh et al., 2020), and productivity increases in the service sector depended on their "industrialization"[17] (Gershuny and Miles, 1983).

[17] As the washing machine, for example, made the previous "service" of washing amenable to industrial production and productivity.

Austrian manufacturing in particular has several characteristics making it an interesting case for the study of technological displacement. In the language of the varieties of capitalism approach, Austria can be characterized as “coordinated capitalism with a conservative welfare-state” (Hall and Soskice, 2001) which has undergone coordinated liberalization over the past decades (Hermann and Atzmüller, 2009). This liberalisation has put pressure on the traditional corporatism (Marin, 1985) specific to Austria, which informed the basic consensus of the welfare regime (Arts and Gelissen, 2002; Esping-Anderson, 1990) and consequently industrial policy and the organisation of labour (Angelo and Marterbauer, 2015). Liberalisation has seen Austrian manufacturing change from heavy consensus-oriented social partnership, with a high percentage of state-owned industries, to a privatised and heavily export-reliant industrial sector. The most recent step of globalization with the greatest significance for Austria has been joining the European union 1995, precipitating a rise in foreign direct investment as well as increase import and export figures (Kowall, 2021). The composition of trade partners has also shifted of the past decade, with a declining importance of the EU, and an increasing importance of exports to eastern Europe and Asia. However, remnants of a more heavily directed past, continue to strongly affect present “competitiveness” of industry in Austria, such as the dual-vocation training and education system.

The relevant parameters of the research puzzle also apply particularly well to Austrian manufacturing: it is one of the countries with the highest rates of adoption of industrial robots in manufacturing (14th highest robot-density globally (189 robots per 10.000 employees IFR, 2019), but also among those countries with continuing high industrial employment. Both criteria apply to a particularly high degree in the Austrian automotive sector (Gnambs, 2019). The automotive industry and its employment regime (Hermann and Flecker, 2015) are of particular relevance to the wider Austrian economy, as it serves a precedence function for other sectors, both manufacturing and non-manufacturing.

Industrial relations in Austria have undergone organised decentralisation in recent decades (Hermann and Atzmüller, 2009). Almost all workers are covered by collective bargaining, mainly due to companies' mandatory membership of the Chamber of the Economy (Glassner and Hoffmann, 2023). Industrial relations are therefore often organised in the form of a "social partnership", based on industry-wide collective agreements on wages and working conditions. This configuration has meant that industrial relations in Austria remained stable in the manufacturing sector, and in the automotive industry in particular, thus avoiding major upheavals such as those that occurred in other European countries such as France and Italy. In terms of the implementation of technological change, "co-determination" or "Mitbestimmung" has been the most relevant principle of industrial relations in Austrian manufacturing, comparable to Germany (Steffen and Schnabel, 2019; Traxler, 2000; Auer, 1994, Auer et al. 2011). Worker-voice in company decisions on technology is provided through works councils (Betriebsrät*Innen) in firms with at least five employees, as well as their rights concerning workplace conditions, dismissals, restructuring, and technological changes. (Genz et al., 2019; Haipeter, 2020; Rego, 2022). While such co-determination has a legal basis and works councils and trade unions have consultative and negotiation rights, they cannot unilaterally block company decisions. Firms are legally required to inform and discuss major changes, such as automation and digitalization, but they are not bound in any way to follow trade union recommendations.

The automotive industry represents the *locus classicus* of research on technology and work, as it is a pioneering sector of automation with a very high technological turnover due to the more complex nature of its production process with correspondingly high labour costs. Consequently, automation and digitalization of production have shaped the automotive industry for several decades (Butollo et al., 2022, Krzydwzinki, 2021, Pardi et al., 2020). The automotive industry has also been an emblematic driver of economic growth and industrial development in the 20th century more generally. Today it still takes precedence in many countries, as it is considered an important source of industrial employment and growth. In the European union about 3,5 million people have worked directly in the automotive industry in 2019, and a further 14 million in adjacent industries (Cetrulo et al., 2023, Gaddi and Garbellini, 2021). The industry accounts for roughly 7% of overall EU-GDP (European commission, 2021) and significant trade surpluses (ACEA, 2021). The EU remains the second largest producer of cars after China, accounting for more than 21% of global car production in 2017 (Cetrulo et al., 2023). The global annual production of cars has increased significantly from about 10 million cars in 1961 to 70 million in 2018, with the total global stock having passed the 1 billion mark in the 2010s (Mattioli et al. ,2020). This global production is highly concentrated in North America, Europe and East-Asia. The automotive industry naturally also has strong economic links to upstream manufacturing sectors such as steel, rubber and glass as well as downstream to oil.

With the financial crisis in 2009, the global automotive industry has entered a decade of crisis[18] which continues today, drawing the future of automotive jobs into question more

[18] https://orf.at/stories/3376514/

than ever before[19]. This crisis is not just visible in a reduction of demand and sales, but also investment and research spending, affecting long-run productivity (Cetrulo et al. 2023). This represents an uncommon situation for the automotive industry as it usually considered one of the most research and technology-intensive manufacturing industries, based on rapid model changes necessitated by intense oligopolistic competition over global sales markets. While the effects of the crisis on the European automotive sector has been a topic of research (Ferrazzi, 2012 ; Haugh et al. 2010 ; Pavlínek, 2012), the research of productivity dynamics has not been a focus, except for a few exceptions (Manello et al., 2015; Mendoza-Velazquez and Benita, 2019; see the corresponding results in chapter 4).

The current production structures of the global automotive industry are important for the contextualisation of the research question of this dissertation and are characterized by high capital intensity and economies of scale. This means significant dependence on high production quantities and capacity utilization for maintaining profits. In tun, this means that the industry is very prone to overcapacity and overproduction. High fixed costs force the production of as many cars as possible, with even the smallest fluctuation in demand having significant repercussions, as output cannot easily be adapted. Mattioli et al. therefore conclude that overproduction is endemic in the automotive industry, which encourages "*indifference in systems resources optimization*" (2020:326). This means automotive firms disregard other potentially more profitable or technologically superior production options in favour of the status quo (chapter 6 and chapter 8). This behaviour is likely aggravated by the structure of global conglomerates and the corresponding

[19] https://brusselssignal.eu/2024/10/german-car-industry-chief-warns-one-in-four-jobs-at-risk-in-next-decade/

intensity of principal-agent problems (of managerial interests diverging from company interests) and financialization (of financial interests diverging from overall company interests).

Due to the requirement of high production volumes and production as close as possible to maximum capacity, aggressive expansion and conflict over market shares is so prevalent in the automotive industry (see chapter 5). Much as described by Benanav (2020) for manufacturing more generally, the securing of market shares from competitors is one of the best, or perhaps only feasible, way to grow in saturated markets. The spatial expansion into the Chinese market of European automotive producers, is the flip side of this coin.

Based (in part) on the high capital intensity and economies of scale, which mostly prevent significant competition to emerge, the industry shows high concentration tendencies (see chapter 4) and is dominated by relatively few global firms (see chapter 5), with 67% of global production falling to the top 10 manufactures in 2017: "*The archetypical example of sector dominated by multinational corporations*" (Mattioli et al., 2020:3). Historically, one of the crucial developments in the automotive industries to allow economies of scale, was the introduction of the all-steel body of cars, which resolved production bottlenecks in the 1920s and allowed mass production. In turn, this required large capital investments, however, and the production of specialised plants to be run at high volumes (Mattioli et al, 2020: 116). The resulting concentration of the industry in the course of the 20th century, developed into high barriers for entering and leaving the industry, based on very large investments.

The characteristics of the product of the industry have also has shifted significantly. While the focus around the turn to the 20th century used to be on providing relatively low-cost solutions and standardised mass-products, saturated markets in particular in developed economies have forced automotive firms to increasingly compete based on product differentiation and variants. This change has very direct consequences for automation and employment (see chapter 6). The switch to low volume products with many variants has also aggravated the profitability dilemma of the industry, however.[20] [21] A solution was to maintain relatively standardised production, for example using the same platform for different models, while keeping variation at the superficial level. This has also meant, however, built-in redundancy and "excess" which means car systems suffer from unused capacity and inefficiency, financially, spatially and technologically (Mattioli et al., 2021). Technological choices of the past have thus locked the automotive industry into high capital-intensive production and business strategies, which together create powerful forces to leave present production structures unchanged despite inefficiencies.

The automotive industry also has a privileged position in shaping policies in most developed economies, due to its provision of jobs, growth and taxes. Political influence is particularly strong and apparent in phases of economic crisis, such as the financial crisis and the present transformation to electrical mobility[22]. Based again on the necessity of

[20] Mattioli et al. give the figure of typical profit margins in the 1920s of between 20 and 30%, whereas this was reduced to 10% in the 1960s and below 5% in the 2000s.

[21] Orsato and Wells argue that as a response to these "low" profit rates car manufactures have focused on multiple-purpose designs and risk reduction leading to a vast majority of passenger cars being five seat vehicles, with maximum speeds over 160Km/h and range of around 400km. What is often marketed as great variety is thus in large degrees of superficial aesthetic overlaid over platform consolidation, common vehicle architectures and modular assembly.

[22] An example is when 500 employees were fired by MAGNA because of a poor state of orders, local government immediately announced rescue packages.
https://ooe.orf.at/stories/3281923/

large production numbers and the high fixed costs of production facilities, the automotive industry has little leeway in adapting to demand fluctuations, making intervention in the form of state grants and subsidies often necessary. Due to the great entanglement of regional production systems with necessarily large automotive plants, the social impacts of relocation are pronounced leading to great political relevance and media visibility (see also the case of MAN in Steyr, in chapter 5). It is thus also not surprising, that trade unions in many cases align with the positions of automotive firms (see chapter 7).

This short overview would be amiss if it did not address, in some capacity, the role of "lean management" or the "Toyota production system" in the development of the automotive industry. Following the "japan shock" of the 1990s, during which Japanese production strategies proved more efficient than European and American approaches, the Japanese system of work organisation became and remains the managerial standard, in particular the automotive industry (Krzywdzinski, 2021). Notably, the efficiency improvements of Japanese car makers did not rely on technological change, but rather organizational restructuring (Adler et al., 1999). These strategies reduced the previous emphasis, especially of European companies, on high-tech automation solutions, in favour of flexibility, as production with high-degrees of automation is prone to overproduction based on fixed-costs degression. Generally, "lean" emphasises outsourcing of low-value added activities, constant improvement requirements from workers (kaizen), work organisation in the form of teams and flexible labour contracts. However, lean continues to produce varieties, the intersection of which Smith and Vidal (2022) describe as "lean enough".

The development of automation strategies in the automotive industry has not been uniform between countries either (Krzywdzinski, 2017; Cirillo et al., 2021). One of the historical differences is different paths in the trade-off between high automation and flexibility. Whereas Krzywdzinski (2021) describes the German automotive industry as having pursued high-tech automation through the 1980s and 90s, accompanied by professionalisation and skilled work, Japanese firms opted for greater flexibility and "manufacturability" of products achieved by organisational rather than technological means (Adler et al., 1999). More important than country-differences, however, is to distinguish technological developments by production departments. In the automotive industry, these departments traditionally are: assembly, body construction and what Krzywdzinski (2021) calls "auxiliary activities", covering the service activities of development, planning and production control.

In the case of body construction, automation has remained stable and high since the 1990s, at about 90-100% with no difference between countries (see chapter 6). Krzywdzinski (2021:33) notes the most important changes in this department as organisational such as the herringbone layout, where welding lines and sub-assemblies are connected to conveyors to which robots have access and more complex joining-techniques necessitated by product changes such as lighter vehicles. Perhaps most impactful in public perception, since the 2000s robot-use has steeply increased, in particular in multi-robot cells, where robots work on components together or simultaneously. However, the use of robots was not as important as increasing complexity and productivity gains based on changes in the product architecture (Krzywdzinski, 2021:37).

In contrast to body construction, the automation of assembly has not significantly progressed since the 1990s, with the most promising change to technological feasibility in this regard, lightweight robots, having largely been disappointed in disruptive effects (Pfeiffer, 2019 and see chapter 6). More than increasing automation, changes in the product architecture, such as the change to simpler electric car manufacture, has reduced complexity in production and thus labour costs. Krzywdzinski notes changes relating to ergonomics, such as lifting aids, and digital assistance systems, digitally controlled screwdrivers etc., which are used to pace and control the labour-process (Krzywdzinski, 2021; see chapter 7).

Finally, much like in assembly, the “indirect areas” of production (product development, planning, production control, quality assurance etc.) have technologically changed more based on “digitalisation” rather than automation since the 1990s. In the automotive industry, digitalisation has meant, like in other sectors, the use of CAD (computer assisted design) software and CAQ (computer aided quality concepts). Krzywdzinski also describes the proliferation of sensors and the collection of data for maintenance and quality assurance, starting in the 90s and which by the 2010s already had several hundred measuring points on production lines. Other changes included the production of virtual prototypes, simulations and more efficient networking allowing MES (manufacturing execution systems) to be used to monitor and control production. Same as with automation, the goal of these digitalisation steps was to save costs in the planning, development and control of production.

Based on these developments, Krzywdzinski concludes that technological change in the automotive industry does not primarily meant increasing automation, and that increasing automation does not in all instances mean less employment or even higher productivity.

While robot-use which has increased massively since the 1990s, for example, automation levels have remained the same, and employment in many instances increased. In many cases, labour-saving changes have been offset by the increasing complexity of production and products (see again chapter 6).

Similar to the different technological outcomes in countries and production departments, so employment developments have differed. Krzywdzinski notes, much like the introduction to this dissertation, that in the three large classical automotive producing sectors of Germany, Japan and the US, employment in manual production has been „surprisingly stable“, accounting for roughly 800k workers in each country. While employment levels between the three large automotive sectors are similar, their occupational composition differs significantly. While in the German automotive industry blue collar work has indeed been declining in favour of white-collar engineers, the Japanese automotive industry shows similar but slower trends, and the employment structure in the American automotive industry is frozen with a „strikingly low“ share of engineers and computer scientists. Albeit this assessment relies on difficult comparisons of worker categories between the countries. Overall, however, metal working occupations have declined, without much change in welding and painting workers. As the latter departments are those which have seen the largest increases in robot-numbers Krzywdzinski see this is indication that over recent decades automation has not directly substituted workers with robots, as this kind of substitution has already taken place in the 1980s and 90s, but rather that changes made it possible for workers to operate more machines.

Naturally, employment trends differ based on whether the automotive firm in question is supplier or manufacturer, as in most cases, suppliers will have less assembly work but more metalworkers and welders. In all cases the main share of manufacturing workers overall is concerned with assembly activities, however. Krzywdzinski summarises that there is little evidence that automation has progressed in the automotive industry since the 1990s. Assembly workers have been very stable, surprisingly so, but machine operations and welding have seen declining numbers.

The automotive sector in Austria specifically, is spatially concentrated and dominated by large globally active export-oriented firms. These firms are very profitable and increasingly so. While employment has increased, this increase dwarves when compared to revenue and output increases. The labour-use regime of the Austrian automotive industry relies on the one hand on a strong vocational training system, producing highly skilled workers, while its position at the border to the European East and South has ensured a supply of migratory labour from other central and eastern European economies such as Poland, Slovenia, Slovakia and Ukraine.

Austria's automotive industry is largely a supplier industry in close dependence on the German automotive industry but also integrated to with other CEE countries. The Austrian automotive industry exemplifies the pressures of the high-end supplier segment of the global automotive industry, while being representative of high-wage, export-driven manufacturing sectors of the Global North in an ambivalent core/periphery position and close relationship to other central and eastern European automotive industries. Although a supplier industry dependent on foreign OEMs, its symbiotic relationship with the German automotive industry resulted in the Austrian automotive industry focusing mainly on technologically intensive, high-value added production. The latter has grown steadily in recent decades, in line with the so-called “premiumisation” (Frigant and Jullien, 2018) or “upmarket drift” (Pardi, 2022) of the automotive market led by German car manufacturers. For instance, Austria is among the countries with the highest and growing share of industrial robots, particularly in automotive manufacturing (Gnambs, 2019). The importance of exports and global competition for Austrian industry, again in particular the automotive sector, means that pressures for technological progress and automation are high and consequences are pronounced.

Within the focus on the automotive industry, the empirical research further hones in on the socio-economic group of those performing the “work of automation” meaning automation engineers, system-integrators, and technology suppliers. While recent contributions on the use of AI and robotics have identified different forms of uses for them (substituting, complementing or augmenting human labour), there is limited research, on when, which strategy is pursued and why. Engineers, however, have a privileged point of access as producers and implementers of new technologies (Gnisa, 2025; Krzywdzinski et al. 2025; Steinhoff 2021). By investigating those performing automation, it is possible to contextualize more aggregate developments, problematize them, extend or confirm them. While engineers are thus an interesting focus, as is their work of automation, they have been researched comparatively little compared to management, workers and unions.

Austrian industry, along Germany and Italy, is also known for the proficiency of its “Systems integrators”. These are automation engineering firms which are hired by manufacturing companies for the coordination and implementation of automation projects, serving as mediator between technology producers and consumers. Engineering mediators have increased in importance, in particular in in Germany and Austria, in parallel to the declining role of corporatist dialogue. Professional engineering groups in both hard and software have thereby taken a much more central role in production and the political negotiation of production politics. While the designation “engineer” overlaps between employees at manufacturing firms, such systems integrators and technology suppliers, they interface at different positions and interests in the production, consumption and implementation of automation technology.

A final reason why engineers are a useful group to focus on is that, unlike management, they are much more likely to step out of “managerial talk”. During fieldwork this was achieved once rapport was established and engineers started “talking shop” rather than company prepared talking points. The strategy was simply to question points to a sufficient extent, so engineers would offer “the truth of the matter” themselves.

Finally, the reason why this research will focus on industrial robots in the first instance, as operationalization of “automation”, is because they show a maturity of technological development, as opposed to for example “AI” applications, have been widely used for some time and specific data is available on their diffusion, such as by the International Federation of Robotics (IFR).

More than other technologies, robots also embody fears and social commentary of technological unemployment (Mokyr et al., 2015). More generally, however, it is difficult to demarcate what constitutes a “robot”, the term being theoretically and empirically overdetermined. In alignment with previous work on the displacement effect of industrial robots (Graetz and Michaels, 2015; Acemoglu and Restrepo, 2017a/b/c; Dauth et al., 2018), I adopt the definition of the International Federation of Robotics: “*[A]n automatically controlled, reprogrammable, multipurpose manipulator, programmable in three or more axes, which can be either fixed in place or mobile for use in industrial automation applications*.”(IFR, 2020).[23]

Industrial robots do not per se represent a sharp rupture to automation technology. Their first use date back to the 1950s with significantly increasing numbers in the 1980s onwards. While industrial robots are thus on the one hand well established, there are also new developments of relevance. The most prominent of these developments is the use of “cooperative” or “lightweight” robots, often framed as representing a new chapter in the history of industrial automation.

The added benefit of such types of robots is that they are relatively cheap, easy to use and that they can be operated without security zones and in cooperation with human workers (Pfeiffer, 2019). Some argue therefore that they are the potentially most disruptive current technological trends with likely high diffusion rates (Fernández-Macías, 2019). As a German automotive magazine has put it: ““intelligent robots” are the “greatest trend” in the automotive industry” (Fisch, 2021). The different forms of human-robot collaboration advertised by producers should allow for a break in the division of labour which was established in the course of the implementation of classical industrial robots in the 1980s: programming (by engineers); maintenance (skilled workers); use (unskilled workers).

There is presently, however, very little research on the use of lightweight robots. Part of this is certainly their novelty, but as Pfeiffer (2019) points out, lacking research is

[23] Although in all likelihood Isaac Asimov’s much simpler definition of „computerized machine“ would perhaps also suffice.

confounding for another reason. Lightweight robots are technologically “mature” (unlike AI applications), can be used in production, and require relatively little investment. They thus should allow for the automation of previously not-automated processes and result in a qualitative leap in rationalization and replacement of workers with machines. However, evidence of this does not exist, providing an additional interesting research avenue (see chapter 6).

While the empirical focus thus lies on robots, as a more than imperfect proxy for recent automation processes, and while they are also an anchor to the empirical investigation, the semi-structure of the interviews also to delve more deeply into the complexity and heterogeneity of automation processes and the structure of machine systems. Robotic machinery, after all, goes hand in hand with digitalization processes and serves as basis for many recent artificial intelligence applications.

4. Conclusion: Ethical Concerns and Limits of Data and Method

There were no ethical concerns apparent for the quantitative leg of this research as it deals with anonymized and aggregated data, does not have ethically or morally dubious topics and required no physically or emotionally threatening collection of data. Regarding the qualitative part of the case study, respondents were briefed on the specificities of the research project and asked to sign informed consent forms. While physical harm was negligible (for me as well as participants), since the participants’ work lives are researched, there was a potential for psychological and economic harm due to a lack of privacy and confidentiality. Both were therefore taken very seriously. All research was conducted according to the principle of non-maleficence and according to the data protection protocols of the Social Science Division at the University of Oxford. In research output, all participants, firm names and locations are anonymized. Firstly, because of the sensitive nature of such information in the automotive industry, respondents did not want to put name and company to their statements, and secondly because the firms in discussion below can be researched with relatively little information. The gathered data is stored securely on a privately owned, password protected computer and moved to a separate hard drive with additional encryption. This raw data is only accessible to me.

There are naturally limits to data and method to consider, both for the quantitative as well as qualitative parts of the case study. For the quantitative analysis, limitations relate to the use of some of the datasets and thus the metrics derived from them. This primarily concerns 1. the IFR database and uncertainty whether robot-use can reasonably approximate automation, and 2. The Orbis database and uncertainties regarding its use for the calculation of concentration measures. While these discussions are very important, perhaps essential, both databases and metrics are nonetheless used in the estimation below, mostly for lack of better sources and as comparable publications do the same. There are several descriptions of procedures undertaken to achieve the final quantitative data set under sections 2-4.

Regarding limitations for the qualitative analysis, the usual conditions of such research apply and have in part already been discussed. The analysis of automation and employment is limited in terms of the focus on the Austrian automotive industry and engineers active within that industry. As the results of the analysis also plausibly show, such findings differ significantly from sector to sector, as well as from firm to firm. Finally, a limitation of the research here presented is the relatively strong focus on one technology: industrial robots. This focus is necessary in order to generate specific results, but robots are just one piece of technology sued in production. A more comprehensive research project with more comprehensive conclusions would need to consider several technologies in greater detail.

Chapter 4 - Spurring Monopolies and Fettering Automation? The Effects of Robots on Productivity, Output and Employment in the OECD Automotive Industry

0. Summary

This chapter estimates the effects robotic automation has had on labour productivity, output and employment, in the automotive sectors of 22 OECD countries between the financial crisis (2010) and COVID-19 pandemic (2019). In order to better understand the development of automation and the drivers of employment increases in the same period, it assesses a recent hypothesis of labour-productivity growth stagnation. The analysis finds that slowing productivity can indeed be confirmed for the OECD automotive industry of the period, but must be qualified as it depends on a “parallax view”, meaning on indicator, time frame and analysed country-sector. It further finds that while industrial robot-use has significantly increased over the past decade, the measure only represents a very partial approximation of automation, with a highly skewed distribution between countries as well as between and within sectors. The inferential analysis shows that robot-use is a significant explanatory variable for changes in productivity. However, whereas in general manufacturing, robots have increased productivity while reducing employment, in the automotive industry the opposite is found. In explaining this counterintuitive difference, the paper illustrates the importance of the relative strength of “employment” and “output” effects based on automation, and the variation of these effects between “core” and “periphery” automotive sectors within the OECD. Overall the findings lend credence to accounts which argue that rather than automation and productivity, it is

structural changes and crisis, in particular of output, which have had the most significant influence on manufacturing employment in the recent decades.

1. Persistent Manufacturing Employment in the OECD Automotive Industry and Productivity's Topical Paradox

Recent accounts of a new[24] "productivity paradox" find that labour productivity growth has decelerated in high-income countries since the early 2000's, in parallel to significant increases in automation (Goldin et al. 2022, Christofzik et al. 2021). In the same period, the OECD automotive industry has seen significant employment increases (Figure 1, chapter 1). Changes in productivity may explain these counterintuitive increases in two ways. One, if productivity growth has in fact been stagnating, or increasing automation has not translated into productivity gains, employment would likely not be reduced or increased if overall output remained steady or increased. Two, if productivity has not stagnated, its increases could have safeguarded employment by also allowing output expansion and preventing offshoring. While the persistence of employment may thus be a consequence of stagnating or increasing productivity, both propositions cannot be true at the same time. This chapter weighs the plausibility of both explanations, in accounting for persistent manufacturing employment in the OECD automotive industry.

While the productivity growth slowdown appears empirically relatively well established, with an emphasis on the contributory role of manufacturing sectors (Brynjolfsson et al. 2019; Goldin et al., 2022, OECD 2019), its causes are still debated (Ilzetzki 2020). Among the most pertinent potential explanations are the lacking productivity effects of new

[24] Compared to the „Solow-Paradox" of the 1980s.

technologies, as well as the stagnating effects of increasing concentration. The automotive industry is a useful avenue for studying these causes. For one, it is one of the technologically most intensive manufacturing sectors, illustrated by the over-proportional use of industrial robots. It is also marked by high capital intensity, sectoral concentration and economies of scale, which necessitate high capacity utilization and make overcapacity endemic (Mattioli et al., 2020).

The OECD automotive industry specifically is interesting in this regard as it both represents mostly “developed” economies, but also a significant variation between them. These differences depend on some countries showing mostly supplier and some OEM activity, high-wage and lower wage regions, different technological intensities, premium and mass products, as well as significant differences in institutional regulation such as union power and labour-laws. This fragmentation may be summarised as a distinction between “core” and “periphery” in the OECD, and very likely has significant explanatory significance for aggregate employment and automation increases.

The goal of this chapter is to assess the hypothesis of productivity-growth stagnation in the OECD automotive industry, understand its causes, and thereby persistent manufacturing employment between 2010 and 2019. To this end, the following section discusses descriptive trends of automation and labour-productivity. Section three presents the results of the inferential analysis of the determinants of labour-productivity. Section four summarises the results regarding the causes and employment consequences of the productivity paradox in the automotive industry, and concludes with highlighting the role of output in these results as well as in current industrial policy goals of the European union.

2. Automation and Productivity in the OECD Automotive Industry

The sampling of the countries to be included in the analysis began with selecting the 30 largest global car producing countries, by number of vehicles produced per inhabitants, adding the largest European economies and finally, an area-focus on Central-Eastern Europe due to its special role in automotive commodity chains (Olejniczak et al., 2020). Maximising the availability of data based on the resulting list has yielded a panel of 22 mostly OECD countries: Austria, Czechia, France, Germany, Hungary, Italy, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom, Brazil, Canada, Mexico, United Sates of America, Japan, South-Korea. This sampling strategy implies two things relevant for the interpretation of the results: 1. A bias towards assembly rather than parts production, and 2. A bias towards the relative national importance of automotive industries rather than their absolute global importance.

The panel for the estimation below consists of a balanced sample of the above 22 countries between 2010 and 2018. It uses real-value added data in PPP $ manually converted from The Conference Board, employment data from WIOD-SEA and the Conference Board and robot-use data from the IFR database. The first control variable of sectoral concentration is based on Orbis revenue data, adapted to avoid accounting inconsistencies, and the second control, capital intensity, is calculated based on data from WIOD-SEA and Compnet Vintage 8.

Regarding the operationalisation of “automation” through robot-density I concur with Krzywdzinski (2021) and Jürgens (2023) that the measure has significant problems, as the analysis also shows. It nonetheless connects to a dominant literature, and is overall the most widely used indicator to approximate automation. I also follow Dosi and Virgillito (2019) in their critique of the use of total and multi-factor productivities as unhelpful abstractions, and thereby maintain labour-productivity as dependent variable. Finally, despite the significant problems of the Orbis-data base, such as NAs and observation degradation, I maintain its use as it serves as basis for many estimations with similar ambitions to this analysis (Table 12 in the appendix). I also concur with approaches problematising a direct relationship of competitive pressures and firm size or sectoral concentration (Shaikh, 2016), but find these measures nonetheless meaningful and worthwhile parameters. Table 4 below collects all variables and quantitative data sources.

Table 1: Summary of Variables and Data Sources.

Data Source	Variable	Country and Time Availability
International Federation of Robotics (IFR)	-Robot-Density (from annual reports): Number of robots per 10.000 workers -Based on: Industrial Robot-Stock	Complete for all countries and sectors between 2010 and 2019 (robot-density more limited and stock missing for Canada and Mexico in 2010)
ORBIS Bureau van Dijk	Firm level revenue, number of employees, BVID numbers of individual firms and domestic and global mothers. Used for the calculation of HHI,c3/10/30 Sectoral concentration measures	All countries and sectors Data limited to ten years prior to data access, two data access points 1. 2010-2020 and 2. 2012-2021
The Conference Board International Comparisons of Manufacturing Productivity	*Labour-Productivity*: Real value added per hour worked (used for robustness checks)	Limited Country Selection (excl. China, India, South-Korea), all sectors 1995-2018

and & Unit Labour Cost		
WIOD Socio-Economic Accounts	*Total Hours Worked by Employees (for manual calculation of labour-productivity); Gross value added at current basic prices (in millions of national currency) (for manual calculation of labour-productivity); Nominal net capital stock (in millions of national currency) (as control); Capital Intensity as Capital Stock/Hours Worked*	All countries and sectors 2000-2014
OECD Structural Analysis Database	*Same as WIOD*	Depending on country and sector at least 2010 up to 2019
Eurostat	*Same as WIOD*	Depending on country and sector at least 2010 up to 2020
COMPNET Vintage 8	*Nominal net capital stock (in millions of national currency)*	Depending on country and Sector at least 2010 up to 2019
National Statistic Bureaus	*Used for single missing values for various variables*	Used mostly for recent years (2018/2019) of single countries

In the remainder of this section, I provide descriptive insights on two trends for the automotive sector that are relevant for this chapter: labour productivity stagnation and accelerating automation.

Figure 3 below plots the changes of labour productivity averaged for all countries in the panel, relative to their 2000 values, with the development for both the automotive sector and general manufacturing separated. From this perspective, the recovery period after the 2009 dip does appear less steep in growth, than the trajectory form before the financial crisis, potentially indicating productivity-growth stagnation. The shift, however, only follows the financial crisis rather than the turn of the millennium, as suggested by the productivity-paradox literature. It is also interesting to note that there appears to be only minimal difference in the development of the automotive sector and manufacturing, despite the fact that the former is usually assumed to be at the forefront of technological developments, and thus ostensibly productivity growth.

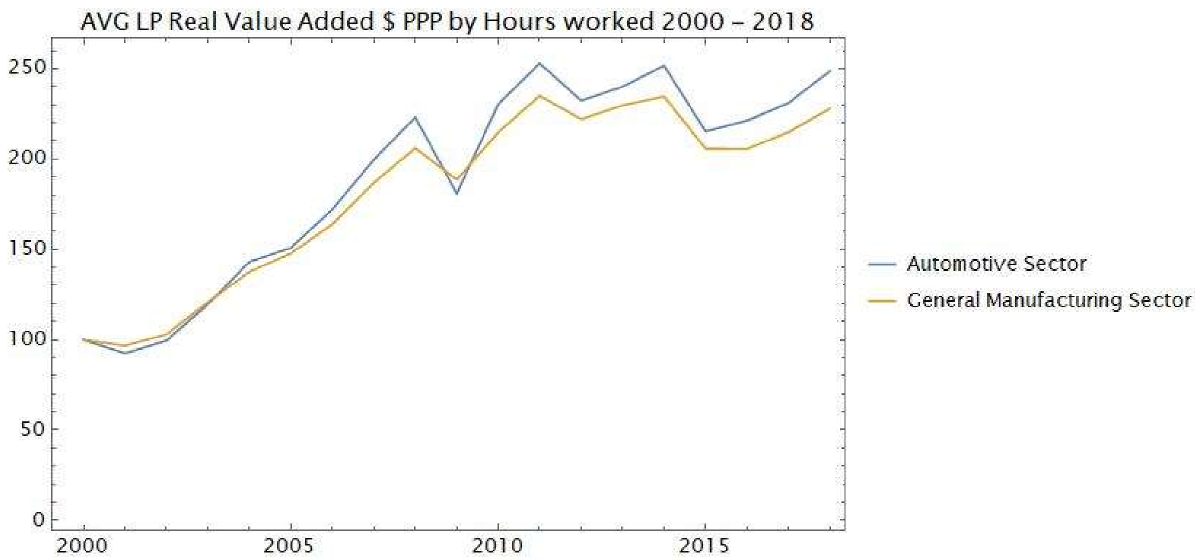

Figure 3: Average Labour Productivity in Manufacturing and the Automotive Sector of the panel countries, excluding outliers and NAs, own calculations and visualization.

Naturally, such an aggregate view abstracts from much heterogeneity between countries, however. Some of these countries may have been in severe decline while others could have carried the average. Replicating the approach of Goldin et al. to use 5 year centred moving averages (CMAs) averaged and compared over two periods, their results can in fact be corroborated (see table 13 and 14 in appendix). Goldin et al. (2022) find significantly lower yearly labour-productivity growth rates in the period 2006-2017 compared to 1996-2005. The data used here covers the years 2000-2017, meaning a period 1 of 2000 to 2005 and a period 2 between 2006 and 2017. Viewed from this metric, lower growth rates in the 2006-2017 period can indeed be identified.

Nonetheless, the above figures provide a somewhat mixed picture. While using different types of averages at different levels, the slowdown does not appear quite so drastic or completely disappears. In this sense, while not refuting Goldin et al. and in fact carrying their analysis of stagnation forward as confirmed, the identification of productivity stagnation is nonetheless dependent on a parallax[25] view, that is, its identification depends crucially on the chosen of metric, level of aggregation, time-period and country-sector.

What is unclear from the diagnosis of overall productivity stagnation, however, is in which constituent part of productivity it originates. As labour-productivity represents the differential of output per employment, it is useful to disaggregate it to understand its overall changes. Figure 4 and 5 below show the average annual growth rates of output, employment and productivity between 2000 and 2018, for the automotive industry and aggregated manufacturing.

[25] Describing the principle in physics where an object appears differently when the position of the observer changes.

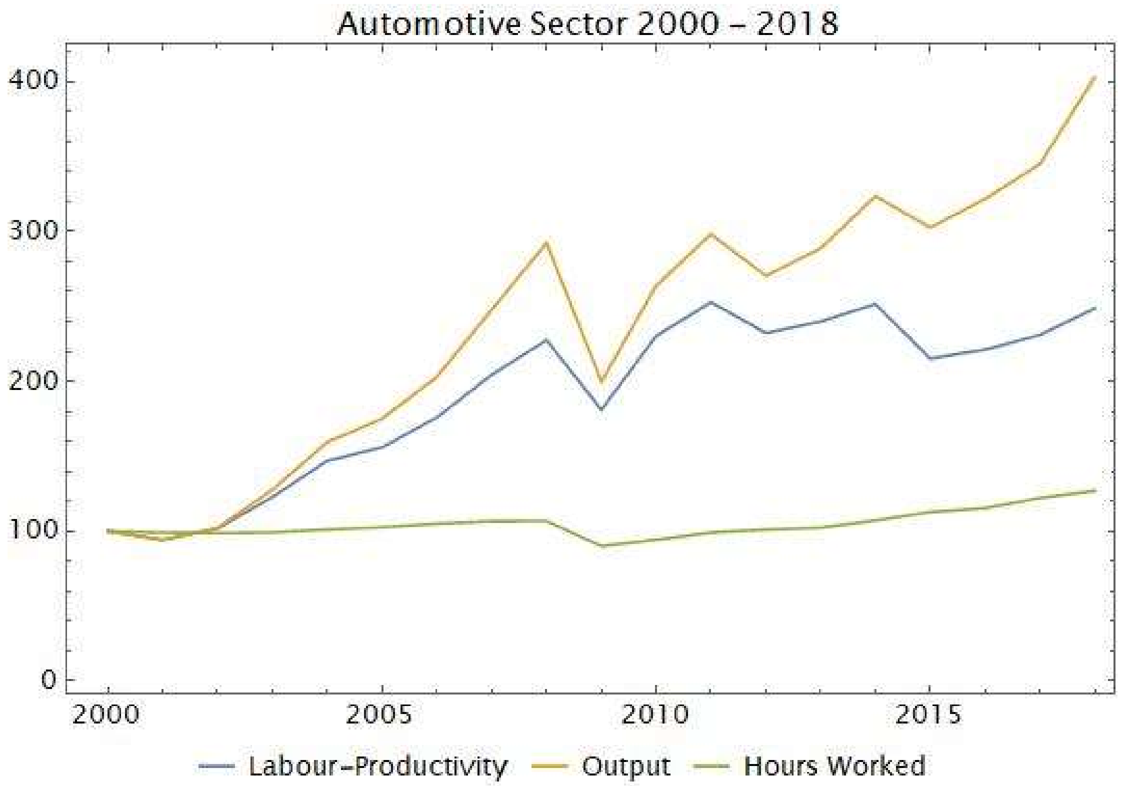

Figure 4: Average annual growth-rates of Labour-Productivity, Employment and Output in the Automotive sector 2000-2018, see data sources above. Own calculations.

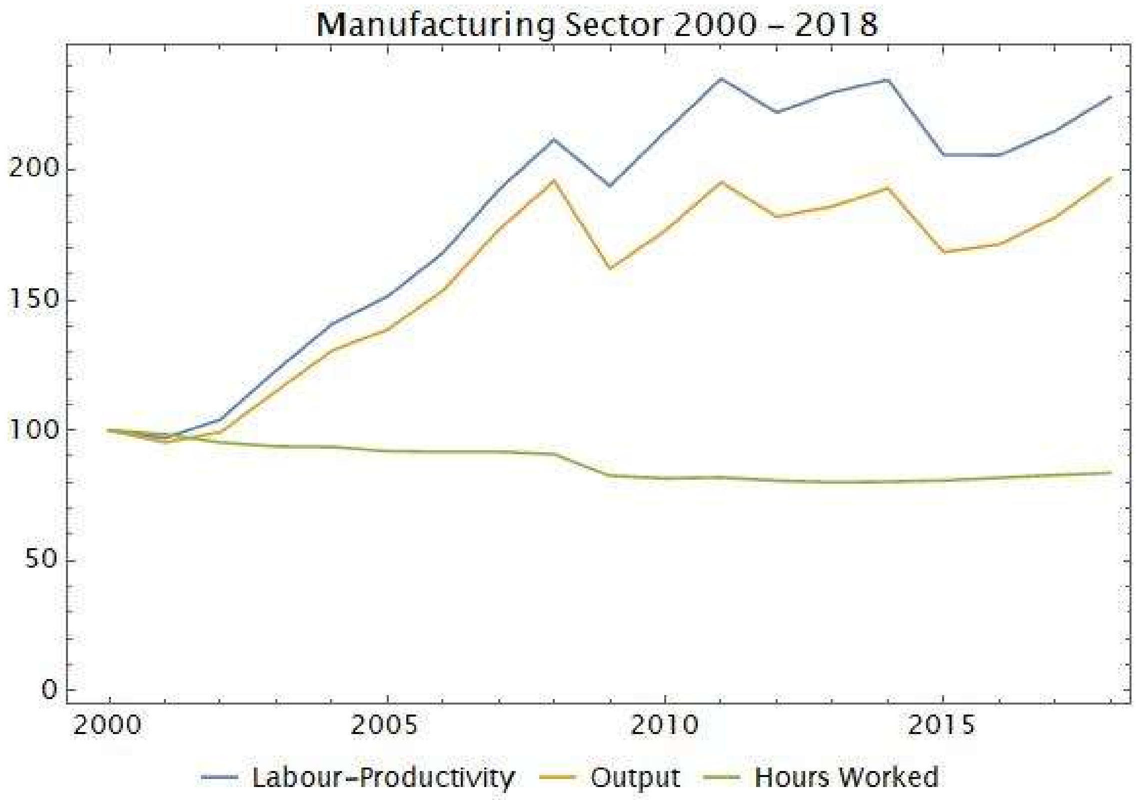

Figure 5: Average annual growth-rates of Labour-Productivity, Employment and Output in the Manufacturing sector 2000-2018, see data sources above. Own calculations.

We see that labour productivity strongly fluctuates in relation to output changes, next to fairly steady, however inverse, employment trends in both sectors. While output has grown more than productivity in the automotive industry, explaining employment increase, in the manufacturing sector, higher productivity growth relative to output explains decreasing employment. The significant difference in both cases thus lies in their output trajectories.

This point can also be illustrated by a narrower focus on the year to year changes between 2010 and 2018, also the period of inferential analysis below. Figure 6 shows that in the automotive industry, output has grown more than productivity, resulting in positive employment.

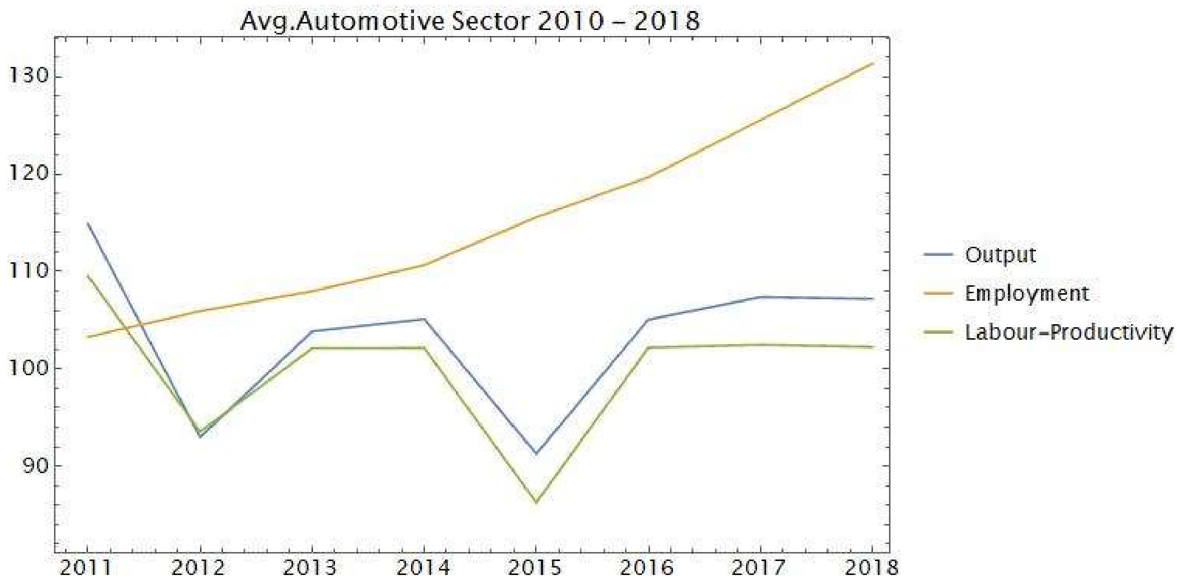

Figure 6: Disaggregation of OECD Automotive Sector Year to year growth rates of Labour-Productivity, Output and Employment. Own calculation, see source above.

This means that it is reasonable to conclude that output was the driving factor in employment increases in the automotive industry, while in manufacturing the development is more ambivalent. To establish the relationship of automation, productivity, output and employment more robustly, and to analyse potential causes for productivity growth stagnation, the multivariate analysis of the following section will add additional insights.

First, however, a descriptive view on the development of automation is in order. Figure 7 below plots the average robot densities (absolute robot stock per 10.000 workers) for the automotive sector and manufacturing of an extended panel of 26 countries between 2010 and 2019.

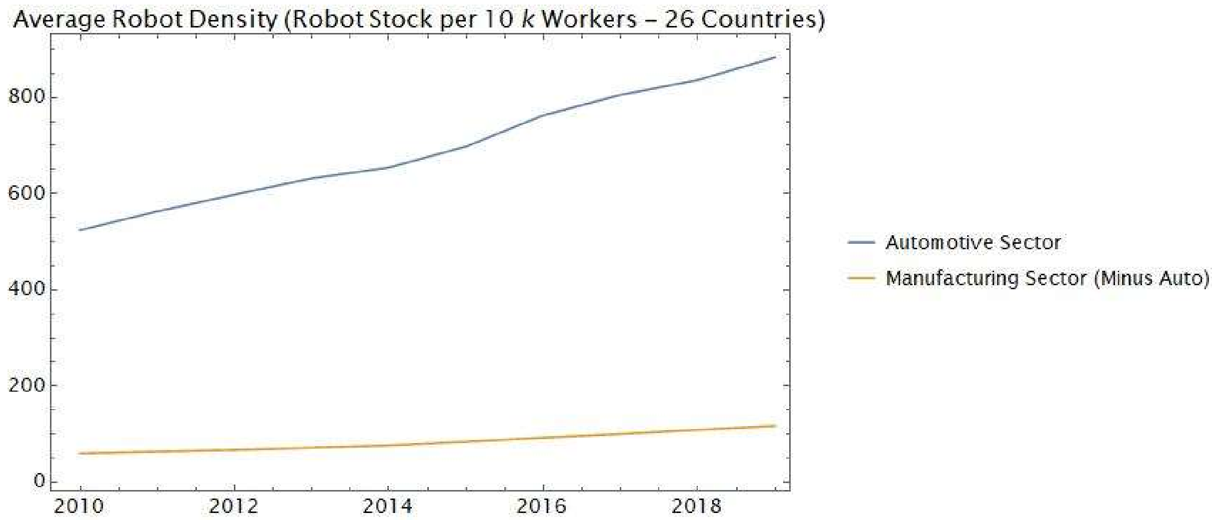

Figure 7: Average Robot Density of country panel Automotive Sector and Manufacturing, IFR data, own Visualisation.

The most significant stylised fact, which is even more significant considering how little it is received in contributions using IFR robot-data (with the exception of Fernández-Macías et al., 2020 and Kleinert et al., 2022), is how skewed the distribution of industrial robots is. First of all, robots are to an overwhelming degree only found in an intensive definition of manufacturing (excluding mining, construction etc.). Within such narrowly defined manufacturing, the automotive sector alone accounts for 42% of the total robot stock of the countries of the sample in 2019. The top 5 countries of the sample[26] ,in turn, account for 78% of total robot stock in the automotive sector in the year 2019; in manufacturing (excl. automotive) for 82%.

Overall, while the distribution of robots between countries is thus heavily skewed, the difference between sectors within countries is even steeper. Between 2010 and 2019, an upwards trend is evident in both the automotive sector as well as manufacturing, the slope of the increase and its initial starting level are significantly set apart, however. In 2010, the average robot stock per 10.000 workers in the automotive industry was 524,2 and 59,7 in manufacturing (a factor of about 8,8). In 2019 these figures were 883,2 for the automotive and 117 for manufacturing (factor of about 7,6[27]). While this illustrates a stark difference in level, it also shows that the gap appears to be shrinking, albeit at a slow pace, despite manufacturing as a whole effectively doubling its robot stock per 10k worker over these 10 years. As with labour productivity, such sectoral averages, however, obscure country trajectories. Table 2 therefore shows Compound Annual Growth Rates (CAGRs) between 2004 and 2019 by country[28].

[26] Which, however, was constructed as to contain the countries with highest number of cars produced per capita.
[27] Including the outlier South-Korea raises this to a factor of about 10.
[28] The table contains 8 countries more than the panel for the estimation. The reason being that while data on robot-use was available for these countries, data on all other variables needed to establish a balanced panel was not. There is nonetheless no reason not to display all available data here.

Table 2: Robot Density, Hours Worked and Absolute number of Robots by Country and Sector. IFR, The Conference Board and OECD STAN. RA" denotes the absolute number of robots, "HRS" the total number of hours worked and "RD" robot density. The HRS data was not used.

	Automotive			**Manufacturing**		
CAGR %	RA	HRS	RD	RA	HRS	RD
Austria	14,9	0,7	6,6	18,3	-0,2	6,7
Brazil	29,3	-	14,5	30,6	-	6,4
Canada	35,9	0,3	4,9	29,6	-1,1	5,7
China	30,6	-	21	40,8	-	29,9
CZ	36,6	2,9	14,3	34,3	-0,3	9,6
Finland	11,8	-1,3	9,2	-0,7	-1,9	0,2
France	-0,9	-3,8	0,2	4,3	-1,4	7,5
Germany	3	-0,6	1,6	3,3	-0,1	3,7
Hungary	58,4	3,6	9,8	32,4	-1,6	15
India	29	-	14,2	32,9	-	13
Iran	42,6	-	-	24,2	-	-
Italy	-2,6	-1,4	-4,8	1,8	-0,9	4,4
Japan	0,4	0,8	-2,6	-0,3	-0,7	3,5
Mexico	38,3	5,2	10,2	38,1	2,7	13
Netherlands	41,4	-0,4	16,5	36,4	-0,9	8,8
Poland	43,3	4,4	8,4	36,7	0,6	18,4
Portugal	20,1	0	6,4	30,3	-1,5	10,1
Romania	48,1	4,9	9	36,7	-1,7	24,1
Russia	52,8	-	-	33,7	-	-
Slovakia	73	6,8	12,3	37,6	-0,7	11,7
Slovenia	30,8	3	9,9	30,1	-0,9	12,1
South Korea	22,5	0,9	7,6	26,7	0,3	10,8
Spain	1,6	-2,8	-0,1	5,7	-1,8	3,9
Sweden	2,8	-0,7	4,2	5	-1,5	4,8
Switzerland	20,6	-	10,3	25,9	-	7,8
Thailand	78,6	-	-	18,2	-	-
Turkey	36,7	3,8	15,5	38,8	1,9	18,2
United Kingdom	1,5	-2,5	1,2	3,7	-2,2	6,1
US	18,6	-1,1	7,3	23,6	-1,6	3,8
AVERAGES	28,3	1	7,98	23,4	-0,7	9,97

This view confirms the previous finding. While robot-use has clearly increased over the past decade, radical breaks are not discernible. Secondly, robot-use is heavily skewed. Striking about this skewedness is the stark difference in *level*s between the automotive sector and manufacturing. It is clear from these perspectives that increasing robot use is carried 1. by manufacturing (intensive definition), which is driven 2. by the automotive sector and which is in turn driven by 3. selected countries. The increasing average thus hides a fragmentation between high and low levels of robot-density, as well as high and low increases in the same. Considering the levels of robot-density for manufacturing also shows that the greatest difference in the development of robots does not lie between countries, but rather between sectors within countries. However, crucially, this does not mean that general manufacturing sectors are "less automated", as simply different machinery might be used in the automation of different production processes (see chapter 6). Furthermore, a note on the distinction between automation and digitalisation is of relevance here (see Pardi et al., 2020 and Krzywdzinski, 2021). Since I operationalize automation through the use of robots, many additional or alternative technologies are naturally not included. I concur with Krzywdzinski (2021) that digitalisation and automation are different processes building on different technologies, which, however can overlap in part. Most importantly, digitalisation is not as straightforward in its effects on labour-productivity as automation, which is why the approximation through robots, as poor a measure as it is, is nonetheless reasonably useful for the purpose of this chapter.

3. Determinants of Labour-Productivity Growth

Moving to an inferential estimation, the goal of the following multivariate analysis is to isolate the impact of robots on productivity, while filtering out effects from market concentration, capital intensity, as well as background noise from country-specific and time-related factors. Thus, a two-way fixed effects model is estimated, including both time (v_t) and country fixed effects (u_i) to account for time trends affecting all variables and unobservable country-specific characteristics that are constant across time but vary between countries:

$$LP_{it} = \alpha_i + \beta_1 RD_{it-1} + \beta_2 HHI_{it-1} + \beta_3 CI_{it} + v_t + u_i + \epsilon_{it}, \qquad (1)$$

where the dependent variable is labour productivity (LP_{it}) for each time period t and country i, calculated as value added per hours worked. The main explanatory variable is lagged robot intensity (RD_{it-1}). Different concentration measures (C3, C10, C30 and the lagged normalized Herfindahl-Hirschmann Index HHI_{it-1}) and capital intensity (CI_{it}) function as controls. Demeaning the above specification to remove unobserved and constant effects leads to a reduced form:

$$\widetilde{LP}_{it} = \beta_1 \widetilde{RD}_{it-1} + \beta_2 \widetilde{HHI_{it-1}} + \beta_3 \widetilde{CI}_{it} + \theta_{it}, \qquad (2)$$

By demeaning, unobserved and constant effects are removed. This yields a fixed effects estimator or "within estimator". The estimated model now only contains the transformed stochastic error term θ_{it}.

To reiterate, in the estimation tables below "labour-productivity" is calculated as real value-added PPP per hours worked; robot-density denotes the number of industrial robots in use per ten-thousand workers; sectoral concentration measures (c) are computed as the share of a certain number of firms (3,10,30) in the total revenue of a sector. The Herfindahl-Hirschman Index is another concentration measure, defined as the sum of the squared market shares α of the "n" firms in a sector. The higher the corresponding value, the higher the share of n firms in the overall production. Formally this means: $H := \sum_{i=1}^{N} \alpha_i^2$. Normalizing the HHI means it ranges from 0 to 1: $HHI\_n := {(H - 1/N)}\big/{1 - 1/N}$ for $N > 1$ and $HHI\_n := 1$ for $N = 1$. Finally, "Capital-intensity" is a commonly used control-variable in estimations of sectoral effects, as it accounts for the different capital requirements of sectors (e.g. mining vs. baking). Its numerator of "capital-stock" means the total value of (fixed) capital used in a sector or economy, and its denominator is real value added.

3.1. Employment- versus Output Effects

The regression output in table 3 below shows the logarithm of labour productivity as dependent variable, with the logarithmic values of robot-density, several measures for sectoral concentration, as well as capital intensity as explanatory variables. All explanatory variables, except capital intensity, are lagged by one period to counter endogeneity. Romania and Slovakia have been removed from the sample before the estimation as outliers, since both show excessive and unexplained growth rates of value-added over the period.

Table 3: Regression Output Labour-Productivity

Regression results (balanced sample): Lag=1

	Dependent variable:							
	Dependent Variable: Labour productivity							
	Manufacturing	Manufacturing	Manufacturing	Manufacturing	Auto	Auto	Auto	Auto
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
HHI	0.056^{*}				0.001			
	(0.033)				(0.061)			
C3		0.003				0.481^{***}		
		(0.052)				(0.125)		
C10			0.006				0.745	
			(0.074)				(0.494)	
C30				0.049				3.697^{***}
				(0.090)				(0.489)
Robot Density	0.074^{***}	0.071^{***}	0.071^{***}	0.069^{***}	-0.026^{*}	-0.038^{*}	-0.038^{**}	-0.013
	(0.019)	(0.020)	(0.020)	(0.019)	(0.014)	(0.021)	(0.017)	(0.023)
Capital Intensity	0.443^{***}	0.480^{***}	0.479^{***}	0.462^{***}	-0.015	0.029	-0.012	0.010
	(0.096)	(0.090)	(0.091)	(0.091)	(0.054)	(0.070)	(0.059)	(0.064)
Time and Country FE	YES	YES	YES	YES	YES	YES	YES	YES
Obs.:	120	120	120	120	120	120	120	120
Rsqu.:	0.235	0.219	0.219	0.221	0.005	0.101	0.071	0.254
Rsq.adj.:	0.041	0.022	0.022	0.024	-0.247	-0.127	-0.163	0.066
Note:								*p<0.1; **p<0.05; ***p<0.01

According to the analysis, concentration has not affected labour productivity in manufacturing , but has had a positive effect it in the automotive sector (however only for C3 and C30 measures). Robot density has had a significant positive effect of labour-productivity in manufacturing, while it has had a *negative* effect in the automotive industry. The control of capital intensity is positive and significant for manufacturing, but not in the automotive sector, meaning it does not capture an additional effect, likely due to the very similar high concentration levels of all national automotive industries.

Given the counter-intuitiveness of some of the results, several robustness checks were conducted. First of all, several model variants were estimated to better understand how reverse causalities and adding/removing variables changes the results. Model Variant 2, seen above, has proven to be the model with the highest number and largest extent of significant relationships, and corresponded to the theoretical considerations of chapter two the best. Table 15-25 in the appendix show collections of regressions results based on different model specifications and data.

Out of these results the most interesting is the negative correlation of robot density with labour productivity in the automotive sector. All other results can be accommodated with fairly conventional theoretical propositions. Labour productivity reducing effects of higher robot-use per worker, however, is a patently strange result. To explain it, labour productivity is disaggregated into output and hours worked, which are treated as separate dependent variables. As shown in tables 4 and 5, robot-density in fact increases both hours worked as well as value-added in both the manufacturing and automotive sectors. However, the effects are generally less significant for the automotive sector, in particular the effect of robot density on value added. This means that the relative increase of value added as output must have superseded that of hours worked in the case of manufacturing increasing labour productivity, while in the automotive sector the rise in hours worked must have superseded the increase in value added, reducing labour productivity in the aggregate and on average. The effects of robot-use thus appear to vary by sector and according to the relative strength of an “output” or “employment” effect. Hence, while there was more work performed in the automotive sector due to increasing robot use, less value added was realized in relation to the positive effect on employment, resulting in productivity decreases. This result differs to those of similar contributions. In their analysis, Autor and Solomon (2018) have found a general productivity increasing effect of robots in US manufacturing driven by increasing value-added with hardly an effect on hours worked. This finding conforms to the case of general manufacturing presented here, but again the automotive sector shows the opposite. To better understand this result, a final analytical step is undertaken.

Table 4: Regression Output Hours-Worked

Regression results (balanced sample): Lag=1

	Dependent variable:							
	Dependent Variable: log hours worked							
	Manufacturing	Manufacturing	Manufacturing	Manufacturing	Auto	Auto	Auto	Auto
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
HHI	-0.029***				-0.090***			
	(0.009)				(0.014)			
C3		0.0001				-0.186***		
		(0.017)				(0.042)		
C10			-0.024				-0.318**	
			(0.027)				(0.153)	
C30				-0.089**				-1.801***
				(0.039)				(0.160)
Robot Density	0.033***	0.035***	0.035***	0.037***	0.050**	0.052**	0.053**	0.041
	(0.010)	(0.010)	(0.010)	(0.012)	(0.024)	(0.024)	(0.023)	(0.026)
Capital Intensity	-0.190***	-0.211***	-0.199***	-0.175***	0.011	0.026	0.041	0.031
	(0.030)	(0.034)	(0.035)	(0.039)	(0.028)	(0.032)	(0.028)	(0.024)
Time and Country FE	YES	YES	YES	YES	YES	YES	YES	YES
Obs.:	120	120	120	120	120	120	120	120
Rsqu.:	0.173	0.16	0.162	0.182	0.111	0.076	0.071	0.184
Rsq.adj.:	-0.036	-0.052	-0.049	-0.025	-0.113	-0.158	-0.164	-0.023
Note:								*p<0.1; **p<0.05; ***p<0.01

Table 5: Regression Output Value-Added PPP

Regression results (balanced sample): Lag=1

	Dependent variable:							
	Dependent Variable: real Value Added (PPP)							
	Manufacturing	Manufacturing	Manufacturing	Manufacturing	Auto	Auto	Auto	Auto
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
HHI	0.027				-0.088*			
	(0.035)				(0.052)			
C3		0.003				0.295***		
		(0.038)				(0.109)		
C10			-0.018				0.427	
			(0.051)				(0.358)	
C30				-0.040				1.896***
				(0.057)				(0.362)
Robot Density	0.107***	0.105***	0.105***	0.107***	0.025**	0.014	0.015*	0.028***
	(0.028)	(0.028)	(0.028)	(0.029)	(0.012)	(0.013)	(0.008)	(0.010)
Capital Intensity	0.252**	0.269***	0.280***	0.287***	-0.004	0.055	0.030	0.040
	(0.106)	(0.093)	(0.094)	(0.096)	(0.058)	(0.079)	(0.074)	(0.078)
Time and Country FE	YES	YES	YES	YES	YES	YES	YES	YES
Obs.:	120	120	120	120	120	120	120	120
Rsqu.:	0.119	0.115	0.115	0.116	0.042	0.052	0.033	0.09
Rsq.adj.:	-0.104	-0.109	-0.108	-0.107	-0.2	-0.188	-0.211	-0.14
Note:						*p<0.1; **p<0.05; ***p<0.01		

3.2. Difference in Output and Employment Effects in Core and Periphery Countries

As noted in the introduction, it is very likely that the aggregate tendencies of the OECD countries in the sample depend on much underlying variation (Carey and Mordue, 2022; Perez and Perez, 2023). To account for this variation in a tentative way, a final step to specify the findings, is to see how grouping the countries of the sample according to countries of the "core" and "periphery" changes these results. The countries of the sample are therefore separated according to a tendential fit of high-tech, high wage economies of the "core" and everyone else in the "periphery" (Table 6).

Table 6: Separation of "Core" and "Periphery" Countries of the Sample

Core	Austria, Canada, Finland, France, Germany, Italy, Japan, Netherlands, South-Korea, Spain, Sweden, United Kingdom, United States of America
Periphery	Czechia, Hungary, Mexico, Poland, Portugal, Romania, Slovakia, Slovenia, Turkey

Running the regressions again with interaction terms (Table 7, 8 and 9 below) shows that in the countries of the “periphery”, robot density has increased productivity through a value-added/output and without much of an employment effect. Conversely, in the core countries, labour-productivity decreases are based on positive employment effects, combined with negative value-added effects. While the countries of the periphery thus appear to have benefitted from their increased use of robots, in the countries of the core this process has not proven as effective and robot-use has not contributed to the realization of higher value-added pointing to ongoing crises of output in the automotive industries there.

Table 7: Regression Output Labour Productivity with interaction term core/periphery

Regression results (full sample): Lag=1

	Dependent variable:							
	Dependent Variable: Labour productivity							
	Manufacturing	Manufacturing	Manufacturing	Manufacturing	Auto	Auto	Auto	Auto
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
HHI Core	0.039				-0.048			
	(0.050)				(0.035)			
C3 Core		-0.057				0.309***		
		(0.057)				(0.082)		
C10 Core			-0.062				1.321**	
			(0.095)				(0.603)	
C30 Core				-0.019				5.406***
				(0.148)				(0.843)
Robot Density Core	0.017	0.016	0.027	0.024	-0.124***	-0.124***	-0.113***	-0.127***
	(0.032)	(0.032)	(0.035)	(0.042)	(0.020)	(0.024)	(0.027)	(0.023)
Capital Intensity Core	0.475***	0.481***	0.495***	0.501***	-0.023	0.011	0.016	-0.032
	(0.122)	(0.113)	(0.114)	(0.120)	(0.061)	(0.072)	(0.067)	(0.078)
HHi Periphery	-0.269***				-0.102***			
	(0.035)				(0.028)			
C3 Periphery		-0.395***				-0.323*		
		(0.042)				(0.176)		
C10 Periphery			-0.696***				-1.991***	
			(0.126)				(0.488)	
C30 Periphery				-0.661***				-5.883***
				(0.200)				(0.985)
Robot Density Periphery	-0.259***	-0.265***	-0.302***	-0.263***	0.133***	0.129***	0.121***	0.096**
	(0.032)	(0.035)	(0.030)	(0.021)	(0.020)	(0.027)	(0.032)	(0.037)
Time and Country FE	YES	YES	YES	YES	YES	YES	YES	YES
Obs.:	154	154	154	154	150	150	150	150
Rsqu.:	0.446	0.401	0.401	0.326	0.109	0.065	0.138	0.195
Rsq.adj.:	0.306	0.249	0.248	0.155	-0.126	-0.181	-0.089	-0.016
Note:					*p<0.1; **p<0.05; ***p<0.01			

Table 8: Regression Output Hours Worked with interaction term core/periphery

Regression results (full sample): Lag=1

	Dependent variable:							
	Dependent Variable: log hours worked							
	Manufacturing	Manufacturing	Manufacturing	Manufacturing	Auto	Auto	Auto	Auto
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
HHI Core	0.001				-0.076***			
	(0.018)				(0.019)			
C3 Core		0.027				-0.103***		
		(0.025)				(0.022)		
C10 Core			0.013				-0.192***	
			(0.041)				(0.058)	
C30 Core				-0.013				-0.362***
				(0.053)				(0.107)
Robot Density Core	-0.020	-0.020	-0.021	-0.021	0.070***	0.068***	0.067***	0.070***
	(0.026)	(0.026)	(0.026)	(0.028)	(0.017)	(0.016)	(0.016)	(0.016)
Capital Intensity Core	-0.331***	-0.325***	-0.326***	-0.328***	-0.115***	-0.093**	-0.095**	-0.101***
	(0.027)	(0.028)	(0.032)	(0.035)	(0.036)	(0.039)	(0.039)	(0.036)
HHI Periphery	0.107***				0.067**			
	(0.020)				(0.030)			
C3 Periphery		0.199***				-0.101		
		(0.036)				(0.082)		
C10 Periphery			0.286***				-0.052	
			(0.075)				(0.138)	
C30 Periphery				0.279***				-0.523
				(0.092)				(0.431)
Robot Density Periphery	0.160***	0.168***	0.169***	0.157***	0.025	0.036*	0.036**	0.021
	(0.041)	(0.042)	(0.042)	(0.038)	(0.024)	(0.019)	(0.017)	(0.023)
Time and Country FE	YES	YES	YES	YES	YES	YES	YES	YES
Obs.:	190	190	190	190	186	186	186	186
Rsqu.:	0.394	0.388	0.354	0.326	0.156	0.157	0.148	0.17
Rsq.adj.:	0.261	0.253	0.212	0.179	-0.034	-0.033	-0.044	-0.017
Note:						*p<0.1; **p<0.05; ***p<0.01		

Table 9: Regression Output Value-Added with interaction term core/periphery

Regression results (full sample): Lag=1

	Dependent variable:							
	Dependent Variable: real Value Added (PPP)							
	Manufacturing	Manufacturing	Manufacturing	Manufacturing	Auto	Auto	Auto	Auto
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
HHI Core	0.067**				-0.116**			
	(0.031)				(0.045)			
C3 Core		-0.019				0.313***		
		(0.048)				(0.110)		
C10 Core			-0.003				0.915	
			(0.077)				(0.577)	
C30 Core				0.036				4.024***
				(0.113)				(0.708)
Robot Density Core	-0.053**	-0.051**	-0.045*	-0.048*	-0.086***	-0.088***	-0.081***	-0.087***
	(0.024)	(0.023)	(0.024)	(0.026)	(0.017)	(0.017)	(0.019)	(0.015)
Capital Intensity Core	0.200**	0.211**	0.212***	0.216**	-0.082	-0.017	-0.021	-0.073
	(0.087)	(0.082)	(0.080)	(0.083)	(0.055)	(0.086)	(0.076)	(0.082)
HHI Periphery	-0.181***				-0.047			
	(0.029)				(0.044)			
C3 Periphery		-0.192***				-0.582***		
		(0.026)				(0.143)		
C10 Periphery			-0.404***				-1.869***	
			(0.083)				(0.598)	
C30 Periphery				-0.387***				-5.455***
				(0.134)				(0.596)
Robot-Density Periphery	-0.065***	-0.057**	-0.086***	-0.063***	0.167***	0.169***	0.170***	0.130***
	(0.024)	(0.022)	(0.019)	(0.017)	(0.027)	(0.019)	(0.013)	(0.017)
Time and Country FE	YES	YES	YES	YES	YES	YES	YES	YES
Obs.:	154	154	154	154	150	150	150	150
Rsqu.:	0.209	0.16	0.19	0.136	0.177	0.115	0.182	0.203
Rsq.adj.:	0.007	-0.054	-0.016	-0.083	-0.039	-0.118	-0.033	-0.006
Note:								*p<0.1; **p<0.05; ***p<0.01

4. Conclusion

The analysis has shown that robot-use as well as sectoral concentration are significant explanatory variables in productivity-growth stagnation, however, with different effects in aggregated sectors. In the automotive industry, concentration has positively affected labour-productivity while robot use decreased it. This means that in explaining stagnation, only robot-use is a viable avenue. In the general manufacturing sector, the inverse is the case, and only concentration appears as driver of stagnation. These results illustrate again the fragmentation, or parallax, of productivity growth stagnation and its causes in countries and sectors.

The negative effects of robot density on labour productivity in the automotive industry have created an additional puzzle. Further analysis has shown that they depend on a relatively stronger "employment" rather than "output" effect. This means that while increasing robot-use has positively affected both employment as well as output in the OECD automotive industry between 2010 and 2019, it has increased employment more than output, creating adverse productivity outcomes. Manufacturing shows again the inverse case, explaining its productivity increases. This not only explains the different effects on labour productivity, but also points to a strong link between employment and output.

In order to explain these results further, and based on expected country-differences within the sample of OECD countries, a final step of analysis has shown that separating the sample into a high-technological intensity, high-wage "core" and a "periphery", illustrates a variation of effects yet again. Whereas the countries of the core show a stronger employment and weaker output effect, the countries of the periphery have seen stronger output effects. This means that the periphery may have indeed benefited more from recent automation than the core, which appears stagnating in output-effects.

This may have several explanations. One plausible mechanism lies in the relocation of production to the periphery countries of the OECD. Driven by lower wage costs, production capacity may have been increased disproportionately in the course of catch-up automation, creating positive productivity gains. The corresponding reduction of production volumes in the core, in parallel to its existing more intense technological infrastructure, could explain the results.

A second potential mechanism concerns the difference in the types of firms and products stereotypically located in core and periphery countries. The different effects of robots on productivity may thus simply relate to a different distribution of tasks, such as supplier activities and OEM assembly. The production and assembly of premium products by OEMs in the core may be less amenable to productivity increases through robots in the first place. The supplier and mass industries of the periphery, on the other hand, may have benefited more from robotic-productivity gains, which likely also already has been realised in the core over the past decades.

A final explanation may simply lie therein that robots and labour-productivity are poor metrics for grasping changes in production outcomes, as has been noted through the chapter as well as the dissertation. The partially confounding results presented here, may the simply be a case of quantitative over-simplification. To reiterate a few shortcomings: most of the machinery in modern production facilities is not sufficiently accounted for by robots, and thus escapes quantification here. Injection moulding machines are crucial machinery with very significant employment effects, but are entirely unrelated to robot-use. Another inadequacy lies in measuring output as real-value added based on “market prices” at certain stages of production. if these prices, say for an engine block, increase, despite many more being produced through automation, it may appear confounding in the aggregate, but is rather clear from the ground view. To test the explanatory strength of these three explanations, however, is outside the purview of this chapter and must be relegated to further research.

The more pressing question is how these findings explain the larger puzzle of persistent manufacturing employment despite ongoing automation. A central take-away here, is that in the interrelation of productivity, output and employment, output plays a much more crucial role than often assumed. It may thereby be more important to account for structural and dynamic output changes, rather than automation and technological changes, in explaining employment. Based on the descriptive analysis, it became clear that productivity has fluctuated in parallel to output in both the automotive industry, as well as manufacturing. In the automotive industry, however, the output increases have been overall greater than stagnating productivity, explaining its employment increases. In the inferential analysis this has of course shown up as a relatively stronger employment over output effect in the OECD core as well as the overall aggregate. Nonetheless, it appears that at the heart of employment increases in the automotive industry and decreases in general manufacturing lies the driver of output. If output is large enough, employment persists, also independently of automation. Hence, the chapter lends credence to accounts which argue that rather than runaway automation and productivity, it is precisely such output dynamics ,which have driven the most important developments of industrial employment (Mattioli et al., 2020; Benanav, 2020). This means, that automotive industry of the OECD has proven a temporary "winner" of output shares since the financial crisis, within longer-term trends of decreasing employment due to manufacturing output reduction in the Global North.

Naturally, there are several limitations to the results presented in this chapter, which double as avenues for further research in addition to the above-mentioned hypothetical explanations for the results. First of all, the findings are pertinent to a relatively limited time period between the economic and financial crises and the COVID-19 pandemic. As is always the case, longer and more comprehensive time-series would be instructive, as would be analyses of other manufacturing sectors over the same period. Importantly, the findings are likely not very stable in terms of future trajectory. Ecological developments, in particular over the coming years, may fundamentally transform the automotive sector on the technological and societal level. Some of these changes are already under way with its electrification and an increased policy focus on sustainability.

Secondly, the availability of data forced the capture of the automotive sector at the national level, although it is well known to function through international commodity chains and production networks. In particular the role of BRIC countries in global automotive production could thereby not be accounted for sufficiently due to data constraints. However, from the perspective of global automotive production in absolute terms, the disentangling of output, employment and productivity needs to account for developments in these countries. Related to this point, the distinction between the "core" and "periphery" countries in the analysis should be revisited in greater detail. Greater heterogeneity could be accounted for with a more exhaustive taxonomy, for example. Countries of the core could further be separated into export-led economies taking advantage of BRIC growth, and inward-led countries which were not able to take such advantage. The periphery countries could further be separated between a semi-periphery and periphery-proper, based on the different commodity-chain functions. In addition to extending the sample, qualitative case studies would be of value here, which could not be supplied in this chapter, but are undertaken in the following chapters for the case of Austria.

Third, again, the use of robots is a very limited metric for understanding of automation, as noted several times throughout the chapter and the dissertation. In addition to qualitative evidence of production and labour-process and the technologies used in them, a wider array of technologies must be considered, where corresponding data is available, a constraint which is usually the reason for a focus on robots.

Fourth, the analysis of this paper has omitted several complicating factors, which nonetheless have import for the developments in question. For one, the role of investment in the above trajectories was not accounted for, neither were demand or Kaldor-Verdoorn effects. Financialisaton was not discussed, and neither were other changes such as shifting resource acquisition strategies. Finally, the findings are limited in describing “employment” as an undifferentiated block. To extend the results it would be crucial to differentiate employment in the automotive industry in terms of its changing composition of occupations, skills and tasks, quality of jobs, wages and demographic changes of industrial work more generally. In substantiating the results of this chapter, all of the above limitations are worthwhile avenues.

The central take-away in the analysis of this chapter, however, was the importance of output amidst aggregate productivity stagnation. It is expedient, as next analytical step, to understand how firms decide which output to produce where. To this end, the following chapter analyses how global competition is influencing the automation and production location decisions of firms in the Austrian automotive industry, hence where which output is produced, in which way and why.

Chapter 5 - Competitiveness of what and for whom? Automation and the Organization of Production Locations in the Austrian Automotive-Supplier Industry

0. Summary

This chapter narrows the analysis to firm behaviour based on qualitative evidence. It asks what role the requirement for “competitiveness” plays in automation decisions, and in turn what role automation plays in the production location decisions of Austrian automotive supplier firms. Based on these assessments, it discusses whether it is indeed maximal automation which paradoxically maintains industrial employment in Austria. The analysis is based on 30 interviews with automation engineers, management, worker representatives and representations of interest. These interviews are flanked by 10 factory site visits at the majority of the largest Austrian automotive supplier plants and one survey among 19 workers at an engine assembly plant. The analysis shows that a “Competitiveness Imperative”, derived from the literature and specified through the statements of respondents, must be relativized as driver of automation and production location decisions of firms in three ways: 1. a regional parallelity of automation strategies, 2. a dependence of automation feasibility on firm size, and 3. a direct and indirect control of OEMs over the automation and production location decisions of suppliers. The chapter therefore concludes that abstract regional or national “competitiveness” has more limited significance in explaining automation, production location decisions and thus persistent manufacturing employment in the Austrian automotive industry, than commonly assumed. While the success of Austrian firms is a logical prerequisite for employment, the goals and strategies of large, global automotive firms in achieving this success, cannot be

reduced to a question of wage-levels and higher technological intensity than in other regions, suggesting that "competitiveness" functions more as political rhetoric than structuring socio-economic principle of manufacturing competition.

1. Introduction: Production and Technology-Use Decisions of Firms and Persistent Manufacturing Employment

At least since the 1980s, debates on the manufacturing sectors of developed economies have been dominated by a constant fear of offshoring, capital flight or simply "falling behind". In most cases, this has led to equally constant renewals of calls for the improved "competitiveness" of these sectors. The recent "Draghi report" (European Commission, 2024) on the future of European competitiveness, for example, is no different. It expresses the danger of falling behind the US and China in industrial production, due to an "innovation gap" to other world regions, meaning unrealised potential productivity gains [29]. The Austrian federation of industrialists recently lamented similar concerns, arguing that Austrian firms are only "partially competitive" anymore and Austria is therefore not participating in international production and growth. However, much more than technological advancement, the federation has argued that high wage costs critically undermine the competitiveness of Austria as a manufacturing location, and that based on these costs "*De-Industrialisation is taking place*". [30]

In parallel to these concerns over competitiveness, commentary on new industrial production technologies such as robotics and AI, has suggested a general return of

[29] One of the more novel elements in the report is the suggestion of increased leeway to establish essentially large European technological monopolies able to compete with large Chinese and US monopolies. In a Schumpeterian twist to the EU competition policy, the supposition is that only such large firms are capable of sufficient investment in technologies (see also chapter 4 and the analysis in this chapter).

[30] https://orf.at/stories/3380522/

industrial production to the developed core. Such re-shoring, near-shoring or friend-shoring of manufacturing capacities is supposedly precisely made possible by a greater irrelevance or reduction of labour costs in the course of new technological possibilities (Butollo and Staritz, 2022). And, as shown in the introduction, employment in the Austrian automotive industry has in fact increased over the recent decade, presenting a *"de-industrialisation paradox*" (Kowall, 2021) .

In order to understand this paradox, and thus why manufacturing employment persists in supposedly de-industrialised high-wage countries, it must be understood how requirements of "competitiveness" determine the automation and production location decisions of firms, either in the course of re-shoring or the maintenance of industrial capacities. Based on a case-study analysis of the Austrian automotive supplier industry, this chapter finds that the conventional narratives of competitiveness do not align with the behaviour of firms. This ,in turn, has implications for how competitiveness is debated, and which role it must play in effective industrial policy.

To start, the following section first gives an overview of the structure of the Austrian automotive industry and the data used in the analysis. Section three confirms a theoretical definition of "competitiveness" from the literature, based on the interview material, and discusses its role in the automation decisions of firms based on three relativizations: the regional parallelity of automation strategies, the possibility of automation based on firm size, and the control and dependencies between different types of firms in making automation decisions. Section four summarises what these results mean for persistent manufacturing employment, which open questions remain, and where further analysis should be directed.

2. The Austrian Automotive Industry: Case, Data and Method

While the Austrian automotive supplier industry is often accorded particular importance in debates on the Austrian economy as a whole, in terms of size, it represents a fairly average industrial sector[31]. In the relative contributors to manufacturing value-added by sub-sector, the automotive industry only accounted for of 6-7% in 2020 (Figure 8 below).

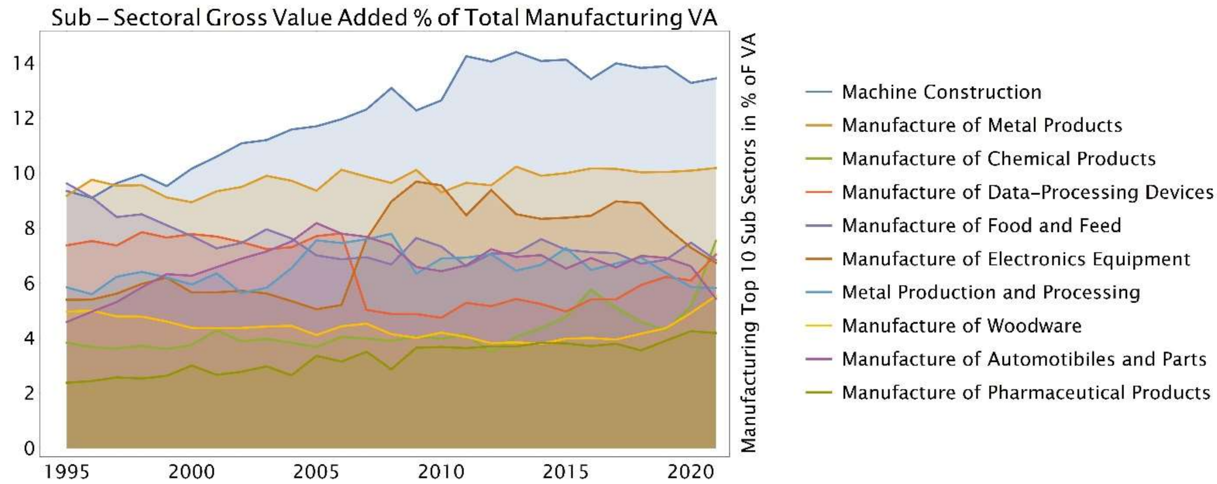

Figure 8: Value-Added by manufacturing subsector, 1995 to 2021, gross value added after ÖNACE categories in Mio. Of EUR. Source: Main National Accounting Aggregates, Austrian Statistics Agency, own calculations.

However, this does not mean the Austrian automotive industry is insignificant. In fact, its institutional features make it a relevant and interesting case for study. The sector is dominated by large, globally active and export-oriented firms. It draws its workforce from a strong vocational training system producing highly skilled workers while its position at the border to the European East and South has ensured a supply of migratory labour in the past. Next to being a supplier for the global premium segment, the Austrian automotive industry has a relative strength in special purpose vehicle manufacture, such as fire engines and military vehicles.

[31] Its very existence must also be credited to the industrial policy intervention of Bruno Kreisky in the 70s, which reasoned that if there is no automotive production in Austria, it should at least be a parts-supplier.

The sample of both, firms and the respondents within firms, was chosen with the requirements of Berg (2001) in mind that 1.) access I possible, they are 2.) available and 3.) capable of answering the questions posed. Virtually all firms in the Austrian automotive industry with upwards of 50 employees were contacted for research participation. The goal was to establish a sample with firms as large as possible in terms of employment and as heavily integrated into international supply-chains as possible, as both factors are likely to increase the technological intensity of production. Ultimately, the *sine qua non* for participation were that they are mainly active in the automotive industry, and that (one of) their main location of activity is in Austria. In addition to manufacturing firms, extensive research on technology providers in Austria, through professional conferences and organisations as well as desk research, provided a larger number of potential respondents.

Within firms, requests were purposively sampled to ensure a maximum spread between departments and roles. There were three strict requirements for participant selection: 1. that respondents belong to at least one organizational unit of interest (management, engineering, and workers); 2. that they have representative shop-floor experience of their roles; 3. that they have representative experience with automation technology (either regarding investment decisions, the technical specifications, or their operation).

While the goal was to achieve a balanced sample, the openness to research participation was unequally distributed between firms and production departments. This is one of the reasons that the majority of the sample consist of engineers, as they were most willing to participate and to do so in their private time. It was aimed to achieve "participant saturation" based on a sample with sufficient "information power", in order to fulfil the study’s aims, based on a specific sample and established theory and sufficient quality of dialogue (Malterud et al., 2016).

Overall 26 semi-structured interviews were conducted on site, in addition to 4 written interviews per e-mail, and a questionnaire sent out to 50 workers in a single factory, of which 19 were returned. The majority of interviews was conducted between December 2020 to October 2023 and ranged between 30min and 2 hours, with a total of 34,5 hours of interview material having been gathered. The sample includes 20 firms overall with a wide variety of products, types of ownership and employment numbers. The products of the firms include: microelectronics, glass and aluminium parts, light systems, body exterior, sintered parts, engines and rims. The technology providers of the sample which offer specific technologies include: automated guided vehicles (AVG), artificial intelligence solutions for predictive maintenance and robots. Some of the suppliers are owned by other large global companies, although all of them retain operative independence. Most manufacturing firms in the sample are producing for the global premium segment of the automotive industry. Table 26 in the appendix shows the structure of the interviews according to company type, position of interviewee, production, production locations and number of employees. The colours designate the type of respondent, green meaning engineers/automatons or technology providers, blue representing management, red worker representatives and yellow larger non-partisan representations of interest. While it seems that “management” represents the largest group interviewed, when counting engineers in management positions or management positions of engineering teams the distribution is engineers/automators: 14, management: 5, works councils: 5, representation of interest: 2. “ATP” in the table stands for “Automation Technology

Provider", "ST" for systems integrator, AS for automotive supplier, V for site visit and GLP for the number of global production locations. Section 5 and 6 list the base-line questions of the interviews as well as the survey.

In addition to the interviews and the survey, 10 visits at 9 factories were conducted, ranging from one to four hours, covering all production areas. The sites belonged to the largest Austrian automotive supplier plants as well as one contract assembly plant. Overall, these visits have yielded 30 hours of non-participant observation. In addition to site visits I have attended a professional automation conference (European Robots and Automation Talks, 2022), which contained presentations form researchers and industry practitioners on current automation technology. Where possible, I have also attended online industry events, both of the automotive industry as well as of automation engineers in Austria.

Using semi-structured interviews is an intuitive starting point, since participants are "*expert holders of social knowledge*" (Silvermann, 2001) interviews are well suited for questions regarding meaning (Kuckartz and Rädiker, 2022), identification, and informal structures. A semi-structure specifically is also advisable in most interview situations (Barriball and While, 1994) and is best suited for exploring attitudes, values, beliefs and motives (Richardson et al., 1965). However, it must be kept in mind that such interviews invariably magnify the unequal relationship of interviewer and interviewee, in both directions (Gacek, 2021).

The interview data was analysed using template analysis (Crabtree and Miller, 1999) in combination with reflexive thematic analysis (Braun and Clarke, 2019). A starting template, or frame of analysis, deemed to be relevant in answering the research questions was constructed based on theoretical considerations. The template was then iteratively refined in the process, meaning codes that did not correspond to data in the transcripts was removed and other emerging codes included. Corresponding to this strategy, epistemologically speaking, the research is designed ‘retroductively’ (Glynos and Howarth, 2007) meaning that the starting hypotheses were constantly revised as empirical research progressed, in the end ensuring the maximum compatibility between hypotheses and data.

The usefulness of observational methods derives mostly form their ability to uncover discrepancies between the “formal system” of given accounts and the “informal relations” actually in place (DeWalt and Wayland, 2002). For example, what engineers say about their work and how they actually do it. Also, as Dargie (1998) argues, observation is useful in research where context is important, research questions pertain to how decisions are made and where behaviour is to be analysed. It allows the observation of processes as they unfold, as opposed to interviews, which give a static impression (Dargie, 1998:66). Disadvantages of non-participant observation are pointed out by DeMunck and Sobo (1998). Chief among them is the difference in information depending on the informant, otherwise known as the Mead-Freeman controversy. The idea is thus to transition from statistical aggregates of the automotive industry, to a ground-level view of observation of how production takes place. Non-participant observation is helpful next to being an important further source of evidence for case study, in that it further allows for an emic/etic distinction and to reveal what people do in contrast to what they say.

3. The “Competitiveness Imperative”

As was established in the literature chapter of this dissertation, “Competitiveness” occupies the central position in most industrial policy debates, and represents the standard intuition of automation and production location decisions of firms[32]. It is therefore not surprising that all respondents during fieldwork, when prompted about how and why automation decisions are made, referred to it in the first instance. Managers, works councils and automation engineers all fielded similar arguments on automation taking place in order to defend the competitiveness of their firms by reducing overall labour-costs. When pressed what precisely was meant by such “competitiveness”, the arguments usually consisted of variations of the following building blocks: 1. high and increasing automation keeps labour-productivity high in Austria, 2. thereby, labour unit costs remain “manageable” at an otherwise unaffordable production location, 3. thereby, “advantage” is maintained over firms from other regions, 4. thereby, industrial production and, paradoxically, industrial employment is able to persist in Austria. Summarizing the corresponding need for ever increasing automation in this argumentative chain, the head of machine construction at a lighting-systems manufacturer put it as:

> “*Without it* [*ever-increasing automation is], we die.*” (M4-45:58)

Many respondents supplemented this general sentiment with anecdotal evidence on the swift punishment delivered for not taking this conventional wisdom seriously enough, from a mid-sized industrial bakery which recently had to close because they had not

[32] The concept of “comparative advantage” it is often derived from, in addition to simple market logics, has been a mainstay in the vocabulary of economic reasoning on any firm behaviour since Riccardo.

pursued higher automation *soon enough*, to a litany of forgotten firm names which refused to automate and have disappeared, collected over the 30-year career of a robot salesman.

The argumentative chain described above can be separated into three subsequent assumptions: 1. Austrian factories are more highly automated than those of other regions (otherwise they would not exist- *competition condition*), 2. Labour-costs differentials between regions and between human and machine are the most important factors in automation decisions, (resulting out of the competitive need to reduce (labour) costs - *regional and relative factor costs condition*), 3. Without ever-increasing automation, manufacturing would cease in Austria (*imperative condition*). In the following, the sum of these assumptions will be referred to as the "competitiveness imperative".

This "competitiveness imperative" and its assumptions are the starting hypothesis for understanding automation and production location decisions in Austrian automotive supplier firms. However, the interviews have shown that such a simplistic argumentative chain cannot account for the heterogeneity of observed outcomes. The three most relevant relativizations of the imperative, which will be discussed in the following analysis are:

1. the "regional parallelity" of automation strategies,
2. the dependence of automation possibility on firm size
3. the command and control relationship between different types of manufacturing firms.

These relativizations do not mean that the competitiveness-imperative and its constituent arguments are entirely untrue or without merit. Competitive struggle, however distorted, certainly remains a central features of capitalist societies. Rather, they illustrate the heterogeneity of automation rationalities and where and how they cannot entirely be subordinated to such an imperative in the practical reality of production. In these cases, then, competitiveness likely functions more as convenient political rhetoric rather than socio-economic structuring principle.

3.1. Relativization I: Regional Parallelity of Automation Strategies

Based on the "competitiveness imperative", we would expect Austrian manufacturing firms to be more highly automated than those in other regions (condition 1+2). Logically, this must also mean that their revenue is export driven, as 1. they are in competition with firms from other regions, and 2. Austria is unlikely to be the addressee of its own industrial output given its small size. This raises the basic, starting question whether Austrian automotive production does conform to the assumption of an export-driven accumulation regime.

Between 2008 and 2021 exports of Austrian automotive firms have increased by 27% (Austrian Statistics Bureau, 2025)[33]. While the export intensity, meaning the percentage of revenues which originate in exports as opposed to national revenues, is redacted in official sources, for reasons of competitiveness, respondents have judged this percentage to be around 95 to 100%. For example, head worker council for a rim-manufacturer:

[33] Source: Foreign Trade by Commodities, Austrian Statistics Bureau, own calculation.

> *„Our export ratio is 98%. All go to big, global automotive firms. The remaining 2% go to another large Austrian supplier."* (W3-14:10)

This export-driven accumulation strategy (Pariboni and Meloni, 2022) can of course only be maintained if there continues to be demand. The premium segment of the global automotive industry, has sufficiently created such demand during the time of fieldwork between 2021 and 2024. During this time, demand for premium segment cars was so high, that at one plant, even over-capacity production could not accommodate it. A production manager:

> "*If you want to have a [car model] right now, you cannot even order it. Orders are on hold. People wait two years for their car, we have that many orders. We just cannot fulfil them. […]* (W5-10:15)

Corresponding to this high demand, revenues and profits reached record highs in many of firms. Worker council at a sinter-parts plant:

> *„We recently had the most profitable year of our history. Here at the site, we had one month with 20 million revenue alone. That was a historical high at the site*." (W1-26:37)

For many firms, their Austrian production location has also remained the most profitable one, in the general upturn:

> "*If you look at the yearly reports of the international production sites, in Slovakia, in the US, in China, in Brazil, in India, if you look at where the most money is made, it's still the Austrian locations. But they still only talk about labour costs, even though Slovakia is still about 1/5 cheaper than we are.*" (W1-14:23)

Hence, Austrian automotive production is indeed highly-export oriented, fulfilling a baseline condition of the "competitiveness imperative". The continued global demand in the premium segment of the Automotive industry is thus a central driver of the persistence of its manufacturing employment. In the words of a systems integrator:

> “*When I export something, when I am producing globally and I am growing, then it is very logical that despite automation labour demand increases.*” (E8-47:58)

Another element is the exceptional profitability of Austrian plants, also compared to other global production locations with lower labour costs, which ties into a relevant point. None of the firms in the sample *only* had factories in Austria, but rather several global production locations embedded in complex international conglomerate structures. Table 10 below shows product, production location and employment of the largest examples.

Table 10: Global Production Structure of Selected Respondent Firms.

Firm	Ownership	Production Locations*	Countries	Employment **
Contract Manufacturer	Subsidiary of Canadian Conglomerate	6	AUT,GER, FR, SLO, CN	NA/11900
Sintering/Bearings	Austrian	29	AUT, SK, GER, SLO, CZ, US, CN, IN, BZ	NA/7546
Engines	Subsidiary of German OEM	3	AUT, GER, CN	4500/NA
Light Systems	Subsidiary of Korean Conglomerate	7	AUT SK, SLO, CN, MEX, CZ, IN	3000/10000
Semiconductors	Subsidiary of German Conglomerate	24	AUT, US, IN, PHIL, HU, CN, KOR, GER, MA, THAI, SING,SWE, MEX	5886/58600
Electronics	Austrian	4	AUT, CN, MEX	NA/1900
Rims	German	7	AUT, GER, SA	500/4255
Plastic components	Austrian	20	AUT, US, UK; GER, CN, NL, BE, CZ, SK, SLO, SA	NA/3500
*Manufacturing locations which produce the same product or belong to firm/subsidiary directly				
** 2023 Local/Global				

This global structure, by itself, does not relativize the regional condition of the competitive imperative, as perhaps firms produce different things with different technological intensities in different places. However, respondents have also described that these sites, be they in Austria, Mexico or China, are essentially operating with the same level of automation. In the words of the head of machine construction at a light-systems manufacturer:

> “*Production [at Austrian site] is essentially the same as in all other production sites*.” (M4-03:11)

Not only does this apply for different production sites within firms, but regions more generally, according to a robotics engineer:

„There are hardly any differences [between countries and regions] anymore. Maybe percentage points, where I say, ok, I can do more manual tasks in the East rather than high-wage countries. But for the most parts automation is the same, just look at the robot-numbers." (E9-21:02).

If automation decisions are independent of production location, and Austrian factories are not more highly automated than their counterparts elsewhere, then a central point in the competitiveness imperative is not fulfilled. Instead, automation levels in the automotive supplier industry have thus converged, for the most part, the remaining differences depending on the type of manufactured product and availability of skilled workers. The head of automation for one of the largest Austrian automotive suppliers summarizes that the resulting state of affairs:

"*Within the automotive supplier industry, everyone is largely on the same level of automation. The degree of automation at sites depends more on the type of process and product. There are no differences to low-wage countries in this. The degrees of automation are the same in Austria, as in Romania and Vietnam. This will not change anymore. This is why for automotive suppliers, automation is not the main topic per se, but rather the structure of the production network and the qualification of the workers. Where is the production location, close to ports and trains stations? What about the qualifications of workers who can operate this. […] When machinery is not in use, it loses money every minute. Skilled workers have to ensure that the machine keeps running. Automation itself has ceased to be a competitive advantage, but it is rather the state of things.*" (M8-15:15)

Rather than producing where labour is cheapest, it appears more imperative to produce where it is available in sufficient quantity and "quality". The regional parallelity of automation strategies described above, and outright statements that automation is not a relevant competitive advantage anymore, describes a different rationality than "old" offshoring narratives. A systems integrator echoes the importance of other criteria than wages:

"*Factories these days, the basic costs […] are the same everywhere. It does not matter if I build this in the periphery in Poland or somewhere else. […] It matters more: do I have to deliver just-in-time? How large are the assembly pieces? Can I*

> *structure them along the transportation route logically? So, to build a new factory in a lower-wage country may turn out to be more cost-intensive than if I built a factory in Germany or Austria."* (E9-23:46)

Within regional contexts, however, labour-costs can still play a role for the allocation of production locations, if to a lesser extent for automation decisions. The vice president of production systems of an electronics manufacturer summarizes their manufacturing strategy accordingly:

> "[*We] produce on every continent what is needed there. So, we produce in Europe for Europe, from Austria or Hungary. Well, Hungary for the products which are under even greater competitive pressure than the automotive parts. Those are produced in Hungary, also for labour cost reasons. But we do not export anything from Europe to Asia or the USA. Instead we have a factory in China for the Asian market, and one in Mexico for the NAFTA market."* (M3-17:9)

Hence, it is imperative to produce where one wishes to sell, rather than where labour is cheapest. The driving factor of this approach of setting up regionally parallel production locations, at least in the case of the Austrian automotive supplier industry, was the requirement of large automotive OEMs who were expanding to these regions and requested their suppliers to also set up production locally. The chief mechanical engineer of an automotive supplier firm describes:

> *"[In the course of internationalization in the 90s] our factory in China was the first. The reason was to follow our customer to their production site. The basic consideration was that to produce in Europe and deliver to China means tariffs. So better to produce where you sell. In this case [large German automotive firm], our main customer, at least then, we didn't want to lose them. They said they would only give us the contract if we produced locally.*" (M4-02:35)

This shift is connected with manufacturing strategies, which naturally depend on where the largest amount of output can be realized[34]:

> *"What has changed internationally, is that up until 10-15 years, China has produced for us. Now, we must say that is less of interest as production location, but to produce for the local market […]."* (E8-25:06)

This primacy of the realization of output, in turn, extends not just to where production takes place but also what kind of product is produced:

> "*Within [OEM name] there is not much relevance to the discussion how to produce things cheaper elsewhere, that is not a topic. Much more relevant is looking at which vehicles have a high contribution margin, where can you make a lot of money. For example, a component, microchip in an assembly can be built into [one type of car] or [more expensive car]. Which car do you think they will build? This is what decides which plant, which location is affected in which way."* (W2-39:58)

What then is the purpose of firms which remain in Austria? After all, the parallelity of automation strategies could just as well mean an even larger irrelevance of Austrian production locations. Overall respondents maintained that the sites in Austria still remain the technologically "most intensive", to some degree, however, mostly due to the type of products manufactured there rather than a regional difference of technological capacity. The head of machine construction at a large automotive supplier firm describes:

> "*The Austrian production site is the corporate mother and origin. It still is ideological. That means we here, are always leader in many fields and dictate standards as well as topics. […] But we always simply have the technologically more demanding products here […]."* (M4-04:11)

[34] Also explaining such counterintuitive positions such as BMW opposing Chinese tariffs because they import themselves from China to Europe (Austrian Broadcasting Service, 2025 b).

Hence, the regional parallelity of automation decisions shows that notions of competitiveness do not readily apply to the production location decisions of firms, at least in the case of the premium segment of the global automotive supplier industry. There, automation decisions depend more on the product and production location decisions depend more on where firms wish to sell and where labour is available rather than where it is cheapest. This does not mean that wage costs are irrelevant, as they are a direct inverse of profits, but in terms of production decisions, they play a much smaller role than commonly argued. Finally, a weak form of the "lead plant" hypothesis is also corroborated by regional parallelity, depending less, however, on regional technological asymmetry than on which type of product is produced at which site and which skilled labour is available.

3.2. Relativization II: Firm Size, Competitive Pressure and the Possibility of Automation

The "competitiveness imperative" as derived above, also requires all Austrian manufacturing firms to pursue maximally "cutting" edge automation in production, as otherwise they would not be able to compete and "die", in the respondent's own words (condition 3). The second relativization lies therein that many automation steps are in fact not possible for smaller firms. Conversely, only large firms can even attempt to conform to the "competitiveness imperative" through maximal automation in the first place.

While large firms do dominate much of the Austrian automotive industry, they do not account for the entirety of the sector and even less so in other manufacturing sectors. The largest Austrian automotive firms, however, show a transnational conglomerate structure, either as subsidiaries of other companies, or by having their own subsidiaries and production sites in other countries. Comparing the firms of the automotive industry with the general Austrian manufacturing sector shows that the automotive sectors has fewer and larger firms, pointing to higher concentration (Figure 9 and 10). As shown in Figure 11, the ten largest firms have accounted for 80+% of the revenue in the sector between 2010 and 2019. Figure 22 and 4 in the appendix specify the developments of number of employees and operating revenue for the six largest automotive firms in Austria between 2016 and 2021.

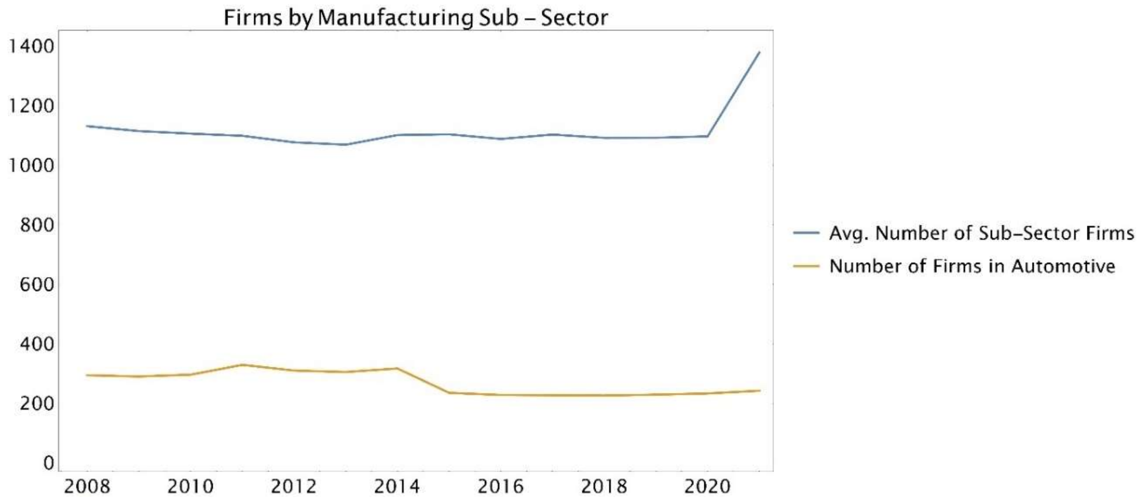

Figure 9: Number of Firms by Sub-Sector, 2008 to 2021, Source: Business Cycle Statistics of Manufacturing, Austrian Statistics Agency, own calculations.

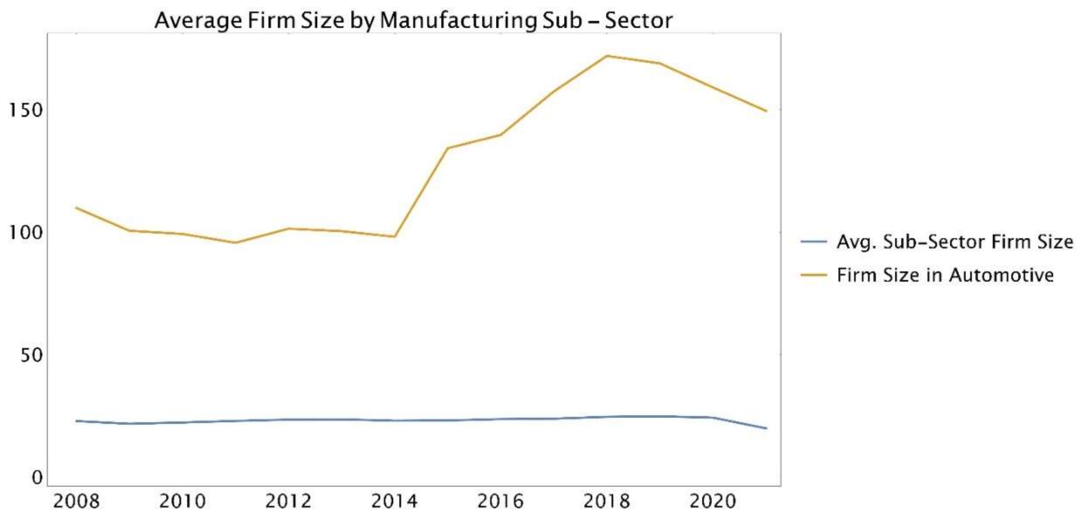

Figure 10: Firm size by employees by Sub-Sector, 2008 to 2021, Source: Business Cycle Statistics of Manufacturing, Austrian Statistics Agency, own calculations.

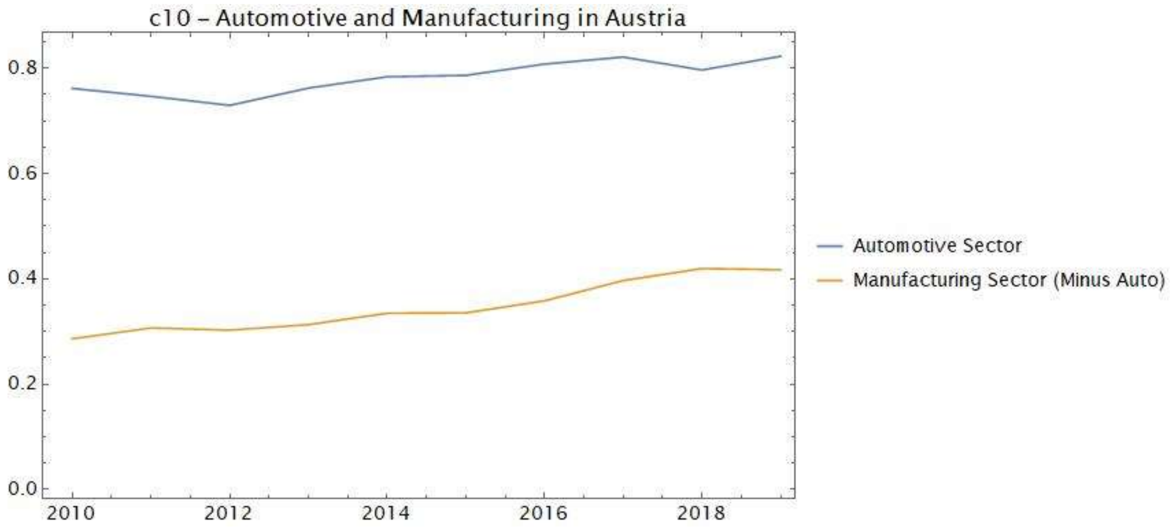

Figure 11: C10 Austrian Automotive and Manufacturing between 2009 and 2019. Source: Orbis Bureau Van-Dijk, own Calculation.

The domination of the Austrian automotive industry by large firms is not just significant as its aggregate development will depend on the decisions of a small number of firms, but also as mentioned, since smaller manufacturing firms are structurally limited in their possibilities of automation and production relocation. This is due to the types of products they manufacture, and consequently the size of their output. In the words of the head engineer of a system integrator firm:

> "*Small firms, their products are much too individual and much too dependent on manual labour. These firms then have troubles with automation. Larger firms have, simply by virtue of needing a lot of revenue, without them consciously wanting it, they have products which are produced in large numbers. This means that there, automation is logical. For smaller firms this is not logical*." (E8- 20:09)

In turn, the size achieved by other global manufacturers gives them particular access to production processes based on their products, which makes it almost impossible, by prevailing economic logics, to consider the "re-shoring" of such production:

> *"This is why firms such as Foxconn with, I don't know, 2 million employees, are doing final assembly and shipping for large OEM's, like in the electronics industry. They are truly globally organized. And when I tell them: I want this type of razor, this month, to be globally launched with however million pieces, then they do this in 10 production plants around the world, at the same time. To "re-shore" this kind of production is entirely nonsensical. This has to be very clearly seen."* (E8-28:26)

A certain volume of production is thus a central deciding factor in the automation-investment-calculation. High volume production and size also correlate with the ability to have the necessary revenue to make large-scale investments in automation in the first place. According to the CEO of a robotics firm:

> "*Large firms, if you think of automotive firms, when they automate, large producers such as BMW or VW etc., they have a lot of capital. […] A large firm will have large project teams and specialists just to do the work of automation […].*" (M3-44:50)

Or in the words of a robotics professor:

> *„In the end, only large firms are customers for automation solutions, because smaller firms simply cannot afford it. Small or middle-sized firms […] don't have the budget and […] thus difficulty to even considering automation […]. Large firms are completely indifferent, they want a certain solution and simply implement it and done. You see this especially often in robotics, where things are sold at horrendous prices for something that is not actually worth the price-tag*." (R1-28:08)

This, one may say Schumpeterian, organisational advantage influences automation strategies but also other competitive strategies such as the prohibitive acquisition of technology from smaller firms:

> *"What is also a possibility, which I have seen a lot lately, is to buy start-ups. You have a specific problem, you lack a certain specific expertise in-house, but which you need, then you simply buy a firm. […] What do you have then? You have the people, you have the know-how, you are buying all of that from them. […] Most of*

all you buy all that "away from the market", your competitor will not have access to that know-how anymore. […] This is not a secret. Bosch, for example, buy whatever fits them. They have their own division which has an eye on buying up useful start-ups. The big ones almost always have something like that." (R1-1:05:10; 51:44)

Finally, firm size not only determines the possibility but also the *need* for different technological interventions. By virtue of size, a firm or factory has high fixed cost of machinery. An automation solution provider describes how this makes certain technologies more relevant to implement, than at smaller producers:

„*We have a list of 50 potential customers, many of which have 20-30 employees. But they are simply too small. They have to live with something breaking down at some point and the sawmill is not operating for 2-3 days. They will just work on the weekends if things are busy. A large firm cannot do that. When they stop operation for 1-2 days, more or less a thousand people will be without work and don't have anything to do. The processes are very interconnected. Which is why they are always on the lookout for new technologies with which they can increase stability*." (E3-15:14)

The relevance of size can also be illustrated based on sectors, rather than just individual firms. One of the reasons the automotive industry has been a pioneer in automation, for example, is simply because of its historically high output volumes:

„*The automotive industry was always the pioneer in automation because of quantities. Every car was often produced in the millions. That's why the degree of automation was very high from the beginning. […] That's why the automotive industry was always looked upon as pioneer by other industries. If it works in the automotive industry, then it works in other manufacturing sectors as well.*" (E9-14:38)

However, the desire to increase output sizes and calls to be more "competitive" are very often not the life or death affair of economic necessity as they are presented (condition 3), but also of personal ambition and prestige. Head of the works council at a Sinter-plant:

> "*We now have a strategy at the company "[company name] 100 years". We are at about 1 billion Euros revenue in the firm presently. 2027 the owner wants 1,7 billion. Because he wants to be among the big global players*." (W1-14:23)

Requirements for "competitiveness" and pushing down labour-costs in such cases is not about surviving or being profitable, but not being profitable *enough*:

> *„This competitiveness, they use it again and again to put pressure on the workers. It's just blahblah. We are doing well. The only competition we really have is [firm name], a Canadian conglomerate which is also active globally. We have always had really good quality. […] This is our advantage over [firm name].*" (W1-32:50)

Two elements must be added here in all brevity: firstly, the competition between countries and regions on the development of technology (see for example the AI arms race between countries etc.) . Secondly, the supersession of geographical regions as arena of competition. The first point is also evident in new industrial policy directions which aim to support and develop "national champions" in particular on the European level, with the idea to establish dominant European monopolies in order to be able to confront the US and China, for example in the "Draghi-Report". Regarding the second point, and in confirmation of Rikap's (2021) thesis, the development and application of automation technology is increasingly becoming a globally simultaneous undertaking. One AI-solution provider for mobile industrial robots, for example, describes their competitive relationships with Google:

> *„Amazon and Google are of course working on the same things. […] The problem is, firms like them, they are just too big. They can instantly enter a market. It does not matter whether you are Knapp or Schäfer or Agilox [Austrian logistics and warehousing automators], because Google is competition for everyone. […] We are*

> *just lucky that they are not focusing on our market right now, probably because it is not large enough*." (E4-12:12)

Rather than the dispersion between regions, as discussed under relativization one, this relativization concerned the dispersion between different firms *within* regions and sectors. At this level, firm size significantly relativizes the propositions of the competitiveness imperative. Certain types of automation can only be undertaken by firms of a certain size, since they require a certain volume and type of product to be viable, with the former taking precedence over the later. The size of revenues and corresponding capacity for large scale investments are also only available to firms of a certain size. In turn automation and attempting to conform to the competitiveness imperative, is a prerogative of large firms. The crucial deciding factor is what product is produced and how much of it. Both of which depend on firm size. This means that variation in firm size and product explain different production outcomes in regions, and contradict the requirement derived out of the "competitiveness imperative" for the implementation of available automation technology at any cost.

3.3. Relativization III of Competitiveness Imperative: Firm Hierarchies and Automation Dependency

Finally, a central assumption of the competitiveness imperative is that decisions and investments are the prerogative of autonomous firms, which undertake them based on their manufacturing and product strategies (all conditions). The interviews showed, however, that the relationship between different types of producers determines a large part of automation and location decisions. While the production location dependence was already illustrated with OEMs forcing suppliers to produce locally for overseas markets, a similar constraint exists for automation. Hence, what is automated and how is often not even the decisions of a supplier in the first instance. Rather than a "competitive imperative" then, the interviews have shown a "control prerogative" of firms higher up on the "food chain". It is correspondingly the lower supplier rungs of this ladder which are under greater pressure to adhere to standards and uncertainty set by those above them. Hence a crucial dynamic, somewhat adjacent to the role of frim size yet distinct, which relativizes a simple "competitiveness imperative", lies on the command and control relationships *between* firms.

Generally, the relationships between supplier and OEM firms is fraught with significant uncertainty. This starts with the process of how production contracts are allocated, namely in the form of project tenders, or auctions. Described by the vice president of production strategy at an Austrian parts supplier as "merciless":

> "*Products are essentially auctioned off. Even one of our customers [large German OEM] for whom we have been working for over 12 years, […], they auction off every single project without mercy. But not in the sense of bidding down, but bidding up! They start with an unrealistically small price, then invite three suppliers and start from the very bottom, completely unrealistic, until some loses their nerve and says: now I strike!*" (M3-29:14)

After this bidding war among suppliers has ended, the OEM sets out the conditions of the tender, and a contract is signed for production over a multiple year period. In the course of the agreed-upon conditions, the OEM can stipulate which automation technology is to be used in the production of which part. While this relationship certainly contains a dynamic of large versus small firm, suppliers are not necessarily "small firms". In the case of Austria, they themselves have extensive global production locations and networks:

> “*With the tier 1 suppliers, at some point, there is no "small" of course, because a firm with three employees will not be a supplier for BMW, to put it bluntly. That just doesn't make sense.”* (E8-07:50)

Nonetheless, they are structurally in many ways at the mercy of their client. An industrial systems integrator and robotics professor describes the cost squeezing of suppliers based on this hierarchy:

> “*That is what is paradoxical about the present situation. The suppliers are struggling economically, all of them you can almost say, and the large automotive producers are turning profits. Its easily explained, the suppliers are being squeezed. In most cases we have to take on cost increases, also in terms of energy costs etc. […] Many manufacturing firms have treated suppliers very roughly. Talk about market power. I am BMW, you have to deliver. Be glad that you are with me! Dumping, pressure, interfering in the production process. OEMs really poke suppliers in the eye.”* (R1-17:34; 37:28)

The resulting pressure and uncertainty for suppliers even extends to subsidiaries within the same conglomerate directly translating “market pressures” as performance goals to subunits of essentially the same firm:

> “*Single firms within the corporation are essentially treated as normal suppliers, even though they belong to the same corporation.*” (M5-42:48)

Which produces curious mentalities regarding who is considered a “competitor” and who is not, as described by the head works council at an engine plant:

> „*Let’s put it like this: our biggest competition is our other production locations*. […] *You are always put into comparison which each other. For example, location in Germany, they did this x years ago, why can’t you? And it’s always about the distribution of future investments, and they say: if you don’t want to do it, fine, we will just go somewhere else. So, they play the locations against each other, of course*.” (W2-43:22; 16:56)

Automation steps are generally undertaken in the course of the manufacture of a new product, rather than within existing processes or based on new technological feasibilities. Due to such project-based production cycles, automation steps are only considered every three to five years, depending on how synchronous these projects are. In any case, which steps are precisely undertaken is only considered after the tender is actually won:

> "*When you make an offer, there are of course a lot of assumptions, because at this point the product is not detailed. When you get the tender, the product is largely engineered, and only then do you specify the machine concept*." (M4-44:51)

While the technological specifics are then fixed, the concrete production numbers are only determined after production has started:

> „ *[T]here is only a rough orientation in the beginning, and the real numbers come in depending on market developments*." (M3-33:08).

This awards great flexibility to the OEM, but such contractual obligation put additional pressures on suppliers, for example, by locking them into reserving production capacities for an extended period of time, often without the machinery being actually in use, creating inefficiency and economic liability:

> "*There are firms for example, which have obligations in the automotive industry to supply spare parts. They have to supply these parts up to 10 or 15 years after the project is done. Now, you can't produce this as inventory, because the quality degrades over the years. So, they have huge areas where machinery is set up without running, waiting to produce a couple hundred pieces every other month. How stupid this is? […] You really wanted that project from MAN or BMW or Audi or whatever. […] Now, there are machines just standing around, you cannot imagine it. After six months they are turned on for one or two days, and that is it. And they can't dismantle them.*" (R1-1:23:00)

Ultimately, the increased pressure on the supplier is of course an externalization of risk by the OEM, which is nowhere more clearly visible than in the contractual obligations regarding "product quality":

> *"Firms destroy themselves because they say: I want to have [large Austrian supplier] as a customer, no matter the cost. And then something goes wrong. You know they do spot check quality control. This means you deliver a truckload of components and three are selected, one has a fault. Alright, the truck goes back. The worst case I have heard of that was when someone sent a boat-full of inventory back, because they looked at five pieces and one had a fault. The boat was completely filled with inventory. […] This is contractually agreed. […] It can very easily break your neck. OEMs are not squeamish with this at all*." (R1-1:12:46)

Consequently, if something breaks, machinery or product, the burden of proof exclusively lies with the supplier of its constituent parts:

> "*The burden of proof always lies with the producer. If someone says: my engine broke down because of your oil filter, then you have to prove that it was not your oil filter. You have to retrace the complete production process. When you can't do that, you have to pay for the damage*. *So, the automotive firms […] they are putting on insane pressure.*" (R1-1:12:46)

This in turn provides a very specific and concrete reason, for example, for the drive of digitalization in the automotive supplier industry:

> "*And that is why the automotive suppliers are attempting to digitalize, at all cost, to do so traceably... to save all those damn photos. Because when someone comes... so that you are not completely vulnerable.*" (R1-1:17:18)

Rather than goals of productivity or saving labour costs, digitalisation thus serves the documentation and preparation for litigation with OEMs (see also Rikap, 2021).

Consequently, the highest productivity gains appear to have been realized at the lower production pyramid rungs rather than the top:

> „*Productivity through automation has risen sharply. Not primarily with OEMs, but the suppliers. […] Every project that is advertised is only under the condition of rigorous automation.*" (E9-18:45)

The described relationship of command and control described above, can also take a very direct form between suppliers and OEMs. In the words of a production manager at one of the largest Austrian suppliers:

> „*The degree of automation depends a lot on the OEM. For [car name] for example, the requirement of the OEM was: I want this batch size, this is what it should cost, this is the quality it should have, and these are the machines you should use."* (E7-39:49)

Or in the words of the head works council at a rim producer:

> „*We implement technology, which is requested by the customer."* (W3 50:27)

Rather than automation being a genuine decision of the supplier firm, they are confronted with a desired outcome, such as for employment numbers, which must then be translated into automation projects. As described by a professor of robotics:

> "*I was at a firm where they were told: if you are not reducing your workers from 200 to 180, then we will move the entire production line to the east. That is the state of affairs. They got precisely that demand. So, then they went back and forth thinking: what could we do… […] where will we automate and displace? These are simply demands from the conglomerates, giving a specific number, and the lower firms simply need to implement this. That is often the case, and then it doesn't matter whether [automation] costs 150 or 200K, or 250K or whatever. Then the goal is different.*" (R1-1:06:37)

4. Conclusion

This chapter analysed the role of “competitiveness” in the automation and production location decisions of firms in the Austrian automotive supplier industry. The analysis has shown that a “Competitiveness Imperative”, derived from the literature and specified through the statements of respondents themselves, lacks in several ways in explaining such decisions and thus persistent employment. This was illustrated based on three arguments or “relativizations”.

The first has shown that firms pursue “regionally parallel” automation strategies. Rather than on regional labour-cost differentials, automation levels depend on the product to be manufactured and production locations are determined based on the final sales market and where (skilled-) workers are available, rather than merely cheapest. Hence, persistent manufacturing employment hinges on final sales markets in combination with skilled labour-availability. This notwithstanding, the factories in Austria also maintained , at least in part, a “lead plant” function of developing and testing new products and methods, which contributes to the persistence of manufacturing employment. Also, this function, however, has more to do with the type of product produced there, rather than regional “competitiveness”.

The second relativization concerned the possibility of automation based on firm size. The competitiveness imperative would require all Austrian manufacturing firms to be at exceptionally high and increasing levels of automation, as otherwise they could not “compete” based on high wage costs. However, as respondents made clear, due to the lower volumes and lacking funds of smaller firms they often simply *cannot* automate. Conversely, the choice to automate is a prerogative of large firms, as is to participate in “technological competitiveness” through such automation. Equally, a relatively large number of smaller firms foregoing significant automation, contributes to persistent manufacturing employment, with the open question, however, how such smaller firms survive global competition.

A third relativization of competitiveness lies in the relationship between firms. The interviews showed that, the command and control relationship between suppliers and OEMs can indirectly or directly determine both automation and production location decisions of the former through the latter. Rather than a “competitiveness imperative” then, the interviews have shown a “control prerogative” of firms higher up in the “commodity chain”. In the case of suppliers, the persistence of manufacturing employment is thus also dependent on the decisions of OEMs. These results also lend credence to recent contributions on the role of large firms in shaping the diffusion of technological developments (Rikap, 2021).

Overall, these findings show that the “competitiveness” narrative has lower explanatory power for automation and production location decisions, and thus employment outcomes, than commonly assumed in the literature and industrial policy debates. While the persistence of manufacturing employment in Austria overall, logically and on the most simplistic level, does relate to the “success” of its firms, the notion that this success depends “competitiveness” understood as maximally feasible automation levels and maximally reduced wages cannot be maintained. In this sense, the “competitiveness imperative” appears more truthfully as political rhetoric, or a-political façade, than actual underlying socio-economic principle for explaining automation, production locations and persistent manufacturing employment.

However, there remains an open question which elements of these findings are general principles, and which are specific to the Austrian automotive supplier industry. It is obvious, that the view of the production logics of transnational companies in the premium segment of the automotive industry cannot be readily extended to other types of products and different countries. As has been re-established endlessly in the Global Value Chain literature: there are significant differences of manufacturing based on different labour and technology-use regimes. Hence, also regional differences in wage and average production technology obviously persist in the aggregate. To answer what is "general" about these findings, and what is specific to the Austrian automotive supplier industry, therefore requires additional empirical evidence form other sectors and countries. It is clear that these findings are nonetheless crucial for debates on competitiveness and de-industrialisation, as the analysis of the specific case is always a test of generalised theory (Burawoy, 2009).

The analysis of this chapter has shown that the rationalities of firm decisions are crucial for understanding persistent employment, and that these decisions depend on other criteria than commonly assumed by aggregate analyses. Among them, are the type of product produced and wider manufacturing strategies. In order to analyse the explanatory role of these criteria, in particular the product, in persistent employment in greater detail, the following chapter will discuss the boundary conditions of technical and economic production rationalities in automation decisions.

Chapter 6 - Entropic Product-Dependent Technological Change: Technological Feasibility and Economic Imperative in Firms' Automation Decisions in the Automotive Industry

0. Summary

This chapter extends the analysis to the internal production logics of firms, meaning how the boundary conditions of technological and economic dimensions are negotiated in the automation of concrete manufacturing processes. This analysis shows that decisions of automation, hence when a labour-process is organised through machinery rather than manual work, do not in the first instance depend on technological feasibility. Consequently, routine-intensity is a faulty operationalisation of automation viability. Not only is technological feasibility secondary, the analysis also shows that feasible automation is actively avoided by engineers due to the increased instability of more complex processes, causes of which are summarised under the concept of "automation entropy". Surmising these points, the section concludes with showing why supposed recent extensions of technological feasibility, through Cobots and AI applications, do not have significant impact on automation decisions and thus, presently, have little bearing on manufacturing employment.

In detailing the driving economic imperatives of automation decisions, the chapter shows that prevailing conventional wisdom, such as relative factor substitution, is also insufficient in accounting for "automation calculations". It is instead argued that a "product imperative", based on the characteristics of the manufactured commodity, is the most decisive criterion. This means automation decisions depend on three main dimensions of the commodity to be manufactured 1: its complexity, 2: the type of processes used in its production, and 3: the scale of the production output. If a commodity

is complex, has many variants, requires complicated and interlocked processes and is only produced in low numbers, automation becomes practically impossible within present economic rationalities. However, this does not mean that other polit-economic factors do not also determine the shape of automation projects within the bounds of this imperative, which is shown based on the effects of narrowing financial requirements on what is considered economically feasible to automate.

Overall the chapter concludes that routine-biased technological change is a poor theory of automation and work. Persistent manufacturing employment consequently does not depend on routine-intensity, but rather a “product imperative”.

1. Introduction: Technological Feasibility and Economic Imperative in Firms’ Automation Decisions

In the recent debates on how new technologies are changing manufacturing work and employment, the question why firms make certain automation decisions and not others, is surprisingly little considered in depth. However, in order to understand the aggregate effects of new technologies on societies and economies, an account of the rationalities of the organising units of production, firms, is necessary. To this end, the present chapter provides a theoretical and empirical analysis of automation decisions in firms in the Austrian automotive industry, in terms of their technological and economic boundary conditions of feasibility. This analysis is primarily based on the perspective of engineers, as they are not only direct producers and consumers of production technology, but also serve as professional mediators between technological feasibility and economic necessity of automation decisions.

The standard view, in particular in economics, finds that the automation decisions of firms can relatively easily be accounted for by combining hypothetical capacities of technologies with the cost differential of worker and machinery (i.e. Acemoglu and Restrepo, 2018). If a technology makes it technologically feasible to automate a task, and the required machinery is “cheaper” than a worker, automation of a labour-process will take place . While this position is as simple as it is intuitive, recent contributions have begun to point out its insufficiency. For the most part this presently concerns the different uses technologies may serve, and consequently varying relative costs. The most commonly reiterated of such uses are: *Labour Substituting* (workers are displaced for tasks or entire jobs), *Labour Augmenting* (workers are supported in their work) and *Labour Re-Instating* (new jobs *because* of new technology) (Waldman-Brown, 2020, Acemoglu and Restrepo, 2020)[35].

While such propositions do represent a useful differentiation, they still place the largest explanatory burden of automation decisions and their work outcomes on the characteristics of technologies themselves. The critique of such technological determinism has of course become standard in virtually all critical social science (Spencer and Slater, 2020). Technological possibilities are thereby necessary, but not sufficient in explaining the organization of production and changes in employment (Holtgrewe et al., 2015). The automation decisions of firms are therefore theoretically overdetermined, and may depend, in any one firm, on managerial strategies, sectoral context, worker skill

[35] As Dosi and Virgilito (2019) note, the distinction of a "productivity-” and “reinstatement” effects popularized today (Acemoglu and Restrepo, 2021) are in fact long-established concepts in evolutionary and institutional political economy. See also Settlerfield and Blecker, 2019:81 for a theoretically well-founded and comparable differentiation to the above technology-uses.

availability, existing investments or industrial relations (Spencer and Slater, 2020). On the level of industrial sectors, labour-availability and competitive pressures play a role. On the level of the entire economy wage levels, occupational development, industrial development, taxes and structural countervailing pressures must be considered. The use and consequences of technologies are thus subject to a socio-economic process of confrontation between social groups, most often workers, management and engineers (Wajcman and Edwards, 2005, Howcroft & Taylor, 2014 and 2022).

The most fundamental difference between a standard economics and such a critical socio-economic view ultimately lies in distinguishing between economic and technological rationalities of production, and a potential divergence between technological necessity and economic sufficiency. While both are assumed to be congruent in virtually all models in economics, excluding select heterodox approaches (Basu, 2021), socio-economic thought has a long tradition of separating them. Veblen (1904), for example, distinguished between the tendency of "industry" to maximally develop machinery and the capacity of production, and the drive of "business", which is to make money. For Veblen, and Galbraith who significantly drew on this distinction (1995), it was clear that in the conflict of technological and economic rationality of production, the latter would always win in capitalist societies. This means that the profit motive would always constrain production in ways which are not technologically necessary. Galbraith goes as far as arguing that all capitalist crisis are ultimately conflicts between technological efficiency and profitability, deriving from contradictory tendencies of industry and business (1995: 45). In a very similar vein, Sohn-Rethel (1974) differentiated between the "production logic" of firms, and the "logic of appropriation". The first represents the needs of productive forces and technological efficiency, whereas the latter represent the needs of the market. In the wider Marxian literature, this can also be understood as a contradiction between the means and relations of production (Ferschli, 2024).

The distinction between technological and economic rationalities of production, or technological feasibility and economic imperative, is not merely ornamental but explains fundamental differences in theoretical perspectives on the industrial division of labour and development of manufacturing work. While for Smith, for example, the industrial division of labour was purely a matter of technical efficiency, others have found the interest of this division and the use of technology therein to reduce the dependence on worker skills (Braverman, 1976) or to establish managerial control over the production process more generally (Marglin, 1974). Neither of which are a consequence of a technological necessity of efficient industrial production, but expressions of the tendency of “business”.

The dominant economics view that technological and economic rationality are congruent, on the other hand, is perhaps nowhere more evident than in the most prominent approach to understanding the automation decisions of firms, Routine-Biased Technological Change (RBTC). The goal of this chapter is therefore to analyse the automation decisions of firms, drawing on the proposition of RBTC, as well as the most common critiques levelled against it, and building on the alternative framework of a “Socio-Economic Theory of Automation” (Krzywdzinski, 2022) described in the literature chapter. The following section two thereby discusses the role of technological feasibility in automation decisions, introducing the alternative concept of “automation entropy”.

Section three presents the results on the economic necessity underlying automation decisions, introducing the alternative concept of "Product Imperative". Section four draws them together in explaining persistent manufacturing employment.

2. Automation Entropy: The Role of Technological Feasibility in Automation Decisions

It is most intuitive to begin to understand automation decisions by considering what is technologically feasible to automate in the first place. If there is no technology to automate a labour-process, it makes little sense to ask when, why or how it is not automated. Such feasibility is also the crucial turning point in the framework of RBTC. To reiterate, the higher the "routine" content of a task, the higher its supposed technological feasibility of automation. The interviews have shown, however, that not only is "routine" a largely irrelevant category in the engineering rationalities underlying automation decisions, "technological feasibility" itself not a deciding factor.

The reason for the latter is that every manufacturing process of relevance, at least for the products and processes of the Austrian automotive supplier industry between 2019 and 2024, could already be automated with given technology. Automation is thus in this sense not a question of technology in the first instance, formulated by a professor of robotics, with extensive experience as shop-floor automation engineer:

> "*[E]verything can be automated. [I]f we want to, we can automate any relevant manufacturing process.*" (R1-23:07)

While this lack of concern over technological feasibility is in itself already a concise critique of technological determinism, it is also not the whole story. By logical necessity, the state of technological conditions *must* play *some* role in what is automated and what is not. However, not one single engineer referred to any notion of "routine" in describing the relevant aspects of these conditions. Instead, engineers were concerned with: 1. tactility and movement, and 2. the physical outlay of production sites. As also supposed by RBTC therefore, engineers did stress the difficulty of automating manual tasks which requires tactility, variability and sensitivity. A systems integrator describes based on the example of Cobots:

> „*Look how slow the Cobot is, and how a worker does it. […] it's not that easy to actually automate something like that. With fine motor skills you can do this easy-peasy. But it's easy to say: everything can be automated, and it's just a matter of details. In certain cases, the devil lies precisely in the details*." (E9-1:07:48)

However, the same engineer also makes clear that in fact also such processes are actually entirely within the realm of technological feasibility, and that their impossibility derives from economic unviability:

> „*Of course, you can use gripping technology with image processing. That can solve many issues. But the effort… such a 3D laser scanner costs 30K Euro. And the you have to program it, train it. Just so you get what a human eye can do in 2 seconds*." (E9-44:12)

The second seemingly technological limit described by engineers is the physical layout of production sites. The group lead of technological strategy at one of the largest Austrian suppliers describes:

> „*Usually at [Austrian city location] we have existing infrastructure, existing facilities. If you start a new automation project there, you are limited. By starting*

> *from 0 you can implement completely different concepts, which would not be possible with the existing infrastructure. So, to use new technology, you need to build a new factory*." (M5-33:51)

Also, here, however, the seemingly technological constraint could in fact be overcome by investing in a new production facility. Hence, technological limits suggested by engineers do not contradict the wider assessment that technological feasibility is not the deciding factor of automation decisions. The result of navigating such constraints is a compromise or bargaining on the boundary conditions of technological and economic feasibilities of automation, which results in the partial automation of most process. Described by a robotics engineer of a logistics automation firm:

> *"You can ask: why haven't they done it yet [automate everything]? Some firms say: well it's not easy in terms of the law etc. of course. But really, it's simply a difficult task to consider everything. Which is why the solutions which exist are only ever partial automation solutions*. *[Technologies] are used if they solve a sufficient number of things. So, you have constraints and then you ask: what can I do within these [economic] constraints?*" (E4-29:50; 33:06)

In fact, not only did technological feasibility not function as primary concern in automation decisions according to engineers, they described actively avoiding feasible and higher degrees of automation. The reason being that the more complex systems are, the more susceptible they are to failure and disruption. The reduced flexibility of "over-automated" systems thus represents a liability in many ways, biggest of which is that large machine systems bleed money when they are not in operation. A simple malfunction of one, perhaps small and seemingly inconsequential, part of a machine in a highly automated system, can lead to catastrophic, and expensive, cascade failure of the entire system. The term "automation entropy" is coined here to describe the principle of highly automated systems being prone to dysfunctions which negate the very benefits of automation. Put differently: the increasing uncontrollability of systems of increasing complexity results in a loss of productive capacity and efficiency, defeating the very purpose of its higher complexity. There is , however, an important difference in the definition of entropy in physics and what is suggested here. In physics, entropy develops in closed systems. “Automation entropy” takes place in open systems where humans make technological choices, and which are thus contingent. An automation engineer of a systems integrator describes the concept of automation entropy in simple terms:

> „*You can overdo [automation] and when something goes wrong you have lower overall output because it does not work.*” (E8-56:12)

Equally succinct, the head of machine construction of a light-systems manufacturer:

> „*A central limit to automation lies in doing it too much. If you over-automate, production usually does not work anymore*.” (M4-59:12)

And finally, in the words of a professor of robotics:

> *“If you automate too much, then there will also be a lot of downtime and no production. A machine which is standing still is bleeding money.*” (R1-50:23)

Such automation entropy can have several causes and consequences. A first, as described by engineers, is the most general form of fragility through complexity. Highly automated systems are complex systems, and complex systems are fragile systems as more things can go wrong or break down, provided cost-intensive buffers and backups are foregone. A high degree of interdependency of all components therefore can represent a greater risk for the entire production system. A high degree of complexity also means a high degree of unpredictability, creating unplannable and unforeseen issues. In the words of a machine construction engineer of a global light-systems manufacturer:

> "*There are always disruptions. If I automate too much, I do not only have the influence of the product, but of the machinery as well. All this is not 100% fool proof*. *[Y]ou can automate anything. But if you do it, and the process does not run well, and the susceptibility to disruption is high, then I have no output and I have achieved nothing*." (M4-12:58;49:10)

Such uncertainty is in many ways antithetical to the drive of manufacturing to establish stability and security of processes. An engineer and VP of production systems for an electric components company elaborates this again in relation to the enormous fixed costs of complex machinery:

> „*At the end of the day, manufacturing is about costs. This means security of planning. You have to imagine, when production seizes for a day, this means costs without end. […]I think it's a Daimler factory where if it stands still for one minute, it costs 3 million euros. When there's no production, there is no output, workers have nothing to do, delivery times get longer and maybe you lose out on orders because you have to catch up. At the end of the day, the main topic is costs. If your machinery works, and it works as expected, then you have security*." (M3-19:06)

A second simultaneous cause and consequence of automation entropy lies in the increased difficulty of maintaining complex machine systems. Respondents stressed that "good" workers are crucial in the success of firms, as it is they who keep production running. At the same time, this notion runs against a common principle of the development of manufacturing work: the de-skilling of workers (Braverman, 1976). The point of higher automation, in particular in manufacturing, is often to reduce reliance on the decisions and skills of workers. Such de-skilling, however, likely also results in a reduced capacity of workers to address arising issues. In addition, paradoxically, the necessary control and maintenance of highly automated systems may also increase exponentially creating maintenance overload (a variation of Jevon’s paradox). Reduced adaptability and exponential volume increase make maintenance work constant and intense, as described by a production master for an automotive contract-manufacturer:

> *„I mean maintenance work is just constant. Every day. Everything looks fully automated, but you constantly need to work on these machines. Theoretically yes, when you program a robot once, it is programmed. But In practice it is not like that. There is always some error, or deviation where you have to make corrections. Or with the material. All parts that wear out need to be checked and change and even the best material has a black sheep. Something always breaks. Sometimes a programming mistake only shows up much later, in a seemingly unrelated context. I mean just think about it: six robots working together. Just one locking mechanism needs to be missing, one goes left, the other right and the parts start flying.“* (W5-38:34)

The third cause and consequence of automation entropy as described by automation engineers can be surmised as a consequence of the previous two as “hidden inefficiencies”. If automation is done poorly or without fully understanding or documenting underlying the steps, problems are integrated into automated production, making them harder to detect and fix down the line. In order to avoid this due to familiarity with the relevant systems, systems-integrators for example usually focus on one robot-manufacturer:

> “*You cannot have a dog in every village, because you have to master programming, the spare parts, the service*.” (E7-20:09)

Based on these two findings the question arises what role technological feasibility plays in the use of ne “new” manufacturing technologies and their role in automation decisions. The technology-specific prompts in the semi-structured interviews to capture the most recent technological developments were “robots”, “collaborative-, lightweight-, cooperative robots” and “AI applications”. Engineers by and large, did not find these technologies to shape automation rationalities significantly. Intersecting with the described secondary character of technological feasibility, this is due to: 1. their niche applicability, and 2. them representing incremental changes to existing technologies. Hence, in addition to technological feasibility being secondary, they also do not significant extend it in the first place.

AI applications, for one, understood as the quasi-automatic analysis of large data sets, had no application in the automation projects described by engineers. A production Vice-president of an electronic parts manufacturer, describes the use, or rather non-use, of AI in their factories:

> „*Then there is the topic on everyone's mind: AI. […] I mean of course they are interesting technologies, but we do not have any pure AI applications […] they are very marginal topics.[…] It's not easy to find a good use-case for AI application which actually pays. It's all very partial, in all manufacturing sectors.*" (M3-17:40;21:16)

AI thus so far has no bearing on the overall structure of existing production process. In the words of an automation engineer:

> "*AI […] is why it's an interesting technology, but nothing that affects the market and production in any way.*" (E8-32:56)

What use may be gained from the analysis of production data, has not only been grasped with "AI" but has been pursued at least since the 1990s, for example, with the use of Manufacturing Execution Systems (MES). However, also within such existing systems, engineers often remarked doubts about the point of the collection of data and its analysis in the first place. A systems integrator:

“*To be honest, I do not think it makes sense to have complete surveillance of all machine components [through AI]. If you consider how you can do predictive maintenance, then the approach of the last few years has been: I take 60 machine parameters and I try to model this. I have not seen any customers who were happy with something like this. You can never sensibly assess all components of a machine. Everything will be partial.*” (E7-26:47)

Unlike AI applications, Cobots have in fact been purchased by some firms in the sample and placed in production halls. However, they were only ever found in low numbers and mostly used for promotional purposes. As formulated by a works council of an engine manufacturer in respect to the “trial” Cobot at their site:

“*Let me show you our useless idiot.*” (W2-29:21)

The reason for this “uselessness” being that Cobots are not a replacement to functions of conventional industrial robots, and their specific function is seldomly useful, as described by a professor of robotics:

“*Human-machine collaboration only has an advantage if the task of the robot and worker are happening at the same time. If they are sequential, I do not need collaboration. It’s easier to take a cheap industrial robot, cage it and be done with it*. *[W]hen co-operative or collaborative robots are used, the production speed is so low, the process is inefficient. If I put a cage around it, the robot will be fast but not collaborative. Truly cooperative would be for the human to put in front of the robot, then the robot does something and moves it etc. This is rarely useful.*”(” (R1-05:36; 54:08)

Consequently, as with AI applications, the use case of Cobots is incredibly narrow:

“Cobots do not replace conventional robots, they are merely an addition.[…] It’s a tool that makes sense only in some cases.” (M3-1:12:19)

Overall, engineers remarked that what is considered “new” in ongoing economic debates, is not so by engineering standards. For example, a former engineer, now occupying a managerial function in a global electrical component manufacturer, describes:

> “*I mean the question is what is “new” automation technology? The technologies which are propagated as new and innovative have not appeared out of thin air, but are rather continual developments of technologies which have been in use since the 1980s. Industrial robotics for example. [T]he level of development is not dramatically different than in the 80s.”*(M3-13:53)

Correspondingly, engineers had a hard time pinpointing single technological development of significance over the past decade, which have changed how they approach automation rationalities. A professor of robotics and practising automation engineer:

> “*I cannot think of a specific turning point regarding technological developments and automation over the past years. It’s a continuous process.*” (R1-33:52)

The Austrian automotive industry in this sense is still very much in the business of heavy machinery, transportation mechanisms, machine tools and their combination with robots, as related by a worker-council representative of a rim producer on the order of importance of their production machinery:

> *„For us, the largest part of automation is machinery. Robots are important […] but the most important technological part of our production are the foundry and the C and C machines.”* (W3-55:39)

Hence, while Cobots and AI applications have received much attention as new revolutionary breaks in extending the technological feasibility of automation, in manufacturing, they are largely illustration pieces, signalling technological sophistication, rather than being useful machinery. This point also aligns with arguments that the uses of, for example, AI are largely to be looked for in the circulation of commodities, rather than their production (Steinhoff, 2021; Pfeiffer, 2021).

3. Product Imperative: The Role of Economic Necessity in Automation Decisions

Having thus established the secondary character of technological feasibility, the crucial question is where precisely the economic limits of "everything can be automated" lie. Extending the staring quote of the previous section correspondingly:

> "*[E]verything can be automated. It's just a question of costs. […] A fully automated factory is theoretically possible. In terms of amortisation or cost-benefits it's impossible.*" (R1-23:07; 2:32:56)

The economic rationality underlying RBTC can effectively be summarised as the principle of relative factor substitution, meaning the comparison and exchange of relative costs of machinery and worker. Cost has, of course, a crucial role in all of manufacturing, and thus necessarily automation decisions. The simple form of an "automation calculation" based on such costs is summarised by a systems integrator:

> „*In the end, let's put it like this, it is a simple arithmetic exercise: when does automation amortise? If I get the task of assembling something, say by gluing, and I have an order over the next 5 years, I need for these tasks 2 or 3 people. Then this is a simple calculation exercise, of which is more expensive, robots or workers*." (E7-14:48)

Sounding simple enough, the same systems integrator immediately points out that firms often do not even attempt this simple calculation in actual automation decisions:

> "*You wouldn't believe it, but in a great many of firms this calculation does not take place. I often come to firms where I am surprised some things are not automated yet and others where I wonder why they are.[…]".* (E7-14:48)

In addition to calculations not being undertaken, where they are, they are much more contingent than presented in the simple form above. Depending on the cause of automation, a simple automation calculation is changed:

> "*Automation has many background reasons. You have to consider there is of course a baseline which is called something like cost-effectiveness, but it is like saying that the baseline of a car is that it needs to be able to drive. Just because it can drive I will not buy it. It's the same with automation. It has to cover other factors as well, for example requirements of quality and reliability etc."* (E8-35:38)

There are also instances when the calculation itself is suppressed entirely, for example where human manual completion of tasks is not possible:

> „*Take the lead frame of a Mercedes G-Class. It has 150 meters of welding seam. In all of Austria and its neighbouring countries included, you would not be able to find enough welders to do this work manually*. […] Yes, *you can make automation decisions based on a very basic calculation. But it always depends. There are projects which are undertaken despite an unfavourable calculation. […]Then the calculation changes, when there are other pressures*." (R1-1:04:36)

Or according to a regional sales manager of a robotics firm emphasising the ambiguity of what constitutes economic feasibility:

> „*This an ambiguous thing. Under which criteria is the calculation of economic feasibility of automation conducted? Of course, you can say, you only do it if it pays. But if you cannot do it any other way? Then the calculation is different. […] Requests nowadays are different in this sense from what they were some years ago. Customers used to fight about price, now they come to us and say: I want a fully automated robot welding system. The price does not matter, what is important is that it requires no people.*" (E5-29:23)

Just as space was described as constraint of automation solutions, they can also drive them, changing the calculation again, as put by a regional robot sales manager:

> *„ So that's the one thing: shortage of labour, quality, productivity increases but also more efficient use of space. In some robot cells where 15 robots work on 100m^2 I would almost need 50 workers. So, you can produce much more on much less space and have higher output*." (E9-31:59)

These points do not mean relative costs of wages and machinery are irrelevant in automation decisions. However, they do show that there is much more involved than usually assumed, and correspondingly the relevant calculations are much more contingent. As put by systems integrator:

> "*At the end of the day, what counts is cost effectiveness. But that can mean many things, such as employing expensive labour because I have a labour shortage, for example. So, it is not simply a question of ROI, but you really have to consider this more broadly.*" (E8-32:56)

More important than such relativizations of relative factor cost substitution, however, and this has is in fact emerged as single most important economic criterion for automation decisions in the interviews, is the product which is produced:

> *"In theory, I can automate every labour-process, if I have a corresponding budget. This is why you have to look at automation not just in terms of production, but more importantly the product. To ask: can this product be reasonably automated? Or: can I design or re-design the product so its production can be sensibly automated*?" (E-17:29)

This means that automation decisions are determined by the characteristics of the product, and not vice versa. The most important determining dimensions given by engineers were: complexity and variety, the processes used in its production, and the overall quantity of the output or batch size. While the first two largely conform to

Krzywdzinskis (2022) socio-material conditions of automation, the third dimension is an addition. All three dimensions together are referred to from here on out as the "Product Imperative".

Since automation is by definition the standardisation of a process, naturally, complexity is counter to its ambition, see also the discussion on "automation entropy". In terms of economic conditions, the higher the complexity and variety of a product, the more expensive it becomes to automate. Complexity means how many separate parts the product consists of, how they are put together and in how many variants it is produced. If we imagine a pin, say of the type that Smith analysed, we can see it consists of one shape, made out of one material. Very likely, it was also produced in only one variant. This means a pin is a commodity whose production is exceedingly amenable to automation. A car, on the other hand, especially in its present-day form, consists of thousands of individual parts and components, can be ordered with a great number of variations (colours, materials and features etc.) requiring many different processes and much assembly. While the overall commodity "car" thus presents problems for automation, its individual components may be easier to automate, leaving, however, at the end the significant work of assembly. Several of the above points summarised by the production manager of an automotive contract manufacturer:

> "*A fully automated factory is theoretically possible. In terms of amortisation or cost-benefits it's impossible. Its unthinkable because of the complexity. It becomes more feasible if you produce a car which is only available in two variants. [B]ut even then, it's incredibly difficult. To develop a robot to place a carpet under the driver seat of one car […] you have costs going in the billions, I do not think anyone will want to afford this*." (M6-3:32:27)

In short, the more complex a product, the more uneconomical automation becomes. The greater the variety of manufactured products, and the types of processes used, the more costly and difficult automation becomes. Or a machine construction engineer for a light-systems firm:

> "*The more different variants [of a product], the less interesting automation becomes.*" (M4-21:14)

The second dimension of the product imperative concerns the types of processes required for a product. Different production processes allow for different degrees of automation. This becomes clearer when thinking about automotive production and its production departments, in particular, the difference between body construction and assembly. Shell-construction in the automotive industry, for example, is largely automated while assembly is not. Welding is very automatable due to its structured nature, connecting cables in assembly is exceedingly difficult automate due to its variability and requirements of tactility. Thus, the process determines automation, rather than vice versa. The technology strategy team lead of the one of the largest Austrian automotive suppliers describes:

> "*In body construction you have a different process than in assembly, where you have 4-5 robots in a cell which make welding points and that is easily scalable. [...] But in assembly there are a lot of very different tasks, a huge number of parts is used, there are different materials, there may be, I don't know, a cable harness through electronic control components, there is glass, gluing operations, screwing operations. […] To automate this is very difficult. Because automation always means to limit flexibility. If I automate, then it has to be flexible enough to produce many products. Then it gets expensive. This is why a workerless factory will not exist*." (M5-37:59)

The final dimension of the product-imperative, and perhaps most decisive in the grand scheme of things, is the overall output of the manufactured product, or "batch-size".

Simply speaking, the larger the size of the production, the more economically feasible automation becomes. Whereas a Lamborghini, for example, is produced in relatively low numbers, which explains the extensive use of manual work in its production, a hairdryer would be produced in the millions, hence its automated production is economically much more feasible. In the words of a machine construction lead at a supplier firm:

> "*[T]he discussion what is to be automated and how, are usually what do assembly-concepts look like. Which in turn depends practically exclusively on the complexity of the product and the quantities. Really, the batch size is the central determining factor how production is automated. The more you want to produce, the more it pays off to automate."* (M4-42:17)

This means that there are contradictory pressures. On the one hand, higher output of production will make automation more feasible, on the other it means more employment. A production manager:

> "*[The number of workers] largely depend on the output of production and thus fluctuates of course*." (M6-3:31:44)

This also means that if a product is "successful", and its output thus increased, it will also enter a different stage of automation, meaning a successful product is an automated product, rather than the other way around:

> "*[W]hat you often hear in firms is the word "high-runner". They have 50 different products and then they have one thing […] which if they produce more of, they can immediately sell. [T]o invest into something like that makes a lot of sense, of course. Even if another product might be easier to automate, that doesn't matter much*". (R1-1:19:49)

In turn, if sales are uncertain this is significant fetter on deciding to invest in the automation of a product:

> *"If I need 1000 pieces of some component, and next year it's unclear, then I will not build machinery to produce 1000 pieces if I do not know how things will go in the future. So, there are many points which enter into this decision*". (E9-41:20)

This importance of output in automation decisions also explains a counterintuitive observation during fieldwork, namely the organisation of the same production process in manual, semi-automated and fully automated form, simultaneously on adjacent production lines. The reason being that variations of products have different production quantities, warranting different degrees of automation. Depending on orders and projects, they are dynamically switched:

> "*What we have just seen, tightening screws manually, can also be automated. […] The reason why the process exists in both versions is again due to the number of pieces. The same tools are used, in the automated case they are just fixed. Depending on requirement and need, I can quickly automate this. […]* (M4-15:34; 03:03)

Finally, it is also crucial to consider that all automation decisions are investment decisions of firms. This means, that within the confines of the product imperative, they have the same requirements of all investment, most notably a return. In this sense the technological constraints discussed above, such as space, could be overcome with corresponding investment choices, which, however, carry their own uncertainties, locking a firm into a certain set of possibilities further down the line:

> „*How investment decisions are made is difficult to answer. The baseline is that every investment must present a business-case, so something which makes cutting costs possible through new technologies. But, you can also make strategic investments. Some investments, for example conveyor technology, is very expensive and these must be long-term decisions across several projects, which is a problem. […] If you try to finance everything with one project, you would not get that project. Some projects run 5 years, some less, so you cannot determine what will happen in the future, which is why investments are done only very cautiously and closely tied to the specific projects which one has*." (M6-31:53)

Hence, manufacturers mostly implement new technologies in the course of extensions of production through new projects or with new factories. Another reason large investment is not intuitively attractive to management is that it likely implies large fixed costs following implementation, hence the economic side of the coin of "automation entropy". Head of machine construction for a light-systems firm:

> "*If you do not have a lot of orders, and you have extremely high costs because of a heap of machinery standing around which cannot be turned off, you have a problem*." (M4-50:21)

High fixed costs given uncertain output quantities are therefore among the biggest dangers of highly-automated production processes, in particular in the automotive industry. This is also one of the points why the speed at which robots are operated is so important. Described by a professor of robotics:

> "*[Robots] only create value when they move. Meaning, during the time they are moving they should also get things done as quickly as possible. This is why [...] a huge criterion is acceleration. […] Everything comes with costs, costs of time or when you have an additional robot or can save one... you always have to view the whole system. A human is hardly predictable. This is what the automotive industry doesn't want. They want strictly deterministic cycle times, and to know them already beforehand. […] This is why automotive automation engineers are so concerned with cycle times, and that is why the robot needs to be fast*". (R1-26:09)

However, viewing automation decisions as investment decisions shows how polit-economic factors outside the product can affect automation outcomes. For example, in line with the literature on financialisaton, engineers have described how the increasing "idiotic" returns expected by management limit what is feasible to automate:

> *"Some firms currently say an automation investment must amortize within one year. Most others say one and a half years […]. 6-7 years ago, this amortisation period was*

> *between 2,5 or 3 years. […] after that I need to make profit. And this is a killer. This is also a reason why automation in Austria is not progressing at the, perhaps expected, pace because these insane managers have introduced completely idiotic amortisation requirements. You know what that means? The entire investment has to be made back within a year! I mean that is unimaginable! […] It is such a limitation, that the short-term profit motive so incredibly placed in the foreground.*" (R1 1:00:48; 1:03:55)

While sounding abstract enough, a works council for a large German OEM with a site in Austria, related a conflict with management over production numbers which relates directly to such narrowing of economic rationality:

> "*I mean, they say things like "we are not earning any money anymore with making cars", only financial activity, leasing etc. This is a conglomerate wide thing. This is in no newspaper of course, but what I get to hear every day in production, because they don't need a filter here".* (W2-19:07; 18:20)

4. Conclusion

The goal of this chapter was to better understand why firms automate some labour-processes but not others. Answering this question in terms of the boundary conditions of technological and economic rationalities of automation in the Austrian automotive industry, contributes to critiques of the presently dominant framework of RBTC. It has thus added to the recently formulated Socio-Economic Theory of Automation (Krzywdzinski, 2022), on the one hand, by explicating in greater depth the role of "technological feasibility" in automation decisions. It was argued that not only do automation engineers not base their decisions on such feasibility in the first instance, they actively avoid it feasible and higher degrees of automation due to the risk of "automation entropy". Consequently, new technologies, such as Cobots and AI applications, which are heavily speculated to increase technological feasibility of automation were found to have very little impact on automation decisions, and thus work and employment, in the Austrian automotive supplier industry.

On the other hand, the chapter added to the understanding of economic imperatives underlying automation decisions. While such imperatives are paramount, the principle of factor substitution based on relative costs is insufficient to account for “automation calculations” as they are undertaken in firms. Rather, the most crucial determining factor was found to lie in characteristics of the product to be manufactured, summarised as “product imperative”. If the commodity is complex, has many variants, requires complicated and interlocked processes and is only produced in low numbers, automation becomes practically impossible within present economic rationalities. In a final step the analysis has also illustrated, that while the confines of the product are crucial, economic rationalities of automation can also change based on polit-economic requirements, such as increasing financial requirements, which make more ambitious automation projects significantly less feasible. The resulting description of the rationality underlying the automation decisions of firms and their consequences for manufacturing work and employment can perhaps best be summarised as “entropic product dependent technological change”. While the inflationary use of different types of “technological change” is likely not very useful, the concepts described in this paper and contained within this summary title, hopefully are.

Regarding the question of persistent manufacturing employment in the Austrian automotive industry, these findings provide a partial but relevant answer. Seeing as the primary driver of automation decisions lies in the requirements of the product, this means that employment equally depends on in it. The more assembly and complex processes are undertaken, the more work may persist. However, this also requires a demand for the products of the Austrian automotive industry, hence premium suppliers' output. Overall output thus has a contradictory consequence for employment, firstly by allowing higher degrees of automation, reducing employment, while also increasing employment by extending output. In addition to the production of high-value added, complex products, another important conclusion regarding persistent manufacturing employment is that it does not actually depend any form of technological necessity or feasibility, but on given production logics and economic imperatives. Persistent manufacturing employment is thereby also maintained by narrowing financial metrics, limiting automation possibilities.

So far in the analyses, the "firm" was mostly treated as a monolith of singular interests. As this is not the case at all, and firms are "contested terrain", the following chapter extends the analysis to the "politics of production" between workers and management, and thereby the role of worker and union consent to technological changes in persistent manufacturing employment.

Chapter 7 - Automatic Consent: Worker and Union Positions on Automation in the Austrian Automotive Supplier Industry

0. Summary

While a number of recent studies has illustrated the potentially negative consequences of new automation steps for workers, suggesting good reason for opposing them, there is presently little evidence of such resistance. This chapter asks why that is the case, hence, why workers and unions consent to, or compromise on, the use of potentially detrimental new technologies, and what such compromise means for persistent manufacturing employment. The analysis shows that consent to a need for maximum "technological innovation" is indeed hegemonic in the Austrian automotive industry, and "automatically" agreed upon by all actors of production. The main driver behind this consent is a partly explicit and partly implicit compromise between workers and management on "developmental concerns", hence, increasing automation but retaining manufacturing locations in Austria and improving the ergonomics of industrial labour-processes. This low "need" for resistance among workers and trade unionists in Austria, conforms to the notion of a "productivity coalition", deemed also by workers to be in the long-term interest. However, this interest is not necessarily uniform. While it corresponds closely to the interests of senior, high-skilled workers, temporary, low-skilled migrant workers, may have different priorities. The increasing fragmentation of the composition of the Austrian industrial workforce along these lines, however, represents a significant constraint on the "possibility" of these workers in resisting technological changes in the first place.

The chapter concludes overall that, rather than as outcome of deliberations through industrial relation systems, consent to automation is the consequence of a "coerced"

compromise based the manufacturing and profit strategies of firms. It is a compromise, as workers do partially align their interests with those of firms, but it is coerced, as the agreement is not transparent, legally-binding or made on equal footing. Persistent employment in the Austrian automotive industry nonetheless rests on the commitment to some form of such a compromise and thus a productivity coalition, and thereby the consent to maximum technological adoption by workers and unions. However, as the technical planning of production is almost entirely at the discretion of management and globally active automotive firms, the actual fulfilment of the long-term developmental concerns of workers, which forms the basis of compromise, rests on very uncertain grounds.

1. Introduction: Automation Resistance and Employment Persistence in the Austrian Automotive Supplier Industry

A significant part of the literature on the effects of technological change on workers, in particular in the sociology of work and industrial relations, describes the primary function of technology to increase managerial control over the labour-process. Firms therefore decide to automate, not only to reduce immediate labour-costs, but also to reduce their overall reliance on workers' skills, deteriorating the latter's working conditions and possibility of resistance (Braverman, 1974, Noble, 2011). Contributions in the debate of recent automation technologies have substantiated such negative consequences for workers, ranging from displacement to increased surveillance, reduced wages, intensification and deskilling (Butollo, et al., 2018, Carbonell et al., 2022; 2020, Pfeiffer, 2017).[36] From this perspective, it would be close at hand to conclude that workers would resist or oppose new technologies, as was also the case in historical worker struggles. However, presently there appears to be strikingly little such opposition. In the European automotive industry, for one, worker and union demands primarily concern assurances against production relocation and wage demands, rather than the technological organisation of production and labour-processes. This chapter seeks to understand why that is the case, meaning why workers and their representations do not resist ongoing technological changes, despite their potentially negative consequences for workers.

To do so, the chapter applies the framework on class compromise between workers and management proposed by Edwards, Belanger and Wright (2006) and Belanger and Edwards (2007), as well as extends it based on more recent contributions (Dupuis and Masciotte, 2024; 2025; Krzywdzinski, 2022). Based on this framework, compromise is understood as different emphases on "developmental-" and "control" concerns of both capital and labour. These concerns are in turn structured by different conditions such as product markets, types of technologies and institutional regulation.

The resulting analysis firstly shows that an overall acceptance without opposition to automation can indeed be identified in the Austrian automotive industry. Secondly, the analysis shows that the main driver behind this consent is a compromise between workers and management on "developmental concerns" (Edwards, Belanger and Wright, 2006), mostly regarding the maintenance of manufacturing locations as well as ergonomic improvements to the labour-process. Thirdly, the analysis shows that while some workers

[36] Or in Galbraith's typical grandeur in reference to Marx's characteristic grandeur: „*The advance of the arts and the accumulation of capital do not benefit the average man. On the contrary, in some of Marx's characteristic prose, they "mutilate the labourer into a fragment of a man, degrade him to the level of appendage of a machine, destroy every remnant of charm in his work and turn it into hated toil… drag his wife and child beneath the juggernaut…[bring] misery, agony of toil, slavery, ignorance, mental degradation*."" (Galbraith, 1995: 56)

may not “need” to oppose automation, others may have reason but not the possibility to do so.

In addition to shedding light on the often-neglected perspective of workers in ongoing technological changes, the central contribution of this chapter is showing that the mediation of such changes through national industrial relation institutions is subordinated to the production strategies of firms. While workers and unions see these strategies as aligning with their own “developmental concerns” they have practically no role in shaping them. Nonetheless, it also becomes clear that the persistence of manufacturing employment in the Austrian automotive industry, does depend on a “productivity coalition” between workers and management, even if the terms of this coalition are one-sided and very different in practice than presented in public discourse.

This final substantive empirical chapter thus concludes the analysis of the “internal” dimension of automation decisions. It is perhaps the most contentious aspect of the analysis of the dissertation, as the “social outcomes” (Krzywdzinski, 2022) of automation, of how labour-processes and the lives of workers are changed and why, is where an analysis of automation truly comes to a head in its societal significance.

2. Automatic Consent to Automation

The Austrian automotive supplier industry is no stranger to worker resistance to technological change. A now famous strike at the “Semperit” tire factory in 1978 concerned technological changes in the occupation of “Wickler”, workers charged with the toilsome job of pulling truck tires over steel rims. New machinery to help in this task was introduced and consequently wages reduced, as management argued that since the labour-process had become physically less toilsome, lower pay would be warranted. The wage reduction proved divisive within the representations of workers, in particular between union leadership and works councils. The crucial point in the debate was whether control over production methods and technological decisions in the labour-process should be ceded to management, in return for wage concessions. While the strike was ended with the affirmation of such concessions, the French conglomerate which had then acquired the firm moved the production site outside of Austria shortly after, and the plant was closed. Overall, the case was a loss for the Austrian representations of manufacturing workers on both fronts: practical co-determination over production technology was conceded creating a precedence, and despite the concession, production was still moved out of the country.

Current views of workers and unions on automation in the Austrian automotive supplier industry reaffirm this position. All three major types of respondents in the sample, workers, managers and engineers, uniformly agree on the need to maximally automate in order to maintain "competitiveness" under threat of plant closure (see chapter 5), and consequently that technological changes are in the developmental interest of workers. A union secretary of the Austrian production union emphasised that the reason for this commitment lies in the concern of workers in the progressive development of the productive forces:

> *"The industrial union line is quite clear. If there are labour-processes which can be optimised, and this is automation, we are for optimisation. […] If they say we will save x tasks, lets save them. [T]his is also a concern of workers, they want progress if it can be achieved by automation."* (W-4:32:06)

Works councils on the other hand, while also finding automation in the interest of workers, stressed that consent was more a question of a futility of resistance. The head works council at a rim producer:

> *"I cannot not put it better than you cannot fight automation. It will happen. The only point is to try to solve it for people in the best possible way. It's a curse and a blessing, but more of a blessing. If you do not modernise… you will not survive. That's how it is."* (W-3: 1:02:12)

The lack of opposition is also mirrored in the perspective of engineers, which do not consider unions a significant "obstacle" to technological changes "anymore", as was the case historically. An automation engineer for a robotics firm with 30 years of experience in manufacturing automation:

> *"The topic of trade unions, well, that is greatly reduced. It's not a significant thing anymore. […] I can't say anything negative. Not like it used to be. Sometimes there's small comments in discussions, but they mostly relate to safety. But trade union opposition to automation, there effectively is none."* (E-9: 47:11)

While overall the consent to automation thus appears frictionless and hegemonic, there are significant differences between the views of the union, works councils and workers themselves. Worker-councils, for example, did not share the abstract interest of the union in the development of the productive forces, and stressed that while automation cannot be fought, they are fighting for concessions where possible. Their main focus thus lies on representing the interests of the remaining workers in the course of automation, rather than supporting the maximal development of the productive forces. Formulated by the head works council of sinter-parts plant:

> „*We cannot stop the process of automation. All we can do is look that the conditions in which it happens, and focus on the workers who remain. But our ambition is also to fight for every part and every machinery, to not have them moved elsewhere*." (W-1: 26:02)

A small-scale survey conducted among workers of an engine plant in Upper-Austria, on the other hand, showed that the views of workers themselves are more varied yet again. The questionnaire was sent out to 50 workers affiliated with the works council at the plant, 19 of which were returned with sufficient information to be analysed. The workers which had answered the survey were from all production departments, including machine operators as well as fork-lift drivers. The answers given on this questionnaire are instructive despite the relatively low number of returns, as they create a more nuanced picture of workers' views, in particular regarding the conflictual nature of automation.

The first question in the questionnaire asked to identify the recently implemented technology which had most affected the labour-process of the workers, over recent years. The technologies deemed most significant were robots (6/19) and camera-systems (5/19), with technological changes connected to electro-mobility (5/19) and digital assistance systems (3/19) not far behind. This reinforces the diverging relevance of different technologies for production departments (see chapter 6). Camera-systems are most pertinent in quality assurance, whereas and digital assistance systems are used in assembly, welding or logistics applications. To determine the effect, and thus worker position to a technology, it is therefore important to first locate it in its position in the production department.

The second question asked whether the implementation of these new technologies caused conflicts in production and if so, what kind. The majority of respondents did in fact find the implementation of technology to have been contentious (10/19). This is an interesting difference to the perspectives of non-opposition to technological changes both generally as well as by the union and works councils. The remaining returns saw the processes as ambivalent (5/19), and surprisingly, given the other answers, entirely unproblematic (4/19). Again, this may be explained by the different types of workers which replied to the questionnaire, and thus the different technologies they considered most impactful. When asked about the type of conflict new technologies caused, most workers described increasing intensification in their labour-processes as most pressing, but also increasing competition between different production sites within the firm. Overall, however, these pressures seemed to affect temporary workers more significantly. Examples from the survey responses:

> "*[Most conflicts happened] where technologies are used to pit production locations of the firm against each other in terms of labour-costs*." W-12
>
> "*In particular temporary workers are scared for their jobs*." W-19

The following question, asked whether workers believed that new technologies should nonetheless be used, despite such potentially negative consequences, to which half of respondents answered yes (9/19), while the other half expressed ambivalence and uncertainty (9/19). Not one respondent, however, was of the opinion that absolutely no new technology should be used in production[37]. Some examples:

> *"Yes, new technologies are essential for keeping the jobs here." W-12*
>
> *"I think technologies should be used to make work easier for workers, but not replace them." W-13*
>
> *"It depends how new technologies are used." W-19*
>
> *"Well, its not really a relevant question. I cannot prevent new technologies." W-23*

[37] The missing respondent did not fill out this part of the survey.

Despite conflicts over technological implementation, however, all respondents, with one exception, said that sabotage played no role at their plant, that it was not pursued regularly and is of no wider concern (17/19). The reason given was mostly that sabotage is not really possible with newer machinery. Examples from the survey:

> "Newer machines make sabotage impossible". W-9
>
> "Sabotage is not really possible." W-12

However, when asked about whether automation more generally would be good or bad for workers, the vast majority of answers were again ambivalent, stressing that it depends on how its implemented, and which type of worker is affected (15/19). Only 2 respondents considered automation as outright bad, and only one as outright good. Examples from the survey responses:

> *"As long as automation does not displace jobs, its good." W-10*
>
> *"Automation is good for health. For the number of jobs its bad." W-12*
>
> *"Automation is bad for workers, but good for engineers." W-18*
>
> *"Automation is good for making work easier, but bad for keeping jobs." W-22*

When asked whether they have any voice in which technologies are implemented in which way, the vast majority said that they had no leeway or influence at all (15/19), however, simultaneously a large majority considered it very important to them and their labour-process which technology was implemented in which way (13/19). As one respondent put it, echoing the described automation entropy of chapter 6:

"*Yes, I care about which technology is used, because poorly developed or implemented technologies simply mean more work for me*." W-22

Respondents were correspondingly frustrated by how management communicates changes in production technology to them, with a majority finding this communication either completely lacking or of very poor standard (15/19). Examples:

"*Usually, management only informs us of changes once the new machinery is already planned and about to be implemented*." W-12

"*Well, they always communicate changes very positively. However, not the negative consequences which we then get to experience*." W-13

Regarding the more general changes to their work and labour-processes the majority of workers lamented in their survey responses that their work has intensified. Even where physical toil was decreased in the course of automation, mental strain has increased proportionally. Summarised by some respondents:

"Less physical toil, but higher mental strain because of more control and requirements based on more intense supervision." W-11

"Higher work intensity, ever more rules and requirements." W-12

"More and different tasks." W-16

"The pressure in work has increased." W-20

"It has become more compressed and faster." W-23

This intensification of work is mirrored in the desire of the majority of workers, when asked what they would change about their work if they could, to have "more time", both in their labour-process as well their lives more generally (14/19). Close follow- up to this desire, was a desire for greater democracy, transparency and autonomy in production decisions and regarding their labour-processes (12/19). Some examples:

> *"More money, better shift-organisation, more democratic control over production."*
>
> *"More time, more democratic control over the labour-process, more transparency." W-9*
>
> *"Money is always important, but I am much more concerned about less working time." W-15*

Finally, when asked about the biggest problem at their plant, answers varied widely. They mostly centred, however, around the stress of work, the fear of losing their jobs as well as larger concerns over the economic situation of the automotive industry, which workers directly tied back to their job security:

> *"That management ignores the knowledge of workers on the production process". W-10*
>
> *"Competitive pressures." W-11*
>
> *"We are mostly worried about losing our jobs. A generally bad atmosphere is the biggest problem." W-13*
>
> *"The biggest problem is the overall development of the automotive industry." W-16*
>
> *"Stress." W-18*
>
> *"Losing our jobs." W-19*
>
> *"Pressure and stress at work, and fearing for our jobs." W-20*
>
> *"Understanding and solidarity among workers but also with management is consistently decreasing." W-23*
>
> *"The economic problems of the automotive industry." W-24*

Given the positions of worker representations, and the more ambiguous view of workers themselves, the question becomes how works councils deal with such discrepancies, as the mediation of such issues represents their daily work. The principle of "Mitbestimmung" or "Co-determination" in Austrian industrial relations, does denote a role of works councils in firm decisions on technological implementation. However, only in as a consultation and information right, without any practical sway over production methods and goals. This aligns with larger trends of receding corporatist dialogue between companies, unions and the sate described elsewhere (Pardi, 2021). Rather, transnational technology providers, consultancies and the new professional groups of engineers, data scientists, financial managers have taken much more important positions in the technical organisation of production.

The interviews reinforce that there is in fact no significant consultation of workers in technology decisions. Most often, the situation has been described as "management does what it wants" or at best, "they give us options on largely inconsequential things". Head works council at a sinter plant:

> „*Investment decisions in automation and technological choices are exclusively made by [management]. […] We are not consulted at all, but merely confronted with the results*." (W1-31:06)

There is, however, a role for works councils in smoothing the edges of technological changes, which otherwise might lead to issues, however, minor:

> "*I mean the processes of new technology adoption are often difficult and bumpy. I mean the idea usually is ok so we will just put this there and the machine will run. But that's not how it is. You need to support this, you really need to deal with this. Otherwise it can happen that something gets a little bit sabotaged. […] I mean the sabotage in this sense was placing a box in the way of an AVG so it constantly has to go around it and does not fulfil its quota. It's as simple as that*." (W2-22:52)

If not primarily on technological implementation, the question becomes where works councils reproach management on invariable conflicts in production. The interviews have shown that the role of works councils is presently mostly relegated to important but very practical topics such as: parking spots, social spaces, break rooms and basic needs such as noise, air quality, lighting etc. The head works council at an engine plant:

> *"Are there sufficient sanitary spaces? Is there food and drink or do you have to walk far in the break? Are there spaces, social spaces. This is where I am intervening."* (W2: 29:21)

Correspondingly, the head works council at a rim producer:

> "*We got a deep freezer vending machine with a microwave, where you have a lot of deep-frozen ready-made meals and next to it the microwave. People like it. Especially in shift work we wanted to see that they have a warm meal during the night-shift. That was incredibly well received*." (W3: 1:16:04)

While larger confrontations between workers and management are mostly relegated to the level of collective wage bargaining on the national level, as shown below, works councils nonetheless are in an adversarial position to management:

> "*Of course, there are always conflicts. […] If there weren't, I wouldn't be doing the job right*." (W3: 21:48)

Interestingly, the most relevant type of conflict which respondents described was not on technology at all, but on what may be referred to as "national outsourcing". At one plant, the works council approached management to decrease the share of temporary workers, as their factory agreement states a maximum share of 30%, which had been overstepped for years. In reply, management agreed to reduce the share of temporary workers, however, not by offering fixed contracts, but sub-contracting the entire logistics department to another firm, meaning that the workers concerned would fall under different and worse collective bargaining coverage. For fear of this strategy undermining working conditions substantially and creating a precedence, the works council, together with the union, opposed the national outsourcing successfully. The head works council at an engine plant describes:

> "*Management essentially argued that logistics is not a "core competence". [T]here is no value-added. No money to be made. [...] But the works council has successfully fought the subcontracting of storage management. It was about 9 jobs, but we saved 700. The plan was to first do logistics and then move onto other departments.*" (W2: 22:52)

While the opposition proved successful, the problem of high shares of temporary workers remained, effectively re-establishing the previous stalemate:

> "*So, the plans were shelved again. We managed to avoid it. But we still have a very large percentage of temporary workers*." W2-30:51

The head worker-council at a large Sinter part production has described a similar strategy of "intra country offshoring" by management, following some automation steps through camera-use:

> "*There is a German firm, a large service provider, which offers to do reclamations, warranties, quality assurance for firms. [T]here are pressures to do this some time, and 6 KM from here, this firm has rented a factory hall and they use their own workers to do quality control, but get paid a third less than our workers here, because they do not need to adhere to collective bargaining agreements.*" (W-1: 19:52).

Overall the perception of works councils was that the conditions of engagement at their plants had deteriorated over recent years. In the words of a works council "*what used to* *be fixed has become variable*" increasing the fragmentation between workers as well as worsening overall working conditions:

> "*The bad thing is, that many of the things that happened in the last years is that many formerly fixed things have become variable. So, you have the fixed position of a payed break and you get variable effort, such as profit-sharing if the year was good. [T]he difficult thing is temporary workers still do not get this, only the regular employees*." (W2:19:35)

As this section has shown, the consent to automation is largely hegemonic or "automatic" in the Austrian automotive supplier industry, despite unions, works councils and workers emphasising different aspect of technological implementation. While the reasons for this consent have already been scratched at, the following section develops them more specifically.

3. "Low Need" for Resistance

Moving more concretely into the drivers of this consent, this section describes the role of what Belanger, Edwards and Wright (2006) have termed the "developmental concerns" of workers, which includes the persistence of jobs at production locations, ergonomic improvements to the labour-process, as well as interest in the overall development of the productive forces. Where these concerns are tendentially fulfilled, a tendentially lower "need" for worker opposition and thus compromise on automation is likely.

Ergonomic improvements through automation mean the reduction of physical strain for workers, and thus improved physical health. Workers may compromise on the overall reduction of employment and even de-skilling, if automation eases such physical toil. Thus, in particular for workers who have moved into senior positions, the notion that automation has improved ergonomics over the span of their careers, is a strong reason for consent:

> *"[Automation] is not necessarily bad for workers. I do see that. Since I have been doing this job, there are no more people moving 150kg welding-tongs around, and people are doing better. People are not sick as much. Simply because the physical toll is less."* (W5-14:01)

Correspondingly, the jobs which are automated, were often argued to have been "bad jobs" to being with. According to a works council:

> *"[The jobs that are automated] are not great for workers anyway. For example, I don't know, exhaust-manifold assembly. There is a lot of weight on these operations. You can do things with cranes, sure, but that takes time. But still, we have said that where we have things which must be classified as "heavy" then let's automate it. […] I mean, maybe you find someone who would say I would really like to hold this protective metal sheet so the cables don't burn. But often these are really, from physics alone, such unlucky positions, where you say why should I put a worker on this job?"* (W2: 50:21)

While the ergonomic benefits are concrete in many instances, especially when compared over decades long changes in industrial production processes, some workers have a more contrarian view than to simply equate automation with improved ergonomics. One works council described health improvements at best as unintended side-effect of cost-cutting rationales of management:

> *„Labour cost reduction is the only goal [management] has. They sell it by saying: ergonomics, health reasons. And they are not wrong. These are very toilsome jobs. The kind of jobs where if you do them all day every day for thirty years, you will have health problems. But I know management well enough to tell you this is not their concern. They are not concerned that people have a good time and end their working life it with their health intact."* (W-1: 30:07)

Equally, improved ergonomics also often leads to an intensification of labour-processes, as also reflected in the survey results. After all, sick times of workers are a significant cost factor and source of uncertainty for manufacturers. Where automation can reduce these costs of heavy physical toil, this is clearly an example where concerns of workers and capital align:

> *"Of course, a robot produces around the clock in clocked cycle times, does not go on vacation or get sick. Its also an improvement in product quality. The secondary effect is to save costs and the third to improve health aspects of workers, if they have to move a ton per day. Workers like this have sick times, exorbitant*". (E7-14:48)

In turn, ironically, by de-skilling work through new technologies or automation, sick times may also increase in turn, as described by an automation engineer:

> *"[About digital assistance systems] we know that workers are completely underwhelmed, because these systems show them every step. Pick-up this, put a screw there. You do not have to think at all. Firms reported that their sick-leaves are increasing because of this. Because work is too automated."* (R1-1:03:24)

The second compromise, already described in the course of chapter 5 as "competitiveness imperative" and more specifically, its "imperative" condition, is the perceived choice between automation and some remaining jobs, and no automation, and firm bankruptcy and/or offshoring, and thus no jobs. As the Austrian automotive industry primarily functions as a supplier for the global premium segment, technologically more intensive forms of production are presented as the only way to defend its usefulness as a manufacturing location despite high wage costs. Workers thus do not oppose automation as the choice presented to them is between losing their jobs, or accepting potentially negative consequences of new technologies, but keeping them. The paradoxical proposition is thus again to save jobs, by maybe making them worse:

> "*Given the political situation, worker representation does not have a strong role in politics. […] This also means that the worker representation must always be constructive, otherwise nothing changes. Of course, the employer side is never worried of being taken advantage of because the bargaining position of workers is always weaker. A firm can always say, well if you are annoying we will move production to the east*." (R2-17:50)

Another element further reducing the "need" of workers in the Austrian automotive industry to oppose automation is their generally comparatively "strong" labour-market position. This position, at least of high skilled workers in supervisory positions, makes the threat of technology less pertinent than that of offshoring, meaning a logical priority of developmental concerns. The aggravation of ongoing manufacturing labour-shortages in Austria illustrates this point. In most contributions, increasing automation is argued to lead to an oversupply of human workers, rather than a shortage (even though Jevons Paradox would allow for this conclusion as the more efficient use of a resource may lead to an increased use of the same). The existence of shortages themselves are still quite striking, however, in particular because automation decisions have recently been framed as answers to such issues (Acemolgu and Restrepo 2021; Ableinaksy and Prettner, 2023). This line of inquiry is thus pertinent as a sub-theme in automation decisions, as publications amass which describe the choice of firms to automate as a way to deal with increasing orders next to labour-shortages, rather than the desire to cut wage costs (Tita, 2022, Prang, 2021). In addition, labour-shortages are at odds with recent theories of "labour-underdemand" (Benanav, 2020).

To little surprise then, the ongoing labour-shortage in Austrian manufacturing was brought up by almost every respondent in every single interview. The head of the platform for industry 4.0 in Austria relating a corresponding perception of change in trends:

> "*[I]n 2016, there was this great dread, especially from worker representatives: we run out of jobs. [Now] its exactly the opposite. We have too many jobs for too few people. […] We also see that these are often precarious jobs, deliverers, or whatever, they exist and are increasing. So, the point is not that we run out of jobs, but maybe out of good jobs.*" (R2-1:03:24)

Following RBTC, we would expect that both high and low skilled jobs are vacant where there is low routine-intensity. Interestingly, however, the overall tenor of interviews was at odds with these conclusions, as simply all types of skills and workers were said to be missing. As put by an engineer for a light-system supplier:

> „*We have an absolute labour-shortage in all departments."* (M4-36:16)

Works council at a rim producer:

> "[We are missing] *Everything. Every level of qualification. It is so, so hard to get people."* (W3- 1:04:05)

Or as put by technological strategy lead of a very large parts supplier:

> *"The problem today is not just that you cannot get skilled workers[38], you cannot get "unskilled" worker [39] either anymore. The times where you said: yes, we can get people here from Hungary, Bulgaria or the eastern countries, which are then doing unskilled work for minimal wages, they are over.* […] *We have been looking for a temporary worker to put things into a machine for three months and we couldn't get anyone. […] And these are unqualified, unskilled through a temporary*

[38] German original „Fachkräfte": Meaning workers with a qualification, in particular vocational training in trades.
[39] German original „Hilfskräfte": Usually temporary workers with no qualifications performing more manual tasks.

> *worker agency. If you are looking for a sheet-metal worker, it is simply impossible to get one.*" (M5- 56:11; 1:52:27)

In fact, in quite a few cases it was in particular those workers on the very middle of the skill-spectrum that were missing. Hence, precisely those jobs which have been assumed to have been affected the most by past automation:

> "*What we are looking for the most are constructors, so the typical graduate from a technical high-school, optimally with experience. We are always looking, that's a big topic, for software development. So, IT training, also without university degree. In our production we have vision systems in use, for example, which so to speak adjust and check the spotlights. And to develop these systems, to maintain them, industrialise them, that's a big topic. For this we need a lot of such workers.*" (M4-38:03)

Crucially, these answers must be put into the context of the production departments and types of firms of the respondents. For example, the needs of machine construction department of a large international automotive supplier of light-systems:

> "*We also need low-skilled workers, just not in machine construction, because there we need qualified technicians. For assembly and the construction, we need metalworkers or electricians, but that cannot be done by an unskilled worker. […] We have special machinery where everything is important and particular. But even these under quotation marks "unskilled workers" for production, we cannot find either right now*." (M4-38:55)

Overall, the shortage does have polarising effects on remaining workers, intensifying work for some, awarding privileges and opportunities to others. A works council describing the former:

> "*This has been an ongoing problem. It didn't start today. The work council has been saying the entire time: you have to do something, people are burnt-out. They are doing overtime because we don't have enough people, but we are still producing at capacity. That means profit is in the foreground. That's the other thing, you use people up. These are good people and you overwork them, so they say in that case, I will do something else. And then the morale dies. Especially, and*

> *this would not have existed back in the day, we have a few cases, which were fountains of good humour, now running around like zombies. It is very rough. It's just too much work*." (W3-1:10:09)

However, this situation creates favourable conditions for other workers. For example, an engineer relating an anecdote of a machine operator which was consequently underperforming but could not be fired because no replacement was feasible:

> "*So, the production manager said, that's a joke, we have to do something, we have to fire that guy. The production manager replied: easy, I have seen this in other departments. Of course, we can fire him, no problem. But do we have a replacement? They didn't have anyone. They cannot find anyone to do the job. So, they have to accept this person's whims."* (E5-31:24)

In fact, the interviews have shown a wide variety of positive effects on the labour-market position of, especially skilled, workers based on the shortage. According to a production master at a supplier:

> "*Right now, the labour market is such that when some firm kicks you out, and you are somewhat capable, you immediate find work again. You just have to walk up and say: hello. And the person will say: Monday.*"(W5-2:04:14)

Expressing his low fear of unemployment, even if the factory closes, which would be a "catastrophe" for the region, if not for him:

> "*For us it would be a catastrophe, if the company moved somewhere else. For the city and the region, and more. Do you know how many suppliers depend on this factory? For me, however, it would be fine, I have 3-4 firms I could start working at immediately. […] I could immediately find work.*" (W5- 1:39:31)

Or according to a robot salesman and engineer:

"*People who can program a robot are pearls of the industry. […]And people who can program a robot and can weld, I would say, they are priceless*. *There are only a few who can do this.*" (E5-38:53)

As has been argued, the assumption is close at hand that such a shortage would simply be addressed by increasing automation. And indeed, automation technology suppliers viewed it as driver to their business:

"*Robotics and automation have always been growing, but especially robotics over the past years has increased very strongly. We are talking about market growth of 15-20% per year. Part of this is, of course, the labour-shortage. You just can't get the people, especially the skilled workers anymore.* (E6-09:26)

According to an electronic component manufacturer:

"*We have tried to automate as much as possible in part because we could not find workers*". (M3- 1:07:48)

This is especially a concern for those smaller manufacturing firms in Austria which are regionally dispersed:

"*This is just to say, there are regions, where there is no other way. In eastern Tyrol, for example, this is the case, as far as I know. Also, here [part of Carinthia]. These are simply secluded regions. You can't just get 50 people all of a sudden. In [city name] a heat-pump firm just opened, they need 400 people all of a sudden. The owner is paying them everything [they want]. He is paying for their apartment... it doesn't matter. Built a giant parking garage. That firm has money without end but that location is simply difficult. And at some point, it doesn't matter where you are, you will run out of people.*" (R1- 40:04)

However, as Noble (1984:41) has also shown for the case of the US in the post WW2 period, increasing automation can in fact significantly exacerbate labour- and skill shortages. Which is one of the reasons that rather than outright replacement, the goal is often to automate in such a way as to make the remaining jobs more amenable to higher turnover and a larger pool of people through deskilling:

> *"That means the goal of machinery is that you make it simple, that people are more easily replaceable. I mean still you won't be able to do the job right away, but you can, for example, you can be utilized there or there. If someone is missing, you are flexible"*. (W3-59:19)

Where new automation steps are implemented, respondent engineers thus made clear that their goal conforms to the classical assumptions of labour process theory: de-skilling, increasing intensity, and independence of the skill of some workers. As described by a Professor of robotics:

> *„At the belt […] you don't need to be able to do that much. And that's why these jobs are kept so simple, so you can take on almost anyone*. […] *But, I think I can say that, that the natural fluctuation means that constantly new workers have to be attracted. In a large firm this is simply a continuous system, which looks static, but there are large entries and exits.*" (R1-41:57; 38:52)

This also means that the workers are mostly an appendage, which follow the rhythm and requirements of the machine system. In line with classical technological control, this may make opposition more a concern of workers, but it is unlikely that they will have the capacity to do so:

> "*A machine can always produce. The robots determine their speed and the workers have to organise so they can keep up.*" (W5-57:00; 57:58)

Hence, firms could produce more, would like to, but lack workers, and cannot address this lack through automation. Why do labour-market mechanisms not supply the sufficient number of workers in quality and skill to further expand production? One reason is that the people for the automation itself are lacking, hence a shortage of workers to automate the shortage of (other) workers. In particular, in the case of those performing the work of programming and installing robots:

“*Its self-limitation. There is a shortage there [with automators] as well. You have to imagine it like this: in the 90s and 2000s where I have gained some experience with robotics, there were sites where hardware made up 80-90% of costs and then 20 people were working on this machine system for months, programming it, setting it up, putting it into operation because the labour-costs where of no concern. Today this is entirely flipped around. Hardware costs of a robot-system are maybe 40-60% of the costs, if even, closer to 40, and the rest is services and software. And this is where costs also get out of control. No firm can afford to have 10 developers at their construction site for half a year. That means ruin for the project, let’s put it like this*”. (E6-34:32)

According to a robot salesman:

„*We have the problem that we cannot sell more automation solutions and robots or install them, because we are lacking the people to put this in operation. To execute this for us*.” (E5 39:35)

While Covid has not created a particular labour-shortage in the case of the Austrian automotive industry, it has aggerated the existing one, also revealing self-sabotaging strategies taken by management of on the one hand de-skilling and displacing workers, but in turn not having the skilled workers down the line they require:

“*During COVID development and training of apprentices has hardly happened, because the firms said: we don’t know how things will continue. They even fired people, many, and now they are lacking the skilled workers. Like saying: woops, we haven’t trained any apprentices for two years, but now we could use someone.”* (W1-50:23)

In this sense capital has sabotaged itself, or rather produced its own inefficiency, limiting themselves through the desire to use de-skilled workers in highly-automated production processes:

“*The most relevant limitation for higher automation and higher investment is very clear the education/training of workers and the know-how in the firm. Many firms underestimate this. I mean, robot-use is nowadays very easily possible, there are certain machine systems where there is a red button and a green button and it will work. If it’s about simply moving parts from one conveyor belt to another. Every firm will be able to deal with this. What many underestimates is that in the rarest instances a robot-system can do without a system of camera or sensors or quality*

> *control without any process-control and this is what makes the machine system really complex. It is not the robot which is the key element which leads to this complexity but the entire machine system. A robot-system has many requirements of interventions which can only be done by well-trained skilled workers and this is where many firms underestimate that this means there must be a commitment inside the firm to get robots running.*" (E6-33:06)

While unions are permanently concerned about plans of management to move production into the Central-Eastern-European periphery, in practice this does not appear as likely as political rhetoric suggests (see chapter 5). Among other reasons, simply because Austrian manufacturing itself has relied on a migratory labour-use regime for decades, building on workers from southern and eastern-European countries, often commuting to Austrian production locations[40]. Ironically, therefore, the workers hit the hardest by a labour-shedding offshoring might be migrant workers to whose origin countries production would supposedly be moved to. This migratory labour regime is, however, increasingly coming under pressure, also in the case of Covid, but mostly in terms of labour-shortages in the entire region of Central-Eastern Europe:

> *"Robot-numbers have exploded in these [peripheral manufacturing] countries as well. Just look at the Czech Republic, they have full employment, you cannot get manufacturing workers. And in Czech factories and industries they are really pushing for full automation, because the labour-shortage is so bad there."* (E9-29:23)´

4. "Low Possibility" of Resistance

While compromises between workers and management in the course of a "productivity coalition" explains a large part of consent to automation, it also aligns particularly well

[40] Every day, for example, hundreds of Slovenians commute to Austria for work in the MAGNA plant in Graz. The same holds for the Czech Republic, Poland, Hungary, Slovakia and even Ukraine.

with the interests of skilled, senior workers. Developmental concerns over jobs security certainly also apply to migrant, temporary workers, even if their position is more precarious in almost every other way. The fragmentations in the composition of workforce, between temporary and regular, migrant and national, as well as skilled and unskilled workers, consequently and logically also reduces very possibility of opposing technological changes in the first place, as worker concerns are likely equally fragmented, undermining between-worker solidarity. The possibility of such a variation of worker interests also represents a notable omission in the framework of Belanger, Edwards and Wright (2006), lending an additional reason to discussing it in this section.

Following the seminal contribution by Marglin (1974), the central drive of capitalist management can also be understood as the fragmentation of production- and labour-processes, in order to establish control through hierarchy. In this sense, it was not the factory which necessitated the capitalist, but the capitalist who necessitated the factory. However, as Burawoy (1985) has made clear, any production must always include some form of consent from workers, as labour-power must be translated into concrete labour-effort (Ferschli, 2017). As Vidal (2022) notes, this includes a contradictory pressure to also ensure the engagement of workers. In the face of these pressures, managerial practices have settled for “good enough” results, meaning managers are not concerned about maximally efficient production, but seek a reasonable balance between control and profit. However, it is still clear that fragmentation among the workforces makes a unified opposition to detrimental or inefficient conditions or technological changes, much more difficult. The simple thesis is thus that a secluded, perhaps de-skilled, labour-process is more difficult to oppose, than if production was not divided along lines of demarcation of skill, nationality, gender etc. In the framework of Belanger, Edwards and Wright, it is assumed that workers will resist, uniformly, if their concerns are not met. Such self-determination might apply to a skilled worker of senior-rank with full-citizenship in the Austrian automotive industry, but perhaps not to female, migrant, temporary workers. There might thus also be significant differences and fragmentation of concerns between types of workers within a firm. That a skilled worker in the Austrian automotive industry may be more interested in the development of the productive forces than a migrant worker in southern Italy is also trivial. As is, that unions likely represent the concerns of the former, potentially at the expense of those of the latter. The ongoing fragmentation of the Austrian manufacturing workforce can be captured along three dimensions: between fixed term versus temporary workers, between male "national" and female migrant workers, and between skilled and "un-skilled" workers.

In the course of the previous analyses, the topic of temporary workers has already emerged at several points. It is, in fact, perhaps the most important, and increasingly so, distinction among workers in Austrian manufacturing. The usual reason given for the increase of temporary employment, especially since the financial crisis, is that it provides flexibility in adapting labour-use to the output fluctuations, especially endemic to the automotive industry. In the words of production project lead manager at a large supplier:

> *„[The number of workers] largely depend on the output of production and thus fluctuates of course. We balance this a lot with temporary agency workers*. […] *So, it's actually the other way around. It's not workers that determine the speed of production. The customer determines what they want any given day. And then you look that you somehow maintain numbers because you can't just fire people every two weeks and then hire them again. Well, this is exactly what temporary work is, actually*." (M6-3:31:44; 2:58:22)

While framed as an exceptional measure, temporary workers have become an increasingly significant buffer for production fluctuations:

> „*We used to have a very high percentage of temporary workers, we still do. Now that production on this line and product is closing and the output of production is going down, temporary workers are also reduced. On the other assembly line its different, they are training 2-3 people at any one time. They are having a lot of stress and the temporary worker percentage is correspondingly high*." (W5-10:05)

However, temporary workers are not even necessarily "lower-skilled", their institutional protection is significantly worse compared to regular contract workers:

> *„I mean they call this strategy a „flexible employment ceiling". You can't do anything about it, it has been put into law in Austria. At our site, such temporary workers are mostly used as machine operators. I mean they are not „unskilled", some of them have a metal-trade education. It's just that firms have increasingly been trying to only hire through temporary work agencies. Often you cannot even get into places outside of these agencies. Such temporary workers have fewer rights and earn less. […] For example, on the weekends, because Saturday is included, we have extremely high shift allowances. Temporary work agencies used to not pay these allowances. In 2014 we managed to change this, by suing a temporary worker agency."* (W1:05:45)

Amendments to the labour law have made temporary workers possible by allowing manufacturers to cover cyclical peak phases by "renting" workers from temporary work agencies. Since then, persistently high shares of temporary workers in production has become a frequent issue of confrontation between works councils and management. The reason being, that temporary workers have lower pay, worse working conditions and fewer rights compared to standard employees, awarding management much flexibility in disposing of them. For unions, they weaken their overall strength in negotiations as temporary workers are not covered by the collective bargaining agreements of the metal-working sector. While often thought of as simply cheaper workers, that is also not necessarily the case, even if they do earn less, and the main advantage of such atypical employment lies in the significant flexibility of hiring and firing. A head works council describes attempting to use this fact as leverage to get workers to be taken over into fixed contracts:

> "*[T]he thing is, temporary workers are not necessarily cheaper. Someone with a regular contract has factor costs of 1:1,6 with non-wage labour costs, insurance etc. But a temporary worker has a factor of 2. Temporary workers are at the base line more expensive than regular workers. So, by introducing equal pay, the idea was to make temporary workers more and more expensive, so it's not the works council which begs management for workers to be taken on in regular contracts, but accounting*.[…] *You know what management is most stressed about? The costs of potential restructuring. Even if there is no immediate threat. Put differently: the risk , the risk of costs, which you have with regular contract workers, to have to give them a golden handshake severance package. During the financial crisis 2008/2009, I experienced this first hand, they suffered this. That calculated their cost then at half a billion euros in the firm. If you compare this, to flexible temporary employment where you do not make any concessions or commitments, and I can fire workers at any time. Than its economically worth it to do that*." (W2:34:33; 37:42)

Ultimately, the strategy of increasing temporary worker gives management room to manoeuvre without having to significantly adapt or invest in the production process. The strategy of temporary workers is also symbiotic to structuring labour-processes for maximal replaceability in factory regimes, by reducing the time and complexity of new tasks, hence a greater independence of management from labour:

> "*A stupid robot is very cheap compared to human. But also, if that dog doesn't have maintenance, it stands still. Workers are more flexible in time and application."* (W2-50:49)

Another fragmentation, which likely reduces the propensity of workers to resist automation, is the increasing share of both migratory and female workers in the manufacturing of the Global-North (Sproll, 2020; Raj-Reichert, 2015). In both cases, management likely expects to pay lower wages, but also to decrease the possibility of opposition due to their greater precarity, residency status and lower standing in the representations of interest:

> „*The reason we only have women in QA is essentially because the wage is lower up there than down there. And more often it is men who say that they do not want to do this monotonous stupid work.[…]*" (W1-08:09)

The strategy of replaceability also comes into play in automating certain parts of labour-processes:

> "*Our goal is to get more women as workers. The more automated, the easier the work is. Other plants have a high percentage of female labour because all I have to do is push a button. I do not need to perform physically difficult tasks. This is different with us. I have been here 20 years, and there used to be so many people, although we had fewer employees than today. But you had to work very hard. Nothing was chained, almost no robots*." (W3-08:07)

In effect, this group of workers is the opposite to the skilled, older male workers often in supervisory roles. On a side not, sexism and racism are very prevalent and normalised occurrences in Austrian manufacturing. For example, when an automation engineer related the story of a malfunctioning machine and its repair:

> "*So, you have to imagine it's a welding tong and you have to exchange small plastic parts at the top from time to time, you need a number 13 ring wrench. You turn it to get it out and again to get it in. It's a task that takes a few seconds and a small schoolboy can do it. The woman who was operating the machine could not speak German and did not manage to change this part. Maybe she's good at sewing on a button, I don't know, but not changing a number 10 screw nut. So, I told the customer: dear customer, this project is saving your companies life. We are giving you a wonderful, fully automated machine and you put an unskilled worker there, which cannot even read or write!*" (E5-20:59)

However, the degree to which female migrant work is used fluctuates heavily between factories:

> “*Our workforce is 90% male, historically because there are many metalworkers. We managed to pay the entire department out there as skilled work. I did not manage to do this with the women*.” (W1-21:27)

With female migrant workers making up a significant part of temporary work as well:

> “*Most of fixed contract workers are male, I would say 90%. But with temporary workers I think women make 30%.* “ (W2-38:41)

Finally, a third main fragmentation among the Austrian manufacturing workforce, which has already been pointed out several times, is between skilled workers of seniority, the worker aristocracy if you will, and everyone else. These workers are doing well, have job security and are for the most part do not oppose automation as it most likely will not threaten their jobs in the first place. Hence the limited possibility of resistance of migrant female workers is mirrored in the reduced need of highly-skilled national Austrian workers in supervisory roles, which make up a relatively small part of employment:

> “*Here in assembly we have no skilled workers. The team leaders yes. Also, in final inspection we have mechanics, skilled workers who do repairs. But the ones putting in components at the stations are low-skilled.* “. (M6-2:55:35)

This final fragmentation can also be reformulated as another trade-off between the benefits of some workers due to automation, at the cost of fragmentation between workers within the plant and between regions. Austrians which hold higher and supervisory positions, and which thus have strong labour-market positions, also have less need to oppose technological change which concerns them less. However, also these skilled workers are not entirely unphased, for example where management pits them and their wage costs against other firm internal production locations. As described by such a skilled worker:

„*We are in competition with no one, just the other production locations. How production is allocated to the largest production locations*. " (W2-43:22)

5. Conclusion

Standard economic theory of the competitive model suggests that technology is factor neutral, meaning that there are no power-asymmetries between the factors of production. As put by Samuelson: "*In a perfectly competitive market, it really doesn't matter who hires whom, so have labour hire capital*" (1957). A large literature in industrial sociology and industrial relations, however, has traditionally focused precisely on such asymmetries and the function of technological change, and in particular automation, to increase control over the labour- and production process. Despite, such potentially negative consequences, workers and worker representatives presently do not oppose automation in the Austrian automotive industry. This acceptance originates in the first instance in a compromise on "developmental concerns" such as the maintenance of production locations and thus jobs in Austria, as well as ergonomic easing of toil. Automation and new technologies are therefore not opposed or sabotaged systematically as their implementation is considered in the interest of workers in Austrian manufacturing. This high acceptance of automation among workers and trade unionists in Austria, and correspondingly low importance of "control concerns", conforms to the notion of a "productivity coalition". Rather than shop-floor battles over "control", collective bargaining over wages is the primary arena of confrontation. While deskilling was shown to be an element of technological changes in Austria, their function to discipline and outright increase control appears to be much less of a factor in automation decisions than was the case historically or is the case in other country-sectors. This does not mean that management has no interest such disciplining and control. The very reason for the very existence of factories, also in highly-automated one of the Austrian automotive supplier industries, remains the standardised and maximally controlled organisation of labour- and production processes, which also Austrian workers of all skill grades are subjected to. However, such control may presently operate at sufficient levels for the given manufacturing strategies, or there is no immediate possibility to increase it through technology. What is clear, is that a sense of technological hegemony, or "need for maximum technological innovation" is characteristic of the Austrian automotive industry and essentially "automatic". Persistent employment is thereby explained in part by a continued commitment of workers and unions to a "productivity coalition", opening the possibility of high-skill automation strategies. However, as the technical planning of production is almost entirely at the discretion of management, the actual fulfilment of the long-term developmental concerns of workers ultimately rests on shaky grounds, explaining significant anxiety about the future of industrial work in Austria.

Chapter 8 – The Partial Automation of the World

The arguments presented in this dissertation can be summarised in terms of two general conclusions. The first, derived from the different explanations given for persistent manufacturing employment, and summarised as a "partiality of automation", suggests a different narrative of automation and work than those dominant in current debates. The second, represents a wider and tentative interpretation of the causes and consequences of this "partiality", situating it in the context of a recent literature on stagnation in the manufacturing sectors of the Global-North. A final section discusses the contributions of the dissertation, limitations to both analysis and interpretation, and suggests extensions to overcome them.

1. Causes of Persistent Manufacturing Employment

The process of automation, of exchanging man with machine in production, is fraught with contradictions, both historical and present. Among the most striking, is that after centuries of the development of the productive forces, work continues. Even in the most likely case, the technologically intensive manufacturing sectors of the Global-North, automation has not ousted human manual labour from production. Rather, the countries and sectors with the highest degrees of automation today, are often also those with the relatively highest shares of manufacturing employment. The work done there is not just a highly-skilled remnant of supervising and maintaining autonomous machine systems and robots or solving engineering problems. For the majority of workers, it still means handling, sorting, quality checking, assembling and everything in-between. Therefore, whereas modern factories may appear devoid of humans when passing through them in guided tours, work surely persists in the hidden abodes. It is peculiar therefore, how debates on automation often simply ignore the undaunted continuing mundanity of work in all its forms around the world. The two most dominant narratives on automation and work are not very helpful in understanding this persistence of manufacturing employment either.

The first, most prominent in public discourse, considers persistent work largely irrelevant, as it is at best temporary. While there may still be many jobs, even in manufacturing, technological advancement will very soon displace them. The vision is a more or less linear trajectory from fire, to the horse, to the combustion-engine, to AI, ending in a society which does not toil, least of which in the manufacture of commodities. Interestingly, most often in this type of narrative, an end of work is considered almost always within the boundaries of capitalist societies. Adapting Fischer's (2013) famous quip, this means that it is far easier to envision an end of all toil than an end of capitalism, or: "capitalism without workers". The recent "AI hype" illustrates the basics of such a narrative well. Once again, technological changes, however marginal and niche, are extrapolated to overcome the need for work sooner or later. The only ironic twist being this time around, that rather than manufacturing work, AI is much more applicable in the previously thought un-automatable "knowledge work" of programming, writing, editing etc. While in the case of recent AI applications, the debate seems to be winding down amidst unfulfilled promises and disillusionment with the potential of the technology, and a likely approaching burst of the bubble, it is just one of many iterative cycles. More importantly, such a narrative is simply contradicted by the persistence of work and the unbroken and mundane continuation of waged and non-waged labour in every corner of the world.

A second narrative, more prominent in academic discourse, in particular economics, is well aware of this continuation, concluding that automation does not lead to any aggregate displacement of work to begin with. New jobs are, and have always been, created in other sectors. Fears of job-loss and negative effects of technology on workers, are a “luddite fallacy”, a misinterpretation of obvious economic necessities in the course of the technological betterment of societies. Correspondingly, the persistence of manufacturing employment simply means that some jobs cannot yet be automated, and when they can, others will take their place. While there is debate within this narrative on whether such new jobs are less toilsome and necessarily improved in terms “skills” and wages, or whether they are polarised between low- and high-skilled non-routine-work, in both cases, any job persists again only as temporary technological boundary. Both narratives are thereby closer than expected, only diverging in the speed of technological displacement, and the possibility of labour-market adjustments.

The results of this dissertation suggest a different narrative, one which does agree with the conclusions of narrative two, but finds the persistence of work to be a structural feature of a mode of production, rather than temporary technological boundary. Correspondingly, there is no necessary mechanism to stabilise employment, or comprehensively displace it. Both displacement and stabilisation can occur, neither must. There is also no necessary and progressive easing of the toil of working lives through technology. Importantly, work persists, not as temporary technologically boundary, in the first instance, but foremost because it is economically necessary. The results of the substantive chapters have shown this by illustrating how the automation of production is necessarily partial.

The role of a ”partiality of automation” in explaining persistent employment was first shown quantitatively regarding the drivers of employment in the OECD automotive industry. Whereas the increase of productivity is usually assumed as driver and consequence of automation, chapter four has shown that output dynamics have been the most important of industrial employment changes in the OECD automotive industry following the financial crisis. This means that in explaining the persistence of employment, automation itself has a partial and secondary function. While increasing output is in fact frequently given as explanation for persistent employment despite automation, also in mainstream economics contributions, it is usually neglected that, given finite global demand for industrial commodities, the struggle over this output means a struggle over the wealth of developed economies, in which someone must lose, rather than the often-suggested narrative of global economic convergence (Marini, 2022).
The point being that the fixation on output is a matter of economic distribution, rather than technical necessity. The importance of output quantities thereby not only creates obvious policy problems given immediate climate breakdown, but also regarding the prominent view that the service sector would be a logical development of work in capitalist societies. While the service sector certainly has absorbed much work over the past decades, this work is notorious for super-exploitation and “bullshit jobs” (Graeber, 2018). Overall theories of the “knowledge worker” and “immaterial production” thereby appear strangely anachronistic. On the other hand, manufacturing has structural characteristics which render it crucial to the wealth of (most) developed economies: 1.

its products, and 2. its jobs. Manufactured commodities, are the only commodities which allow for significant jumps in value-added in different productions stages, meaning it is possible to import parts cheaply, assembled them and export them again dearly. While much agriculture produce continues to be exported and traded, it cannot achieve anywhere near the trade surplus of exporting advanced machinery, e.g. which is why Germany and Austria do not specialize (at least not exclusively) in the export of potatoes, but of industrial machinery. This also means, in economistic terms, that manufactured goods having a higher international elasticity of demand, as domestic demand is seldomly sufficient for firms to grow. As argued by Kaldor, neither economies of scale (Kaldor-Verdoorn law[41] :Kaldor, 1966) nor export driven multipliers can be created with any other product or sector. It is for this reason “industrialisation” continues to be the primary development strategy of economies (Chang, 2003). Manufacturing is a singular, perhaps the only significant, engine of growth (Benanav, 2020; Brenner, 2006). As pointed out by Škuflić and Družić (2016), before the financial crisis in 2008/9, the prevailing notion was that de-industrialization amounts to successful economic development. It was only in the wake of the crisis that industrial policy was proclaimed as crucial path to re-establishing industrial production as a base of societal wealth (Rodrik, 2009). The second specific characteristic of manufacturing is its jobs. Manufacturing jobs are often of higher skill content and have higher wages than average service jobs (Felipe et al., 2019). Hence, the higher the share of manufacturing employment, the higher societal job quality in many cases. Furthermore, many jobs counted among service employment structurally depend on manufacturing (Scott, 2015). Both points make clear why the retaining of manufacturing employment is such an important industrial policy goal. Even more

[41] Meaning the increase of productivity by virtue of increasing output

fundamentally, however, entirely digitally produced services have a material base which must be manufactured (Huws, 2015). In turn there are reasons which make it unlikely that the service sector will increase conservative metrics of the wealth of societies. It is likely true, based on the heterogeneity of services (garbage disposal and brain surgery) no outright statement on the nature of productivity increases for the entire service sector can be made. However, within this heterogeneity, it is also clear that many activities which fall in the purview of the service sector, are in fact inherently averse to productivity increases as described by Baumol (1967). This concerns any and all activities of care-work, but also education and administrative processes, as their definition of “output” is fundamentally different to that of manufacturing. Rather, recent contributions on the intensification of work have shown that output in these professions has been increased at the cost of significant quality of work and life of those performing those tasks (Krzywdzinski et al., 2024). The fact that the service sector in many ways is still very much constricted in its output increases, needs little further argumentation than pointing to those professions, such as kindergarten supervisors, whose “output” cannot be increased by other means than increasing the numbers of workers on a job. The point here, however, is that rather than maintaining that services are not stagnating in productivity, or that they are unimportant for national affluence, the goal should be to critically assess whether productivity and output are useful categories to apply to them in the first place.

In chapter five, a second element of the “partiality of automation” has been derived from the analysis of the decisions of global conglomerates on technology-use and production locations. Automation was thereby shown to only be a partial explanation for the production location decisions, as well as the “success” of firms in the Austrian automotive industry. While persistent employment logically depends on such success, the notion that it depends on maximally feasible automation levels and maximally reduced wages and thus "competitiveness", was relativized in three ways. For one, the automation approaches of firms in the Austrian automotive industry did not differ significantly by production location, despite some affordances for a "lead firm" function. Automation also depends more significantly on firm size, and more precisely the funds and output quantities available to large firms, than the wage-costs of regions. In addition, particular supplier firms are often in command control relationships with OEMs meaning automation and employment decisions are quite often not even made by themselves. The behaviour of large firms thus diverges from common assumptions, showing that rather than a focus on technological advantages, prohibitive legal strategies are central goals (Rikap, 2021), resulting in partial automation. Where automation is drawn upon in the propagation of discourses of "competitiveness" appear more as a-political façade rather than socio-economic principle.

A third dimension of the "partiality of automation" was illustrated in chapter six, showing that production itself is only partiality automated. The analysis has also shown that rather than the propositions of routine-biased technological change, automation decisions and thus manufacturing employment depend on the type of product which is produced. Where these products are complex, produced in low numbers and require complicated processes, automation becomes, not technologically, but economically impossible. Correspondingly, the persistence of employment in Austrian manufacturing is best explained through the type of products manufactured. In particular the element of complexity is relevant here. As the development of societies tends towards the increase of such complexity (Rosa, 2005; Brand, 2014, Hodgson, 2003), as do the products of the automotive industry (Krzywdzinski, 2022), it represents a significant rebound-effect of automation on employment (Butollo, 2024). It is also noteworthy that the output dimension of the product imperative corroborates the results of chapter 4 in an interesting way. While output increases employment, it also increases the economic feasibility of automation. This contradictory dynamic explains the persistence manufacturing employment next to automation as a self-reinforcing upwards spiral. If this virtuous circle is not entered it is likely that neither is found: manufacturing employment nor automation. In contrast to the propositions of RBTC, it is was thereby found that precisely highly-routinised work of assembly makes up a significant part of persistent employment in the automotive industry. In fact, inversely, the analysis has shown that clerical work such as banking are likely much easier to automate than many manufacturing processes, however not due to different degrees of "routine". A factory is by definition a site of routine and standardization, rendering the question whether something is routine or not somewhat mute. However, and crucially, as Pfeiffer (2016) has shown for the case of manufacturing assembly work, such labour-processes are in fact also much less "routinised" than often assumed. Even if such a category was adopted, the analysis has shown that "technological feasibility" itself plays little role in automation decisions to begin with.

Finally, a fourth element of the partiality of automation, was shown in the analysis of chapter seven, where persistent manufacturing employment was found to depend on partial class compromises between workers and management. A reduced *need* of resisting automation was argued to originate in a compromise on automation in exchange for continued production and ergonomic benefits. This compromise is carried by a relatively strong labour-market position of (at least some) manufacturing workers in Austria. A reduced *possibility* of resistance, on the other hand, originates in the increasing fragmentation of industrial class-composition. (Partial) consent to a "need for maximum technological innovation" was found to be hegemonic in the Austrian automotive industry. In the paradoxical employment strategy of retaining jobs by automating them, however, automation plays a partial role, as firms may still decide to move production despite such compromise (see chapter 5). Nonetheless, the willingness and cooperation within a "productivity coalition" with management regarding production goals is another facet of the persistence of manufacturing employment in Austria. In addition, the control of recalcitrant and oppositional workers, and the breaking of shop floor power of unions appeared as much less of a factor in automation decisions than assumed in the literature, and was the case historically. In contrast to recent positions in economics (Acemoglu, 2024), it is not the strength of opposition of unions and workers which drives the implementation of automation in the case of the Austrian automotive industry,, but rather their willing consent.

The narrative of a "partiality of automation", summarising these findings, thus shows that standard narratives about how economic imperatives shape automation and employment outcomes are incomplete and/or incorrect. Specifically, this concerned the supposed effects of labour-productivity increases based on automation, the competitiveness requirements on firms, routine-bias and worker resistance. It thereby confirms and extends socio-economic theories of automation and work, which also emphasise contingency and partiality. The story told in this way, however, is not an easy pill to swallow. The decline of manufacturing employment in developed economies certainly appears linear, just like the decimation of agricultural work. But what is often ignored in this intuition, is that it mostly relates a very specific time-frame, namely the Global-North over the past five decades. Since the industrial revolution, there have been many processes of de- and re-industrialization at different places, at different times. While undoubtedly automation and technological change have massively increased productivity, thus reducing the need for much employment in manufacturing sectors, a clear and necessary trajectory of its development can nonetheless not be inferred. As the constant reconfiguration of technological possibilities, and economic conditions has shown, its shape, size and location are always changing. “Capital moves” in the words of Cowie (2011). This is not to say that manufacturing employment must remain at a certain level. But, there are strong counterfactuals to a linear reduction, not the least of which, are current labour-shortages in developed economies and the persistence of manufacturing employment itself, which also represents a historical high-point of people working in manufacturing, globally speaking.

Hence, the “partiality of automation”, similar to the “socio-economic theory of automation”, suggests that there is no simple or linear narrative about the trajectory of manufacturing employment to be told based on automation. This view can, however, explain why decades upon decades of automation have not led to the expulsion of living labour often envisioned, but rather new technologies used in the intensification of work and its precarisation rather than factories without of humans. Persistent manufacturing employment is part and parcel of such partial automation. As work changes continually, although less than most often assumed, an “end of work” is only ever applicable to particular kinds of workers in particular instances. While new jobs may certainly originate in parallel to such technological displacement changes, this is not a necessary outcome, and where employment increases, it is not an immutable law that skills and wages increase with it. While RBTC can argued to have similar finding, this dissertation has shown that routine is in fact not an especially important category for understanding automation and its effects on work. What would therefore remain of the theory is a principle of polarisation, which is indeed a fundamental feature of capitalist societies. Most importantly, however, rather than placing the largest explanatory burden for the persistence of employment on technological criteria, the findings of this dissertation stress (socio-)economic conditions. Three axioms can thereby be extrapolated from analysing these conditions, all of which have been formulated at different points in other contributions and literatures, and are thus not new, but can be stressed here as crucial in any theory of automation and work:

1. Automation does not follow a necessary and given trajectory but is conflictual and contradictory. Structural change logics of production are more important for understanding employment developments than technological changes themselves.

2: Automation is not a “factor neutral” development but intensifies existing, or produces new, competitive dynamics, conflicts and inequalities of production and wealth between and within countries, regions, sectors, firms and types of workers.

3: Automation is a process, whose outcome must be achieved by social actors and there is no technological necessity how it changes the organization of work. Consequently, its effects on employment are ambiguous both in quantitative extent as well as qualitative content.

2. A Cause of Inefficiency and Stagnation?

The previous section has argued that persistent manufacturing employment is explained by a "partiality of automation". This partiality implies that much manufacturing work, although certainly not all, persists not out of technological, but out of economic necessity. Conversely, where toil persists, this is not necessarily based on a lacking development or potential of the productive forces, and thus does not merely represent a temporary technological boundary. This section *tentatively* and *hypothetically* develops the consequences of such an interpretation of the partiality of automation. From the get-go it is clear, however, that any such analysis exceeds the empirical base of this dissertation significantly, and can thus only ever represent an interpretative hypothesis which requires significantly more extensive research to substantiate. It is nonetheless a worthwhile exploration of the potential consequences of the results of this dissertation, as it connects to a recent literature on the stagnation of manufacturing sectors in the Global-North. To this end, the section first explores how the partiality of automation can be understood as a subordination of technological possibility to economic imperative, which in turn may allow it to be interpreted as a form of technological inefficiency. The dimensions of such potential inefficiency are then discussed based on a re-examination of the results of the empirical analyses. Then, connecting to a recent stagnation literature, an inverted-U type relationship between the development of capitalist societies and technological development is hypothesised. Finally, the recent example of AI applications is drawn upon to argue for the relevance and applicability of these arguments.

Next to growth of material affluence and freedom of choice, “efficiency” is one of the most frequently invoked arguments to illustrate the superiority of capitalist modes of production in organising the material and social needs of societies. The related formal proof that market-based production and allocation mechanisms are maximally efficient (Fama, 1970), as long as they are not distorted by politics, is one of the central axioms of modern economics. This axiom applies in particular to technological development: since it is in the profit interests of firms to develop and apply new technologies, it follows that capitalist societies are defined by a constant, revolutionary and efficient development of the productive forces. However, if technological feasibility and economic imperative diverge, or the former is limited by the latter, this would mean that technological potentials are possibly not realised. This would mean that the profit interests of firms and technological development are in fact not necessarily congruent, opening the possibility of technologically “inefficient” production outcomes. While it is relatively widely accepted that technological feasibility is logically not congruent with economic feasibility, the extended argument that technical and economic rationalities of production are not congruent in capitalist societies, is highly contentious. Therefore, some analytical distinctions are in order.

In economic modelling, “efficiency” means “pareto-optimal”, hence that a change in the allocation of commodities (or factors of production) is efficiency increasing, if it benefits one actor without harming another one. An “optimal” outcome is achieved, when such improvements cannot be made anymore. The view on efficiency adopted here is different, in that it takes social rather than induvial needs as basis: where the wrong amount is produced, either not enough or too much in correspondence to social needs, where provisioning goals are not achieved even though reallocation of resources could do so, and where methods of production exist which would reduce required work and toil, either in terms of available technology or organizational methods, but are not used, such production outcomes are considered “inefficient”. Inefficiency therefore means that a “better option” is available to fulfil social provisioning needs, but is not pursued. The driving gambit of this section is that the subordination of technological feasibility to economic rationalities can warrant such a classification of “inefficiency”. As classical studies have shown, however, it is important to stress that the use of more technology, or just higher automation, does not necessarily and by itself mean more efficient production (Womack et al., 1990). There are good reasons to not pursue higher technological intensity and automation, also from the perspective of social provisioning, as has been substantiated through the concept of “automation entropy” in chapter six. However, conversely, lower automation and manual toil are also not necessarily technologically more efficient, even where they are so economically, meaning more profitable. The point here is that rather than considering efficiency solely in an economic form, which equates to profitability, technological efficiency, understood as production outcomes serving social needs, as defined above, is a fruitful perspective. Hence, the hypothesis is that what may be economically efficient, is not necessarily congruent with technological efficiency understood as social provisioning outcomes. It is expedient to illustrate this perspective with examples from the results of the substantive chapters.

The topic of productivity-growth stagnation of chapter four readily connects to the question of efficiency. Since productivity is essentially a measure of (technological as well as economic) efficiency, if one is stagnating, so must the other. In the literature on productivity stagnation, it is also often theorised that technological development itself may have slowed, perhaps returning to the technological stagnation which has characterised most of human history, in which the advancement of the 20^{th} century was merely an exception. This supports the general approach of this section form an unexpected mainstream-side. The difference being, that such accounts usually simply consider this a problem of technology, as its development has just become harder since, the "low hanging fruit" has been picked. The analysis here on the other hand, is more interested in structural production conditions. Chapter four, for example, has in this sense illustrated the role of output in potentially inefficient production outcomes. As the automotive industry crucially depends on capacity utilisation and economies of scale, it faces endemic issues of overproduction and overcapacity. It is here that a first illustration technological inefficiency, as production outcomes which over- or undershoot social needs, can be made. This does not just mean a waste of resources, but also that production capacities are either underused or overused under great material and workforce strain. That the output itself is not technologically necessary per se, is shown by the increasing importance of life-style variations of products. On the other hand, while it is clear, that higher output is desirable for country-sectors, as it equals profits, employment and taxes, it also requires increased use of resources, necessitating higher CO2 emissions etc. In all likelihood, this will be the case independently of more sustainable production methods and technologies, given the emissions and resource use resulting from production. Hence, a focus on output will likely create adverse, thus inefficient, environmental impacts.

What makes demand and thus output so volatile in the automotive industry are mostly uncertain market conditions, leading to requirements to produce at capacity and to expand production in oligopolistic struggle over shares between car makers. Resulting crises of over- and underproduction, the two primary types of capitalist crises, are inefficiencies in social-provisioning in their own right. Another source of technical inefficiency, however, discussed in chapter four thus lies the nature of competitive pressures. Standard economic theory finds a maximum of uncertainty, confrontation and competition over production outcomes to be efficiency increasing. Schumpeterian thought has the opposite view, while Marxist accounts are often split. Galbraith has argued that the insecurity and instability implied in competitive models of economic organization, seldomly, if ever, apply to economic production reality. In the practical world of material provisioning, competition is something to be avoided at all cost (1995:35), which is why firms tend to grow in order to reduce uncertainty and risk as much as possible. In contrast, Galbraith argues that reducing risk and uncertainty almost by itself increases output and productivity, rather than diminish them (1995:94): *"A high level of economic security is essential for maximum production. And a high level of production is indispensable for economic security*." However, over the past decades, rather than pursuing economic security, stability and technological development, (manufacturing) firms in developed economies, have increasingly invested in financial capital (Moody, 2018:151), creating what Foster and McChesney (2012) have referred to as "*overproduction, stagnation, financialization trap*". The flip-side of this trap appears as chronic underinvestment in child- and health-care services or other forms of social investment and provisioning security, which are continuously aggravated by an increasing productivity-wage gap in OECD countries. Notably, the separation of productivity increases and workers' pay can be classified as pareto-efficient.

Connected to the question of competition, but at the level of regions, chapter five has shown that automation and employment decisions depend on what large conglomerates in the automotive industry deem advantageous to them (in reducing their risks, for example). Another example of technological inefficiency conceptualised as failure of providing for social needs despite technological possibility, may possibly be identified therein that what these firms may consider expedient to their profit interests, may be at odds with the long-term development of technological capacities of the regions in which they produce. For example, the issue with the closure of the plant in Steyr, described in chapter five, was not that it was not profitable, or that there was no demand for its output, but that it was not profitable *enough*. From the perspective of the region and the workers of the plant it must be considered an inefficient decision to lose production capacities and associated technical skills, not to mention jobs.

In addition, "Competitiveness" may not only have low explanatory power for firm behaviour as shown in chapter five, but may also be bad industrial policy goal to begin with, connecting again to the question of competition. While "competitiveness" is often framed as the drive to more efficient resource utilisation and increased technological development and productivity, as any form of competition, it necessitates zero-sum outcomes, for example regarding confrontation over production locations. This means that in order to win, someone else has to lose. Within the EU alone, the competition for production locations has already led to a significant polarisation on many levels, which may threaten its overall stability (Kapeller et al. 2019). Even where the European periphery can attract transnational firms by promising low labour costs and low taxes on profits, the resulting gains may be very short-term, irregular and reversible if firms move to even more favourable pastures, rendering the strategy of potentially little substantial value in the long-run. For example, where economic integration leads to less regulation, giving international firms a much wider range of possibilities of action than those available to states, leading to beggar thy neighbour policies and likely reduced technological development and application. More than anything, the developmental trajectories of periphery countries appear to keep them in the periphery, rather than a convergence to the core. That it is not a desirable or efficient perspective that the periphery of the world persists at a technological low level of industrial activity, or that a downward race competing on cheaper labour and mindless toil is not a useful manufacturing and social-provisioning strategy for societies, should be fairly obvious. Rather than levelling these differences, increasing automation in the service of regional technological competitiveness thus ossifies and strengthens them (Marini, 2022).

"Competitiveness" therefore simplistically identifies firm interests with those of workers and regions. What large conglomerates deem advantageous to them, however, even where they are "Austrian" firms or maintain production locations in Austria, does not align with the goals of regions to sustainably develop productive capacities. The point is, there is in fact no automatic win-win of global competition (Chang, 2003) and what may be good for an international firm, may not be good for the region where it conducts production, or its workers (Reich, 1990). In turn, just because firms are "competitive" does not mean they developing and implementing technology extensively, or that the countries and societies in which they operate, are. In fact, it is very unlikely that any necessary and significant technological change, for example regarding sustainability, would be undertaken by large international firms, simply due to the large investment requirements, and the path-dependent inertia of established production sites and technologies (Mattioli et al., 2020). Hence, the short-term profit maximisation logic is contradictory to the long-term development of regions and their productive, technological capacities.

In addition, as described by Rikap (2021) large firms appear to have increasingly become fetters on technological development. Where firms prioritise the commodification and monopolisation of immaterial knowledge, which was also shown in the analysis, and its control over technologies through legal and institutional means, this means that, unlike the assumption of standard economics, the profit motive does constrain technological diffusion by preventing productivity increasing spill-overs. By focusing on patentable innovations and proprietary technologies, or just buying up start-ups rather than investing in research and development, large globally active companies ensure that their technological advances become insulated assets, shaping long-term technology trajectories by prioritising changes which ensure the safest monopoly position. Hence, firms make technological decisions based on legal strategy, rather than technological merit.

Two other types of inefficiencies are connected to this but are merely posed as open questions here: is a globally fragmented and "lean" system of provisioning material needs truly efficient in terms of social provisioning? We may consider the shortages and confrontations in the course of the COVID pandemic regarding vaccines and masks. The second question relates to the development of technology, more specifically the present national confrontations on the development of AI systems. Is such parallel development of, essentially the same technology, truly an efficient use of resources and labour-power?

The question of technological efficiency is perhaps most directly addressed in chapter six and the boundary conditions of technological and economic production rationalities described there. Ultimately, it showed a subordination of technological possibility to economic imperative. This means, that it is not a technologically feasible maximum of automation which is pursued but a profitable compromise. Putting it concretely, if the only reason better or more ambitious technological production solutions are not pursued are (narrowing, see argument on financialisaton) economic rationalities, then this would suggest that the use of technology in industrial production *could* be technologically-inefficient. Whether it is the case, would need to be substantiated with concrete technologies in very concrete instances. Vidal (2022), however, has argued similarly regarding managerial practices which reduce the "empowerment" of workers in their labour-process, limiting the adaptability and improvement of production, which would be possible with more "empowered" workers.

Another point here relates to relative factor costs more specifically. Even if relative factor costs are considered the deciding factor in implementing new technology in production, this does not explain what they are relative to. As for example described by a professor of robotics in the appendix under section one, what would in truth need to be considered to arrive at a technologically sound measure of the degree of automation is extensive information on the *social* forms of an economy. This means a calculation of what costs are compared with what, and what the use of technology is valued at supplying. For example, as also described in the chapter, the functioning of critical infrastructure may be a value unto itself. The point being that what is considered inefficient depends on the goals. As was pointed out above, however, it is equally imaginable that higher automation would not lead to greater efficiency, especially where this is defined as a better way for higher profits. This means that the assessment of efficiency, as higher output with less input, is always a relative one. What one firm finds efficient in production may be considered inefficient in another of the same type, and more likely with a different product and production process. What a single firm finds efficient, maybe not be the same as what is efficient for a sector. What is economically efficient for a sector may not be the same as from the perspective of societal technological efficiency. What is efficient for a worker may not be same as for capital.

The results of chapter seven can be discussed in terms of this last point. While mutually beneficial compromises *can* be achieved, as the chapter has shown, the conventional view of economics that capital and labour share efficiency as a goal, but just differ on ways to achieve, does not hold. As Wright (2004) has argued, efficiency itself is conceptualised differently with capital stressing profit while labour favours the development of the productive forces and quality of life. Flanders (1975) on the other hand has shown, that it is precisely the desire of management to develop its control prerogative as assurance of efficiency, which actually undermines it. Streeck in turn, has argued (2004:426) that often institutions which were created without concern for “efficiency” and were in fact fought by capital, in Germany for example, as “irrational constraints”, turn out to now crucially sustain (economic-)“efficiency” down the line. If a labour-process is more toilsome, dangerous or otherwise detrimental than technologically necessary, it is likely considered inefficient by workers, but not necessarily management. The seminal contribution in this vein is, of course, by Noble (1987) who showed that even in the course of the development and implementation of technologies, such as CNC automation, the technologically most efficient developmental paths are often dismissed in favour of profitable solutions, which are often those which reduce the dependence of capital on the skill and availability of workers. Rather than immutable facts of technological design, technological decisions are part and parcel of conflicting interests, which also extend to what is considered "efficient". Much like the closing of a factory which is not profitable enough, as described earlier, is not in the interest of workers, so are many technological choices. However, these choices do not necessarily follow technological necessity and efficiency, even if they sometimes overlap or are presented that way. Mainstream economic theory does not contain such a differentiation, of course, besides antagonistic demands on wages (see again the quote by Samuelson, 1957). However, as Moody argued (1997:3) "*there is no 'win-win' solution to the age-old conflict between employer and employee*."

In most contributions, it is usually workers who oppose nominally more efficient production methods, standing against the progress of industry. However, industrial sabotage of efficiency from the side of capital and management is equally well-documented. Veblen (1912) for example, has famously described the withholding of efficiency gains by American industrialists in favour of greater control over production and profits at the time. To hold back capacity, or not, is of course the purview and a strategy of engagement among oligopolies (Galbraith, 1995:157). Hence, contrary to the assumption that only workers would be able to sabotage production and refuse objectively more efficient methods and outcomes, capital and management are equally capable.

Ultimately, as also described in chapter seven, one of the reasons for the persistence of manufacturing employment is simply that workers can be fired. They thus afford greater flexibility in production, as capacities can be increased or reduced without expensive investment in specialised machinery. This is the fundamental "comparative advantage" of human labour Autor suggests as guiding principle of technological development (2015):

to be the recipient of economic risk and uncertainty. To see this as efficiency, when viewed from the perspective of workers, requires much imagination. As was also seen in the results of the small-scale survey: the goals of economic democracy and efficiency may in fact intersect more than usually assumed from the perspective of workers. The point being that the precariousness of the world is quite irrational and inefficient for those who suffer it most.

It is important to stress again that these, more than anything hypothetical, interpretations of the results of the substantive chapters are necessarily tentative. They do seem to support, however, that technological efficiency, understood as the use of available means to cover social needs, appears limited by current, and narrowing, forms of economic rationality. This would mean that the use of technology in creating social use-values does not necessarily overlap with the profit motive. Correspondingly, Horkheimer has succinctly summarised automation which do not serve social needs, as “abolishing work in the work way” (Horkheimer, 1989 [1956]:36).

In most critical contributions on how new technology changes work, the focus usually lies on degrading working conditions and wages. While this is worthwhile, the view adopted here is different, focusing on the development and use of technology in the first place. By doing so, it adopts a similar view to recent contributions on the stagnation of industrial production in the Global North (Benanav, 2020; Schoener, 2022, Copley, 2022; Vidal, 2022; Frey 2025). In this literature, however, the potential divergence of technological and economic production rationalities is a relatively little discussed contributory cause of stagnation, even though it appears particularly applicable to the financial, spatial and technological inefficiency of the production structures of the global automotive industry (Mattioli et al., 2021).

The literature on stagnation usually locates the beginning of said stagnation of the industrial sectors of the Global-North in the 1970s (Brenner, 2006). This allows a relevant extrapolation of historical tendency of the above hypothesised technological inefficiencies (output volatility, winter takes all, narrow economic rationalities and blocked empowerment of workers amidst labour-shortages). Perhaps then, the relation of technological development and capitalist production, or congruence between economic and technological efficiency, could be described as inverted "U". Whereas in the respective beginning they were (nearly) congruent, this relationship could have increainslgy diverged, explaining stagnation. A similar argument has been argued for the relationship between democracy and capitalism (Therborn, 2020). It would be close at hand to look for the vertex of this curve in the profitability crisis of manufacturing in the 1970s, and the transition of Fordism to Post-Fordism (Vidal, 2022). Whereas the unique period of mass-consumption understood as "Fordism" was driven by mass production, standardisation and efficiency increases, this exceptional period of economic growth and technological development ended with declining profit rates, intensifying global manufacturing competition, and consequent overcapacity creating downward pressures on prices, demand and profits. A post-Fordist phase of stagnation may be what we see now, increasing attempts of sustaining profit rates through financial instruments, and a potential divergence between which technology is profitable, and which improves social-use values. Such arguments for grand historical trajectories, however, again clearly exceed the empirical base of this dissertation. It is not overgeneralisation of the results of this dissertation, however, to say that automation has economic limits. Equally, it is apparent that technology changes, perhaps progresses, also in present capitalist societies. If anything this interpretative section simply opens the question, whether this is the case because of the profit motive, or in spite of it. The basic formulation of the hypothesis explored here is thus, once again, most elegantly put by Marx (1991:358): *„The greatest limit to capitalist production is capital itself."*

While the veracity of this claim must be substantiated elsewhere, the saliency of the argument can be illustrated based on a recent example of technology-use. AI applications, currently, primarily serve the function of text and image creation, programming-aid, the individualisation of marketing strategies and algorithmic control. These functions, however, have little bearing on the organisation of industrial and reproductive work. Despite monumental costs of development, and need for energy and work, AI thus presently has very little material social usefulness. Case in point: it can suggest endless iterations of love poems with different styles, languages and tones, but not help to do the dishes. While the applications themselves are thus become increasingly sophisticated, their usefulness is disproportionately limited, incapable of achieving relevant goals of productivity, displacement or efficiency. It essentially represents a "baroque" form of technology (Kaldor, 1982), which despite sophistication, is hardly useful for the majority of humanity and the majority of the work that is being done. Most of all, it absorbs resources which could have been dedicated to other technological developments of potentially greater and more urgent use. Instead, massive amounts of notoriously tedious, toilsome and poorly paid labour are necessary to prop up the lauded efficiency gains of the technology (Muldoon et al., 2024). The reason for this does not lie in lacking technological feasibilities of contemporary societies, but the economic rationality of how they are organised and steered. Or: technological possibilities are curtailed by dominant social relations of production.

The interest of this dissertation does not lie in avenues of intervention, such analyses must be relegated elsewhere (Ferschli, 2023). However, it is interesting to return, briefly to the social and economic consequences of what was just argued. Firstly**,** as the partiality of automation is structural in origin, dependent on economic imperatives rather than temporary technological boundaries, it represents an unlooked-for affirmation of *some* labour-theory of value. Clearly, also this argument must be substantiated elsewhere, where this is the decided goal of the engagement (as for example begun here: Ferschli, 2024). But if anything, that automation has not led to factories devoid of humans but rather the partial de-industrialisation and automation of developed economies, suggests a crucial structural role of living labour in the production of value, and by extension profits, if not strictly prices. Caffentzis (2013:72) formulated labour-saving technological development as the ultimate conundrum of capitalist societies, eternally locked between wanting to displace workers and developing the forces of production, but equally needing them for production. Tomšič (2015:66) has also summarised this point in recourse to Moishe Postone, that capitalism can exist without capitalists, because the capitalist drive to self-valorisation is "structural, systemic, autonomous", but capitalism without workers represents a structural impossibility, hence, partial automation. This line of thought is ,of course, merely a cursory extension. Nonetheless, it provides an argument for the origin of the partiality of automation and thus why decades upon decades of automation have not resulted in the expulsion of living labour often envisioned before, as well as why new digital technologies have led to the intensification of work and a greater reliance on precarious work instead of factories devoid of humans. It also connects to the "labour saving" function of machinery. This function, seldomly coincide with the easing of work for the worker. As Schmidt (2019:57) reiterates Marx's reply to Mill's question whether "any machine ever made the work of anyone easier": this was never the purpose of machinery to begin with. Consequently, it is also not surprising, as Schor (1991) has found, that the notion that the technological development of capitalism reduces toil and working hours, is one of its most persistent myths.

Secondly, the results of the analysis provoke the question of what in fact constitutes an affluent society. While many developed economies, or such "affluent societies" have achieved material security and the technological means to maintain it, over the course of the last century, they have not achieved the next logical step of securing a minimum of needs for all its members to live in decent comforts without privation. To borrow again the words of Galbraith (1995:260): "*To furnish a barren room is one thing. To continue to crowd in furniture until the foundation buckles is quite another. To have failed to solve the problem of producing goods would have been to continue man in his oldest and most grievous misfortune. And to fail to see that we have solved it, and to fail to proceed thence to the next task, would be fully as tragic*." Rather than concerning themselves with making the remaining work easier and eliminating toil as necessary fact of economic organisation, developed economies see the opposite as necessary. If, as Galbraith (1995) noted, the goal of capitalist societies, and firms, was truly to simply produce a maximum of material output to cover the largest possible material needs, then much more would be attempted to actually do so. However, at any given time, out of the five logical ways output may be increased (1. Using more resources and capacities; 2. Using them more efficiently; 3.

Increasing the supply of labour to extend output; 4.increasing the stock of machinery; 5. investing in technological), at best one or two are used at any point in time (1995:103). Except in conditions of war, where all five become immediately available, despite a simultaneous reduction of the labour-force. The notion of an easing of work on the other hand is seen as entirely undesirable, and even maximally damaging. The concept of marginality in economics is perhaps nowhere applicable other than in this one case where economists refuse to apply it: a diminishing urgency of production.

Instead, it is hoped that the technological advances and innovation of the private sector will address the major challenges of this century. This ignores, of course, that the most significant inventions over the last two hundred years were in fact not developed by firms in the pursuit of profits, but rather by institutions, researchers at public universities or research groups deliberately shielded from market competition, such as at Bell-Labs. Air transport, to name just one example, would not have been able to sustain its own basic research effort, needed to coalesce into an industry. The same holds for nuclear energy, satellites and computers (Galbraith, 1995:206). Much relevant scientific work, perhaps most, lies outside of market endeavours and private enterprise. Rather than the common assumption that free market production is the primary driver of the development of technologies to reduce mindless toil and drudgery, industrial society and capitalism are thus clearly not necessarily congruent social forms (Gershuny, 1978). This is why Shaik (1980:75) has argued that technological displacement is also the dominant form of technological change in industrial capitalism because it serves profit requirements best, more so than technological changes which increase the use-values of products or the efficiency of production.

Inefficiency is thereby just one example of the wider irrationalities of capitalist societies (Meiksins-Wood, 2017). Whatever the precise approach to overcoming it, and thus unnecessary failures in social provisioning, it is clear that it is not technology itself which is the deciding factor, as it often merely serves as spectacle (Debord 1967). A society, or even world, without scarcity, aligned with human needs is not a technological project but a political one. This is, of course, easily pointed out. To do it differently, in the words of Brecht, is the simple thing which is hard to do.

3. Contributions, Limitations and Extensions

The analyses in this dissertation have contributed to the literature on how current technological changes and automation are changing work and employment in the manufacturing sectors of the Global-North. More specifically it has analysed the causes and consequences of firm decisions in the automotive industry, looking to explain persistent manufacturing employment. It has thus contributed to a socio-economic theory of automation and four more granular literatures: on the productivity paradox, on the role of competitiveness in the behaviour of large automotive firms, on the critique of routine-biased technological change and the boundary conditions of technological and economic production rationalities, and finally, the role of worker and union consent in technological changes. While the minutiae of the findings and contributions to specific literatures has been discussed in the corresponding chapters and the above summary, it remains to discuss how the finding are limited, which question of interest remain and how best to address them.

Firstly, the findings of the quantitative analysis pertain to a relatively limited time period and country sample. While the specific perspective on the aftermath of the financial-crisis in the OECD automotive industry was the point of the analysis, as always, extending both the number of countries and time-frame would be instructive. In particular the role of BRIC countries in global automotive production would need to be accounted for in greater depth. In line with extending the sample, more qualitative country-sector case studies would be also of value. For example, in order to specify the distinction between the "core" and "periphery" countries in the analysis. Different categorisation could thus also be attempted, to see how it changes results, for example by further separating the countries of the core into export-led economies, taking advantage of BRIC growth, and inward-led countries which were not able to do so. The periphery countries could further be distinguished in terms of a semi-periphery and periphery-proper, based on the different commodity-chain functions they serve.

Secondly, all the arguments presented in the qualitative analysis are, of course, based on the conditions on the Austrian automotive supplier industry, hence specific products and manufacturing strategies. The results of the analysis may very well vary in other sectors, even if the overall conclusions are likely to remain the same. While focusing on one manufacturing sub-sector, the automotive industry, and one country within it, allowed the empirical analysis to become manageable, it is thus a partial picture. To substantiate the findings, quantitative as well as qualitative country analyses similar to the one undertaken here, would provide insights. In addition, analyses which include other sectors, such as agriculture and services, as well as in -depth case studies of individual firms and factories would be helpful.

Thirdly, due to constraints of time and space, this dissertation could not sufficiently account for the dimension of commodity chains and the input-output relations between country-sectors. The outcomes of firm behaviour, in particular in the automotive industry, depend on the commodity chain position they occupy. While discussed partly, these differences in automation and labour-use strategies would need to be investigated in an extended analysis. For example, a comparative case study based on interview data from automotive plants in neighbouring countries of Austria in the CEE, such as Slovakia, Slovenia and Hungarian would prove insightful. These findings could then in turn be connected to a quantitative analysis of occupational change in the EU manufacturing sector and labour-shortages. Another worthwhile approach here would be, rather than comparing country-sectors, to compare firms based on equivalent production processes. For example, understanding the differences in welding processes and occupations between factories in Austrian and Hungary. Seeing whether, and if so why, the same labour-processes are organised differently, would provide additional insights on the specialisation of Austrian plants and explain the persistence of manufacturing employment in relation to other central-eastern countries.

Fourth, as discussed throughout the dissertation, the use of robots is a very limited metric for understanding of automation. In extending qualitative evidence, a wider array of technologies could be considered. Technologies could also be connected more directly to prevalent managerial strategies and paradigms and how they shape their use.

Fifth, the findings of this dissertation are limited by the depth of analysis of manufacturing employment in terms of its segmentation of occupations, skills, quality of jobs, wages etc., hence, what kinds of jobs are precisely contained within the absolute employment levels discussed. This could also include a more in-depth analysis of the labour-process of automation itself, in order to determine whether it is affected by changing technological possibilities, and in particular whether this type of work is itself increasingly becoming de-skilled. In particular the increasing use of generative AI in software development, may reduce formerly held leverage of skilled knowledge workers.

Finally, the overall conclusions of this dissertation should be substantiated, both the analysis of the partiality of automation and its reasons, as well as the arguments of the interpterion section. Next to historical studies to test the propositions, evidence from other countries and sectors within a wider research program would be needed in developing these avenues of inquiry.

Appendix

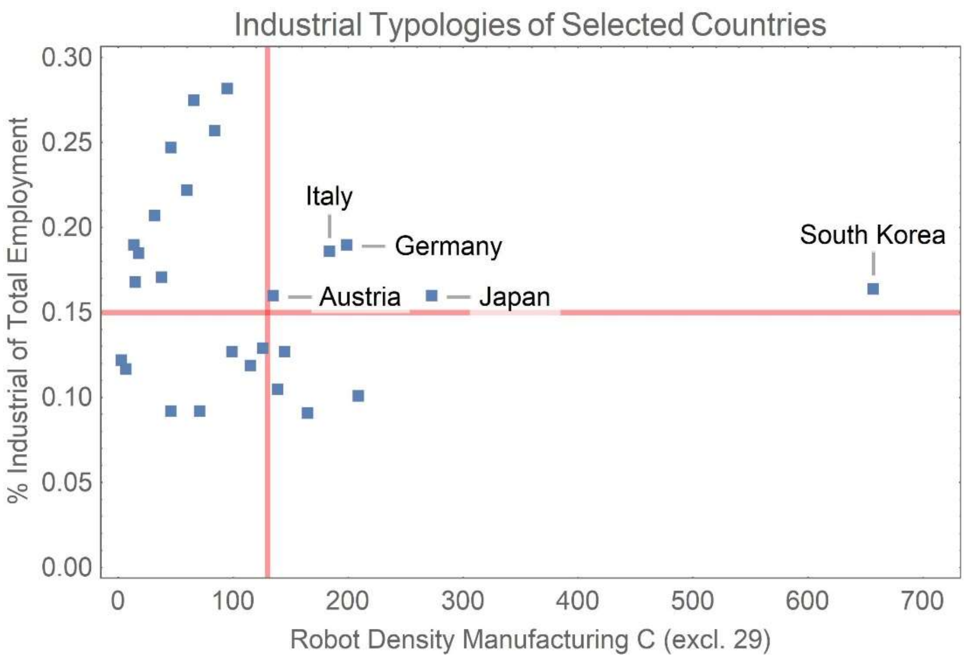

Figure 12: Industrial Typologies, Quadrant 2 Callout, Panel countries 2019, C minus C-29. Sources: IFR, ILOSTAT SDG Indicator 9.2.2.

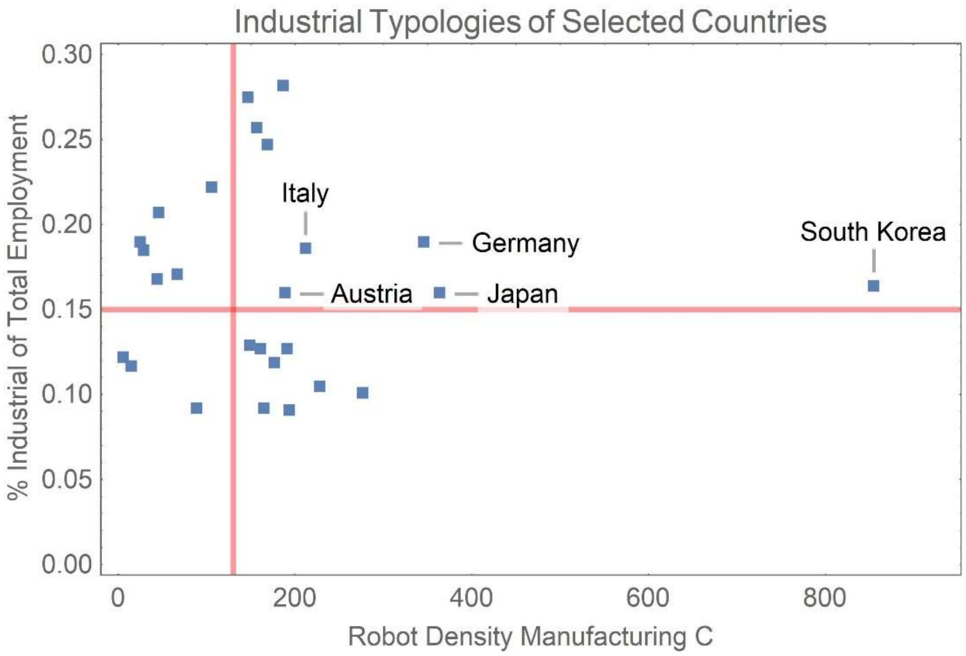

Figure 13: Industrial Typologies, Quadrant 2 Callout, Panel countries 2019, C. Sources: IFR, ILOSTAT SDG Indicator 9.2.2.

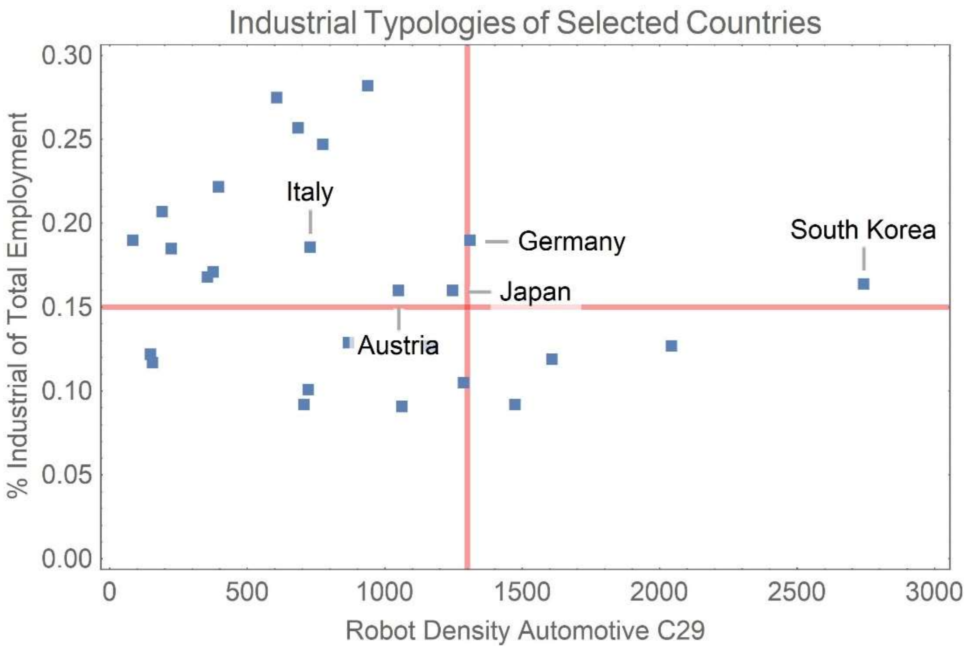

Figure 14: Industrial Typologies, Panel countries 2019, C-29. Sources: IFR, ILOSTAT SDG Indicator 9.2.2.

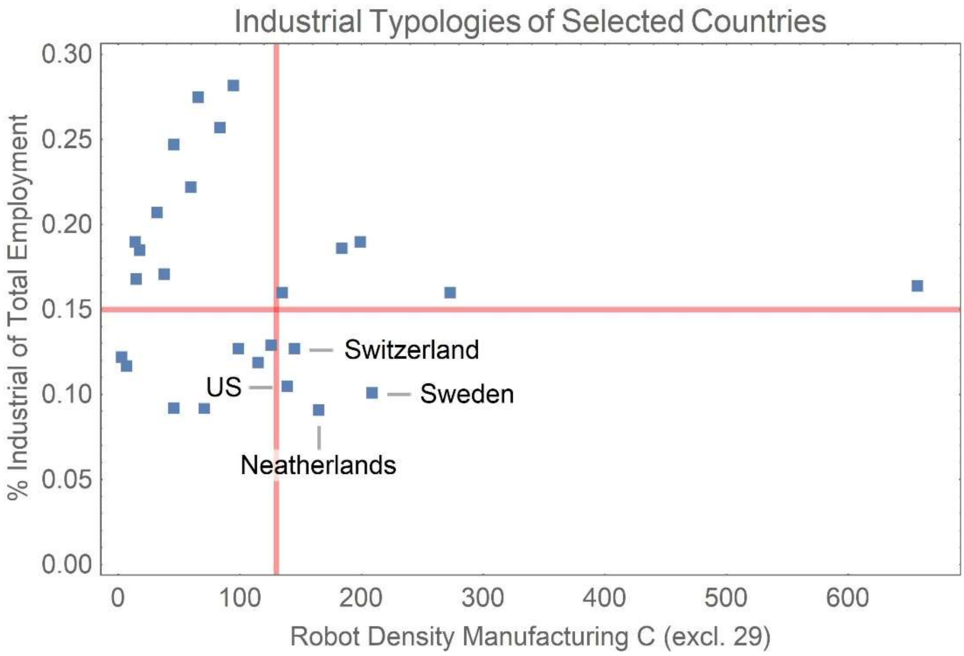

Figure 15: Industrial Typologies, Quadrant 3 Callout, Panel countries 2019, C minus C-29. Sources: IFR, ILOSTAT SDG Indicator 9.2.2.

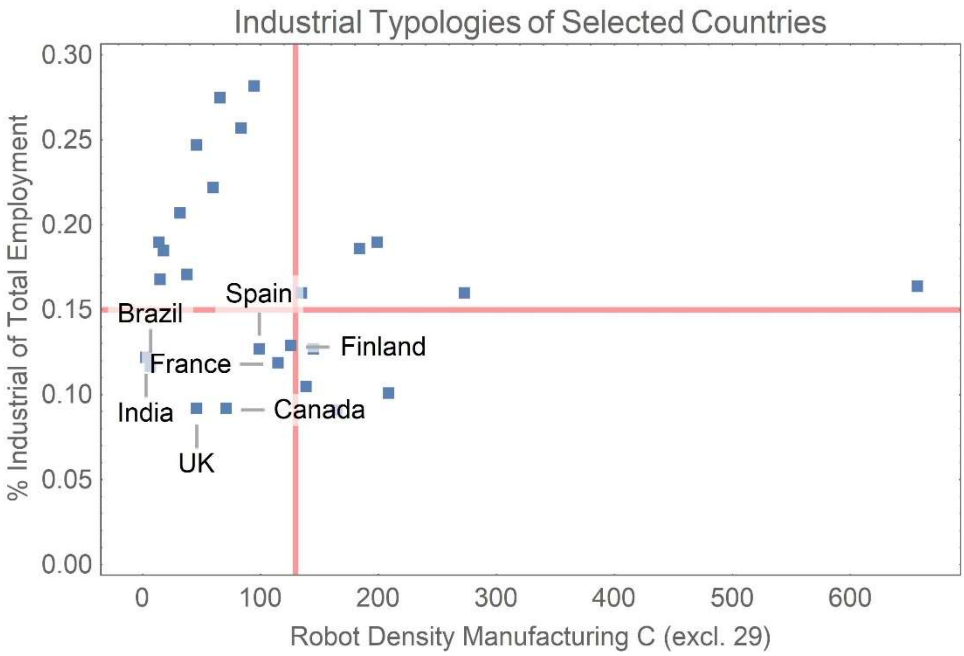

Figure 16: Industrial Typologies, Quadrant 4 Callout, Panel countries 2019, C minus C-29. Sources: IFR, ILOSTAT SDG Indicator 9.2.2.

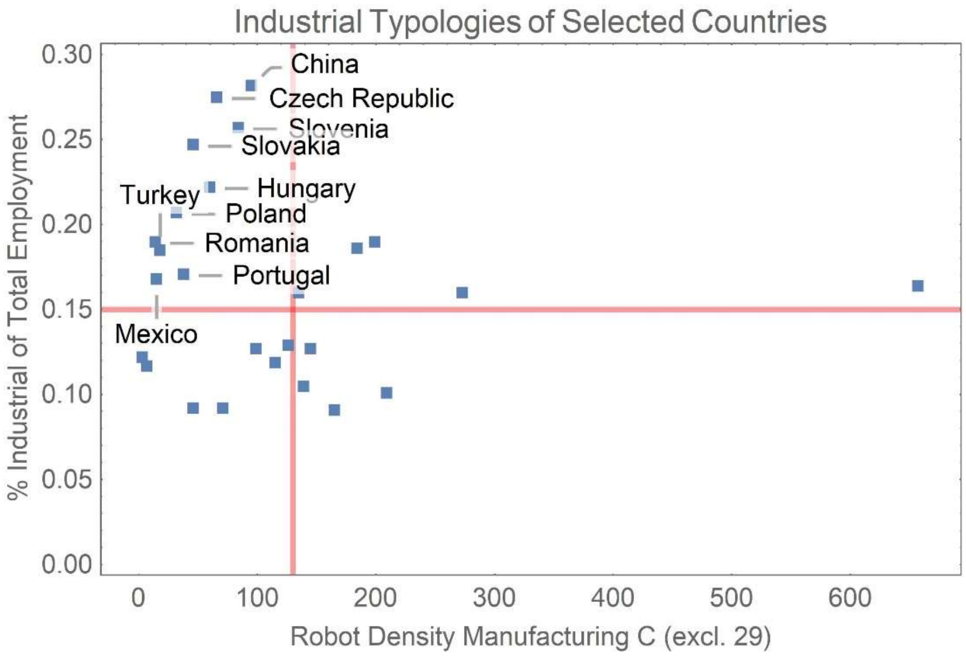

Figure 17: Industrial Typologies, Quadrant 1 Callout, Panel countries 2019, C minus C-29. Sources: IFR, ILOSTAT SDG Indicator 9.2.2.

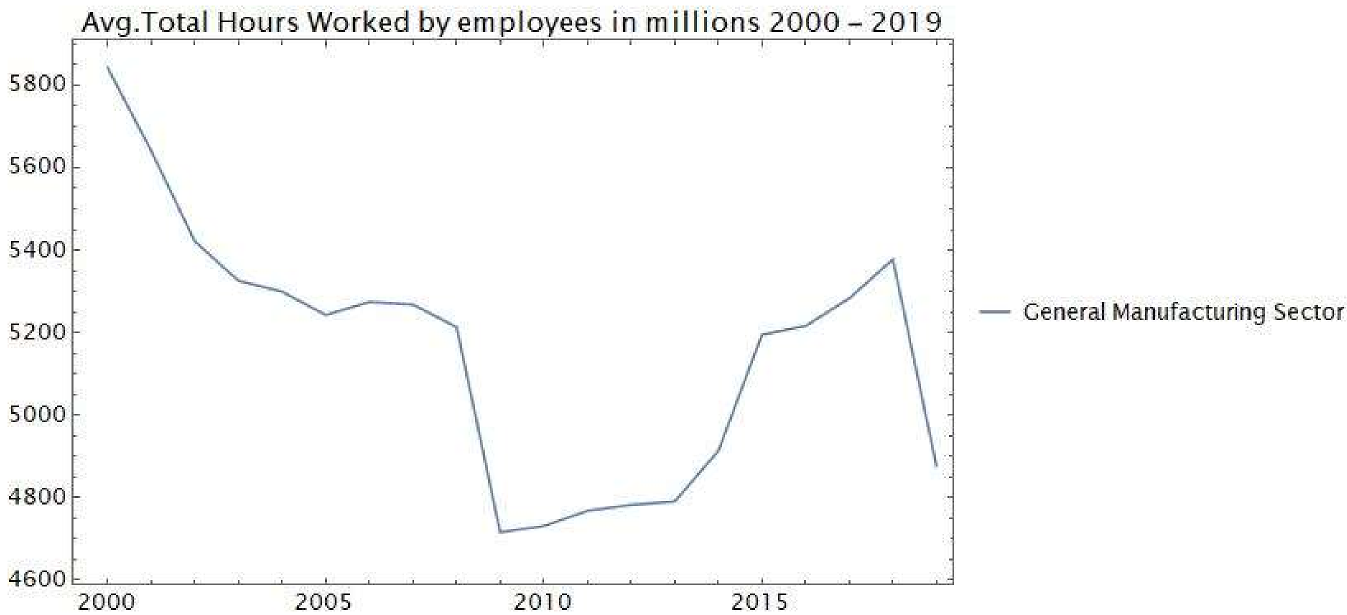

Figure 18: Average Hours Worked in the Manufacturing sector, 2000-2019, Countries: Canada, Mexico, US, Japan, Austria, Germany, Spain, France, Italy, Netherlands, Portugal, UK, Sweden, CZ, Hungary, Poland, Romania, Slovakia, Slovenia, South-Korea, Turkey, Finland. Source: WIOD, OECD Stan and The Conference Board; own calculation.

Figure 19: Manufacturing Employment Austria. Source: Business Cycle Statistics for the Manufacturing Sector, Austrian Statistics Agency.

Figure 20: Automotive Employment Austria. Source: Business Cycle Statistics for the Manufacturing Sector, Austrian Statistics Agency.

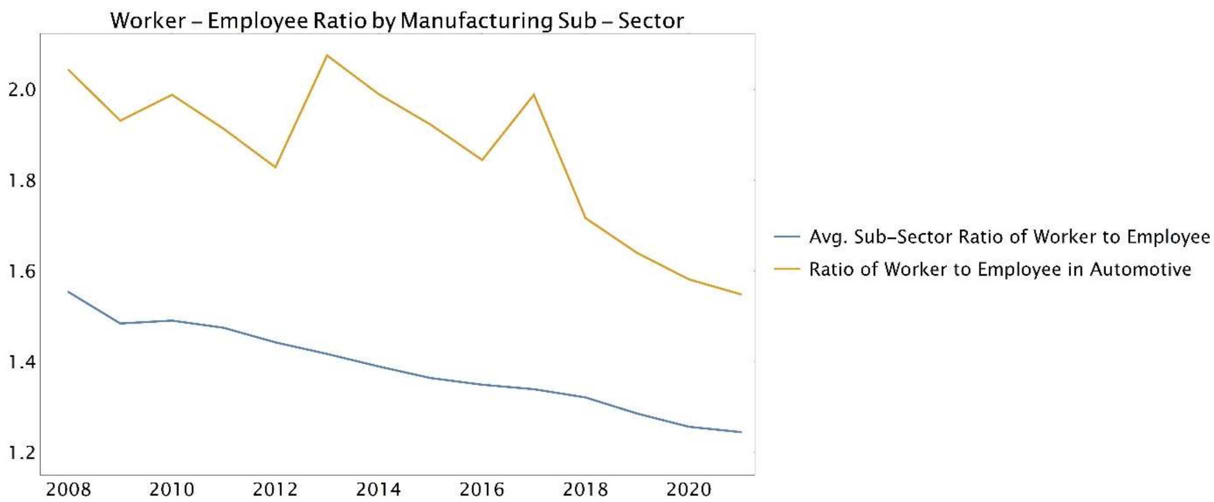

Figure 21: Ratio of Workers to Employees by Sub-Sector, 2008 to 2021, Source: Business Cycle Statistics of Manufacturing, Austrian Statistics Agency, own calculations.

Table 11: Automotive Characteristics 2008-2021. Source: Austrian Statistics Agency

Totals C-29	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2015**	**2014**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Total Firms	294	290	296	329	310	305	235	317	228	227	226	229	233	242
Total Employed	31527	29174	28698	31485	30704	29851	30240	30160	31858	35749	38872	37177	35230	36187
Total Workers	19947	18124	18000	19507	18766	19028	18746	18894	19598	22675	23513	21979	20545	21066
Total Employees	9840	9383	9066	10193	10231	9120	9871	9500	10622	11401	13694	13599	13168	13597
Total Technical Production	11358069	8568494	10565394	12415662	11924173	12649279	12689230	12814848	13822333	14295296	16332030	17286068	13252088	15320686

Section 1: Technical Definition of Degree of Automation

"*Degree of robotization is clearly not enough. [I]f you really want to do it right, really right, there are MTM. With this you can classify labour-processes. So, you take a job and then you say the worker has to pull away a foil. First, he has to take a box and put it on the table. Then he has to pull away a foil...and for each of these tasks you get a time in a table. Alright. The exact same thing exists for robots as well. So, what you would need to do is take the number of tasks and the time they require, and contrast them to what the robot is doing. So, how many tasks does the human worker do, and how many tasks does the robot perform in that firm? How much time is used by the human worker, how much time by the robot. The problem that we always have is energy and the costs. That they are compared to the human. So, how much energy does a human use, in reality, what does it cost in terms of resources, how can this be compared to a robot? This, I haven't seen anyone do this properly and seriously. Because what would this include? Is the private life included in that as well, you know what I mean? Because he [the worker] has to exist [live]. He doesn't just exist in the firm. So, the total system of human or worker and the total system of the robot, so what does it need for the robot to become a robot, up to the labour-process, what did it need, all the education and whatever until it stands there. You know what I mean? That would be the most serious approach that the number of tasks of a human worker are compared to the number of tasks of the robot in order to determine a degree of automation. This might be 0 or 1, or somewhere in between, depending on what you are looking at. So, it would be between 0 and 1. From 0 to 1*". (R1-31:49)

Table 12: Publications using Orbis

Publication	**Research on**	**Data Source**	**Data used for**
Weche und Wambach 2018	Development of Concentration in Europe	Orbis	Calculation of Mark-ups, 2007-2015, firm observations from 17 of the EU 28
Weche and Wagner 2020	Concentration and Digitalisation in Manufacturing	Cost Structure Surveys	Calculation of Mark-ups 2005-2013, manufacturing industries Germany
Stiebale et al. 2020	Concentration and Automation rise in Manufacturing	IFR and Orbis	Mark up calculations for six European countries 2004-2013
Ponattu et al. 2018	Concentration, Digitalisation and the Wage Share	Orbis	Sectoral concentration 2008 and 2016
De-Loeker and Eckhout 2017	Rising market concentration and macro-economic consequences	CompStat	Calculation of Mark-up 1980 to 2014
Cavalleri et al 2019	Concentration in the Euro are	Orbis	Calculation of Mark-ups 1980 to 2014
Bighelli et al 2020	Concentration and Productivity in Europe	Compnet	2008-2016
Autor et al. 2019	Concentration and fall of labour-share	Among others Orbis	Mark-ups six European countries 1980-2014

Table 13: 5 year CMAs Automotive Sector

Auto Avg %	**2003-2005**			**2006-2016/7**			**Δ2006-2016/7**		
Panel	**1 -NLP**	**2-RLP**	**3-NLP2**	**1 -NLP**	**2-RLP**	**3-NLP2**	**1 -NLP**	**2-RLP**	**3-NLP2**
Canada	**-3,2**	8,6	**-4,4**	0,1	**-2,5**	**-2,5**	3,3	-11,1	1,9
Mexico	5,8	**-3,8**	5,4	3,5	**-5,3**	5,2	-2,3	-1,5	-0,1
US	2,6	8,4	2,6	**1,2**	**1,4**	**1,9**	-1,4	-6,9	-0,7
Japan	**1,8**	7,4	16,2	**0,0**	4,1	5,5	-1,8	-3,3	-10,7
Austria	6,9	14,3	**1,7**	**1,7**	2,3	**0,3**	-5,2	-12,1	-1,4
Germany	5,3	14,0	4,8	5,0	4,7	6,4	-0,4	-9,3	1,6
Spain	8,1	13,4	6,9	2,7	3,9	**1,9**	-5,4	-9,5	-5,0
France	**0,7**	10,3	5,3	5,0	**0,9**	5,2	4,3	-9,4	-0,2
Italy	2,3	8,5	8,0	3,4	3,3	2,7	1,1	-5,2	-5,3
Netherlands	5,1	11,3	**0,9**	**1,7**	**0,4**	**1,9**	-3,3	-10,9	1,0
Portugal	**1,6**	12,2	2,2	**1,4**	3,4	3,6	-0,3	-8,9	1,3
United Kingdom	2,0	9,3	4,8	7,8	**0,9**	**1,6**	5,7	-8,4	-3,2
Sweden	2,1	14,3	**1,6**	6,7	5,9	**1,5**	4,6	-8,4	-0,1
CZ	6,2	24,4	2,1	3,4	6,9	7,7	-2,8	-17,5	5,6
Hungary	9,7	11,6	**1,7**	5,9	**1,3**	7,7	-3,8	-10,3	6,1
Poland	7,8	15,1	6,2	5,2	6,1	3,4	-2,6	-9,0	-2,8
Slovakia	3,9	25,7	10,6	3,6	6,8	5,8	-0,3	-18,8	-4,8
Slovenia	9,2	7,5	5,6	4,0	5,2	6,0	-5,2	-2,4	0,4
South Korea	6,4		34,0	4,7		7,3	-1,7		-26,7
Finland	4,4		6,5	3,6		3,4	-0,8		-3,0

Table 14: 5 year CMAs Manufacturing Sector

Manu Avg%	**2003-2005**			**2006-2016/7**			**Δ2006-2016/7**		
Panel	**1 -NLP**	**2-RLP**	**3-NLP2**	**1 -NLP**	**2-RLP**	**3-NLP2**	**1 -NLP**	**2-RLP**	**3-NLP2**
Canada	2,2	7,8	2,1	3,4	**0,2**	2,4	1,2	-7,6	0,3
Mexico	6,2	**-6,1**	4,4	2,2	**-7,1**	3,0	-4,0	-1,1	-1,4
US	6,7	6,5	6,6	3,4	2,0	3,6	-3,3	-4,4	-3,0
Japan	**1,8**	9,2	7,7	**1,0**	3,7	7,4	-0,8	-5,5	-0,3
Austria	3,9	11,4	**1,6**	3,0	2,9	**-0,1**	-0,9	-8,5	-1,8
Germany	3,8	12,7	4,5	**1,6**	**1,5**	**-1,4**	-2,2	-11,2	-6,0
Spain	4,7	8,0	4,0	3,5	3,5	3,0	-1,2	-4,5	-0,9
France	3,0	11,8	3,7	2,5	3,4	**1,9**	-0,5	-8,4	-1,8
Italy	2,3	7,8	3,8	2,2	2,0	3,8	-0,1	-5,8	0,0
Netherlands	5,1	12,1	3,0	2,3	2,5	2,5	-2,8	-9,6	-0,6
Portugal	4,5	10,9	2,2	2,7	2,3	2,1	-1,8	-8,5	-0,1
United Kingdom	5,4	9,8	5,0	3,9	**-0,6**	2,3	-1,5	-10,3	-2,7
Sweden	5,3	12,7	4,5	2,2	**0,6**	2,7	-3,1	-12,0	-1,8
CZ	6,7	19,7	5,5	3,2	5,6	3,4	-3,5	-14,1	-2,1
Hungary	11,5	11,8	4,1	6,4	**-0,6**	2,4	-5,1	-12,3	-1,7
Poland	5,9	13,9	6,7	5,2	4,9	3,2	-0,6	-9,0	-3,5
Slovakia	10,7	23,2	11,5	3,2	9,2	6,6	-7,5	-14,0	-4,8
Slovenia	8,5	23,2	6,1	4,3	9,2	5,3	-4,3	-14,0	-0,8
South Korea	8,5		24,0	4,9		12,1	-3,6		-11,8
Finland	3,6		11,1	1,5		3,6	-2,0		-7,5

Section 2: Limitations in Individual Datasets and Variables

There are limitations to the use of some of the datasets and thus metrics derived from them. This primarily concerns 1. the IFR database and uncertainty whether robot-use can reasonably approximate automation, and 2. The Orbis database and uncertainties regarding its use for the calculation of concentration measures. While these discussions are very important, perhaps essential, both databases and metrics are nonetheless used in the estimation below, mostly for lack of better sources.

A first issue with the IFR database is, that it is not transparent. It is provided by a robotics advocacy group and collects self-reported sales figures of the largest global robot suppliers. The data it provides for current of robots, assumes depreciation rates for the robots sold in previous periods. This is unlikely to correspond to their actual service lives. Second, and more major: robots do not represent the entirety of the technological configuration of modern factories. They may constitute a larger part of it, depending on what is being manufactured, but never the entire manufacturing process. Quite simply, this means that a higher number of robots per worker does not necessarily mean that some sectors are more highly automated than others. They may simply be automated with industrial machinery not counted as “robot”. Nonetheless, it is a measure to approximate some kind of technological intensity and it is the most widely used data for contributions in this vein.

The central issues with the use of data from the Orbis database for the calculation of concentration measures lie in 1. the data availability (massive NA’s and larger companies are represented more thoroughly, the limited time-frame for the data of 10 years[42]) and 2., the need for accounting-corrections. While formally Orbis is a very complete database, only the largest companies usually have complete time-series while the entries for smaller companies suffer from massive “n.a.”s.“. Larger” datasets extracted from Orbis, as sometimes found in the literature, are thus not necessarily “better” as, a very large part of the contained observations may be “empty” . The extent of this problem can be gauged by looking at the selection of some countries in table 5 in the appendix. For the case of Germany for example, out of the 5067 listed firm-observations in the automotive sector in the year 2019 only 586 are not n.a.’s. The second issue relates to accounting uncertainties and the possibility of double-counting. In Orbis, it is sometimes the case that subsidiary companies are listed in the same dataset as parent companies (domestic or global). This can potentially lead to double-counting if a parent company is listed as consolidated and one of its subsidiaries as unconsolidated. For the procedure for the correction of the data (as suggested by Grabner 2016, and implemented by Ferschli, 2021) see the extended appendix. Finally, the use of Orbis data also opens more general questions such as the geographical heterogeneity of competition and the usefulness of categories of economic activity. Rossi-Hansberg et al. (2021) for example show, that national and local concentration are not the same thing and considering the cross-country and cross-sectoral ownership of firms, and the organization of global production networks, it almost seems farcical to rely on crude categories of economic activity. Nonetheless, if one does not wish to research each company individually, a necessary simplification. Figure 17 to 24 in the appendix shows the resulting concentrations measures (HHI, c3, c10, c30) for the automotive sectors of all countries as well as the manufacturing sectors excluding the automotive sector between 2010-2019. Table 25 and 26 show the “valid observation degradation” of the used Orbis data for 25 countries of the sample for the year 2019.

[42] While access to historical Orbis data is possible, it is cumbersome and such low quality that the effort is not warranted.

Section 3: Notes on the Construction of the Final Panel

The final construction of the panel(s) for the econometric estimation, is thus the result of the amalgamation of various different data sources. In addition, a number of values was inter- and extrapolated where this was reasonably possible, as already described. The unbalanced panel, most important for the following estimation, running from 2010 to 2019 for 25 countries, is centrally constraint by IFR data which only begins with relatively complete coverage of sectoral disaggregation in 2010. While the constraint of Orbis data at the first point of data access would be 2011, CompNet data as well as extrapolation has been used to gather as many 2010 values as reasonably possible. While the manual calculation of labour productivity allows for a much wider panel than the use of pre-calculated indices, and values of single countries and sectors could have been calculated up to 2021, the final date of 2019 is the most common limitation. As mentioned before, the sample was chosen primarily with the relative importance of the automotive industries of the selected countries in mind, which has then been balanced with data availability and the trustworthiness of said data (Russia, India, China of course not as convincing in sources etc.). The central caveats of selected variables, were such a discussion seems relevant, are revisited now in brevity.

Sectoral Concentration Indices: HHI, C3, C10, C30: The HHI panel is fairly complete except for Thailand, Iran, Russia (Auto and Manu). Several missing values have been imported from the CompNet database and several values extrapolated, mostly for the year 2010. In the case of the manufacturing sector for all countries of the panel, where other sources could not be found. This extrapolation does not seem overly risky since the time-series are stable, and the values in question are those at the beginning of the time-series. Since concentration levels are as high as they are, interpolation or extrapolation of values was capped at 100, as this represents 100% market share by n-number of firms. The C3 values for the Swiss automotive sector are suspicious and equally the C30 values for Switzerland make no sense, as they are lower than the C10 values. As no more reasonable values could be found, they remain in the panel.

Total Hours Worked: While the final panel is especially piecemeal here between 2014 and 2019 (see table 27 and 28 in the appendix), only very few values were extrapolated. However, values for Brazil, Switzerland, India and Russia could not be found beyond those listed in the WIOD database (ending in 2014). China and Iran are entirely NA. For the cases of Japan, France, UK, South-Korea, Turkey and Finland only the year 2019 was missing and thus extrapolated at little risk. While the case is generally, as always, more severe for the specific sectoral automotive sector, the basic structure translates to manufacturing.

Real Value-Added: A similar picture holds for Value-Added, with only three values having been extrapolated. The central constraints lay in the automotive sectors of China, India and Russia after 2014 as well as the values for 2019 for Japan and South-Korea. The form in which Value-Added was gathered here was as *Gross* Value-Added at *current basic prices* (in millions of national currency). The possible variations of this metric between Gross/Net; chained prices and in USD etc. have been mentioned before. The construction of the panel can be retraced in table 29 and 30 in the appendix.

Capital Stock: Finally, arriving at the most difficult part of establishing the panel, the issues with capital stock data. While considerations on how capital can and is measured, as well as the accessibility and comparability of international macro-economic databases, would warrant a section or chapter of its own, I will limit my descriptions to a minimum. Two issues were central to consider here: one, the limited availability, and secondly, the approach for its measurement. Regarding one, it was surprising how little internationally comparable data for capital stocks was available, considering capital stock is an important variable in itself but also important numerator in capital intensity, which is of particular import for regressions on concentration. The final panels and their construction can be retraced in table 31 and 32 in the appendix. For the final panel below, I had two employ two "calculation tricks". The first has to do with the fact that for many countries, the sub-sector "automotive production" was not available, but was contained within the more general "*Manufacture of Transport Equipment*". In the cases of Canada, Japan and South Korea, therefore, for the years that *were* available from the WIOD database on capital stock in the automotive sector, the relative share of capital stock of the automotive industry as part of transport equipment production was averaged over the years, rounded and used as deflator (Canada showed a percentage of about 60%, Japan 70%, South-Korea 80%). The available values of capital stock in the sector of transport equipment of those countries were then reduced by respectively 40, 30 and 20 percent for all missing years and taken as approximation of the capital stock in automotive manufacturing. This concerns a total of 15 values (3 countries, 5 years each). The results fit nicely with the available years of the time-series which came before, speaking to the soundness of the strategy. The second "trick", concerns the database CompNet. CompNet in its 8th vintage contains several datapoints for capital stock not otherwise available (for France, Italy, Hungary, Poland and Romania). However, the values found in the database did not align with the preceding ones taken form the WIOD database for unknown reasons. It was in addition exceedingly difficult to discover these reasons as CompNet's documentation regarding the specific parameters and origins of estimations is weak to say the least. For example, no information could even be found in which currency the values in question were given. An exploratory application of exchange rates also could not explain the difference in values. Trusting, however, that the CompNet values were *somehow* reasonably constructed, instead of discarding them, the percentual changes from each year to the next were calculated and new values calculated based on the base values from WIOD. Thus, the relative change in capital stock for the automotive industries of those countries was taken from CompNet and mapped to the last available WIOD datapoints from 2014. Despite these efforts, Mexico, Brazil, Turkey, China, India and Russia still have NAs 2014 upwards, leaving the panel partially unbalanced. Missing final values for Switzerland, Germany, Spain, France, Italy and Netherlands in 2019 were extrapolated.

Section 4: Orbis Observation degradation and Data corrections

Orbis is the most widely used cross-country longitudinal database for individual firm financials, containing observations disaggregated up to the four-digit NACE 2 level, for every country and sector. The data is collected by Bureau van Dijk based on balance sheets, income statements and secondary sources for both publicly listed as well as privately owned firms. For the purposes of this analysis, I have extracted revenues, employee numbers and accounting indices for all relevant countries, for both the automotive sector (NACE rev. 2 C-29) and the manufacturing sector excluding the automotive sector (NACE rev. 2 C minus C-29). While the goal was thus to extract every single available observation for each country and sector, Orbis has implemented varying limitations on the sample which can be exported from the online-interface at a time. Thus, the number of observations per country in the final data-frame does not only depend on the number of companies registered in a sector, but also by the export-limit imposed by Orbis. This limit is however in the thousands, and does not represent a problem for calculations of concentration, for which only the largest observations are of significance in most cases (due to the pareto-distribution of revenues in most sectors). Another limitation lies in the fact that Orbis data is only available for ten years prior to the year of access[43]. The 10-year frame of access, despite being

[43] While there is a separate database of historical data by Orbis, having gained exploratory access to this data, it became clear that its quality is too poor to warrant the effort of its cumbersome extraction.

certainly a sales-decisions by Orbis, does carry some theoretical merit. As firms enter and exit markets, a fluctuation of which firms constitute an economic sector and its dynamics occurs. By limiting the observation years to a maximum of ten, the database reduces the risk of comparing apples and oranges. However, it is certainly also true, that companies have constitute a central part of a country's sector over decades. This is certainly more the case, the larger a firm is.

The time-series extracted from Orbis run from 2011 to 2020, hence one year off compared to other data availabilities. The extension into 2020 is not problem obviously, as this observation can simply be ignored. The missing values for 2010 were, however significant concern. In the end, concentration measures from the 8th vintage of the European Commission's COMPNET database were used to complete as many time-series as possible. The remaining missing values were extrapolated using the simple Trend-function in Excel, based on linear regression. Since this extrapolation concerns the first year of the series in a largely unrealistic metric, this was judged not too risky. In single instances, which are however of minor importance, but nonetheless the operation must be documented, single values have been interpolated to complete timelines. Where observations did not suffice to calculate certain indices for certain years, linear interpolation was used for certain cases. This concerns only a small number and almost exclusively concerns the construction of c30 measures in the automotive sector. The Orbis data itself cannot be reliably be interpolated to address the problem of large "n.a."'s, due to the great extent of missing values. Generally, linear interpolation determines a missing value through convex-combination of two other data points. In the formula below y denotes revenue and x, year.

$$y(x) = y_0 \frac{y_1 - y_0}{x_1 - x_0}(x - x_0) = y_0 \frac{(x_1 - x)}{x_1 - x_0} + y_1 \frac{(x - x_0)}{x_1 - x_0}$$

The concentration measures in the estimation below are based on revenue data gathered from Orbis. However, measuring concentration, both with Orbis but also generally, is not entirely unproblematic. Regarding the second point, while Industry or sectoral concentration derived by estimating the concentration of revenues can serve as a proxy for market concentration, it is not equal to it. As Heidorn and Weche (2020) argue, available industry data can be used to approximate market concentration, but they do not fully meet the economic definition of markets. The approach most often used when strictly "market concentration" is the goal, is the use of mark-ups. Mark-ups essentially mean the extent to which companies set prices which are higher than their costs, thus perfect competition prices, demonstrating how much "market power" a firm has. Such mark-ups can and are often calculated with Orbis data as well, however, since they rely on the assumption of specific production functions, this represents an analytical commitment that might in fact turn out to be obfuscating when studying concentration. The perspective on tried and intuitive sectoral concentration is maintained here, as it delivers a very direct idea of the concentration in a sector (considering that the figures are treated in a circumspect way and what they actually represent and *can* represent). There are also constraints within the Orbis data themselves which must be considered. The biggest constraints in using Orbis are, 1. its aforementioned limited historical availability. 2. The fact that while *formally* Orbis is a very complete database, only the largest companies usually have complete time-series while the entries for smaller companies suffer from massive "n.a."s. At points this problem has been so severe that not even c30 measures could be computed for the automotive sectors of single countries, meaning that for specific years not even 30 observations with numerical values could be found with otherwise hundreds or even thousands of theoretically possible observations in the database. "Larger" datasets extracted from Orbis, as sometimes found in the literature, are thus not necessarily "better" as, again a very large part of the contained observations may be "empty" and without numerical values. The extent of this problem can be gauged by looking at the selection of some countries in table 5 below. For the case of Germany for example, out of the 5067 firm-observations in the automotive sector in the year 2019 only 586 do not equal 0[44], meaning they contain actual numerical values, which can be used in calculations.

NA's in Orbis data, Automotive Sector 2019 for Selected Countries, own calculation

Automotive Sector by Country in 2019	**NA's / Total observations (valid observations which do not equal NA or 0)**
Austria	1051 / 1140 (89 ≠ 0)
Germany	4511 / 5067 (586 ≠ 0)
United Kingdom	11197 / 11581 97 (384≠0)
United States	12992 / 30000 (17008≠0)
Japan	249 / 4464 (4215≠0)
China	22484 / 30000 (7516≠0)

Nonetheless, as also illustrated in table 16 in the appendix, despite its shortcomings, Orbis nonetheless serves as the standard, *and still most complete*, database for firm-level financials and therefore manually computed concentration measures. A third constraint in using Orbis data, and this was the central issue in priming this data for calculation, lies in 3. Accounting uncertainties or the possibility of double-counting. In Orbis, it is sometimes the case that subsidiary companies are listed in the same dataset as parent companies (domestic or global). This is not a problem in and of itself. However, the accounting of the revenue of both parent as well as subsidiary can be recorded in four different ways, corresponding to different accounting-consolidation codes with which observations are designated in Orbis: C-codes (1 or 2), meaning "consolidated", having integrated all statements of a parent and its subsidiaries into one value. And U-codes (1 and 2) meaning "unconsolidated", *not* having integrated statements. The precise phrasing can be taken from Orbis (2011:390)[45]. Depending on the type of account of the observation in question, this could either include all revenues of subsidiaries, in the case of a parent, or not. If a consolidated parent company is listed in a dataset as well as its unconsolidated subsidiaries, this would mean that revenues are counted double, once for the consolidated parent and once for an unconsolidated subsidiary. If concentration indices were calculated without accounting for this, concentration levels would arguably be reduced by adding seemingly independent companies in the sample, which are not in fact independent. Say company A is the national parent company of company B, both collected in the same dataset and located in the same sector. If A shows a consolidation code of a "C" (1 or 2), this would mean that all its subsidiaries are already integrated into its statement. This means, that if there is, in addition, company B with a consolidation code of "U" (1 or 2) in the dataset, which also is a subsidiary of company A, the revenue of company B is counted twice: once integrated into the parent company's revenue, and once by itself. The

[44] Every empty or n.a. value in the matrix has been assigned the value 0 prior to counting.

[45]

C1: designating the statement of a mother company which integrates the statements of its controlled subsidiaries or branches with no unconsolidated companion
C2: designating a statement of a parent company integrating the statements of its controlled subsidiaries or branches with an unconsolidated companion
U1: designating that a statement is not integrated with the statements of possibly controlled subsidiaries or branches of the concerned company with no consolidated companion
U2: designating that a statement is not integrated with the statements of the possible controlled subsidiaries or branches of the concerned company with a consolidated companion

solution adopted here is the same one as set out in Ferschli et al., (2019 and 2021 based on the suggestion in Grabner, 2016). The corresponding programming steps for Mathematica are attached in the appendix. They generally follow this logic: first it must be determined whether the data set contains a national parent company which is consolidated as well as its subsidiaries which are unconsolidated, which could trigger double counting. Generally, if only U-codes can be found, meaning that all observations are unconsolidated, there is no problem. The observations would still need to be added up to represent the parent company's entire revenue. In the cases where double-counting could occur, either the parent company could be dropped while adding up all subsidiaries, or all unconsolidated subsidiaries could be dropped from the data set, leaving only the consolidated parent. This has to be done for each year, sector and country, of course. Which option is chosen has different repercussions: Option one estimates the resulting concentration conservatively while option two might ignore the revenue of subsidiaries in other sectors. While the safest approach would be to calculate both alternatives and compare their merits in-depth, in the calculation of the indices below, variant two was pragmatically chosen without this comparison. While there are no categorically right or wrong answers in which approach is chosen in which instance, it is important to be aware of how the corresponding choice may determine the result. Theoretically there are also complications to consider which cannot be engaged on an aggregated statistical level: what if the parent company has an independent economic activity in addition to the sum of that of its subsidiaries? What if relevant subsidiaries are classified within a different sector, but organizationally still belong to the revenues of a parent (meaning that the added U's do not equal the C)? Such complications would unfortunately have to be researched and assessed case by case, firm by firm, however. There are also potential issues resulting from the fact that economic sectoral coding is a very crude grid to capture economic activity in the first place. For example, a parent company may easily be located in a different NACE sector than its subsidiaries event though their revenues belong together and are technically accrued in the same sector under the same type of economic activity. But legal fiction has placed one or several parts of the company in a different economic sector. The opposite may also be the case, where parts of a firm strictly belong in another sector but are counted among the original sectors revenue. These problems are additionally exacerbated when considering international borders and economic activity between countries. Adding the revenues of a global parent company would require very extensive research, analysis and knowledge of international tax-strategies. All this is especially true for the automotive sector of course, which is dominated by large global firms in constant flux of mergers and acquisition. Given these constraints, however, and adapting the data in the ways described above, as well as being aware of partially massive "n.a.'s", the revenue data of Orbis can be used to calculate sectoral concentration measures.

Another abstraction to briefly mention, although it is more thoroughly addressed in chapter 2, is that what "concentration in manufacturing" in fact means. What has been done in the construction of these indices for the manufacturing sector, is to treat the entire field of economic activity as in competition with one another. Then, based on this pool of producers, it is estimated how much of the total revenue of "manufacturing" is captured by the largest producer. However, say the largest producer is a manufacturer of cement, and the 100th largest produces bread. They do not share the same pool of revenue to begin with and an estimation of "competition" between them or a "concertation" of the sector is a fiction[46]. Here mark-up calculations would indeed

[46] What would need to be done, in fact, would be to gather data on all sectors separately, estimated their concentration, and then average the results for all sectors. This would give a more representative, if still not strictly "correct" result. Gathering this data is a lot of work, however, and more importantly, not possible anymore for the same time-series as the original Orbis-data for this estimation has been

improve the analysis perhaps. While a fiction, this approach is, however, not pointless. Given that these values are constructed for all of the manufacturing sectors in the sample, the metric is sui generis comparable. Since the point is precisely this comparability between countries, and in comparison, to their own automotive sectors, their use is not unreasonable and can still teach us something about the economic structure of countries. Figure 17 to 24 in the appendix shows the resulting concentrations measures (HHI, c3, c10, c30) for the automotive sectors of all countries as well as the manufacturing sectors excluding the automotive sector between 2010-2019. Table 25 and 26 show the "valid observation degradation" of the used Orbis data for 25 countries of the sample for the year 2019.

Section 5: Survey Questions

1. How do you perceive the speed of technological change at your plant? Fast, slow?
2. Which technological change has affected your work the most over the last couple of years, or the course of your working life?
3. Have there recently been conflicts about the implementation of new technologies? What were the technologies, and what the conflicts?
4. Do you think new technologies are good for workers? / Are you for or against more automation?
5. Do you sabotage machines? Why, why not? (well…)
6. Why does management use new technologies?
7. Do you have control over tasks and the technology you use in production? (well….)
8. Do you care about what technology is used in production?
9. How has the labour-shortage affected your perception of worker autonomy and control in production?
10. Do you think technological development is important for Austrian manufacturing to continue?
11. How are technological changes communicated to you? As order s or briefings or consultations?
12. Who implements new technologies? Who trains you on these technologies?
13. How has your work changed over the past years?
14. Has the change to electromobility changed the tasks or your work?
15. If you could change something about your work, what would it be?

downloaded in 2020. Thus, only a robustness-check could be constructed for a limited number of years against which to compare the other derived concentration measures.

Section 6: Baseline Interview Questions

A.) Introduction and Overview
1.) Personal introduction
2.) Description of project and process (anonymization, informed consent form)

B.) Firm
1.) Which sector does your company belong to and what do you produce?
2.) How would describe the market conditions under which you produce? (many or few employees, competitive pressures, national or international markets)
3.) How are your production capacities organized? (high or low-tech, nationally or internationally)

C.) Position
1.) What is your position in your firm and what are your responsibilities?
2.) How long have you had this position for, have you had similar positions in other firms?
3.) How would you describe your professional experience with automation and specifically robotics?

D.) Automation in the automotive sector

1.) How has automation developed in the past ten years in your firm, in particular the use of robots? How does this development differ from other firms in the Austrian, Central-European and global automotive industry?

2.) What were the most relevant technological developments in the course of this automation over the past ten years?

3.) Which criteria go into making an investment in new automation technology? Who ultimately makes the decision?

4.) How important is technological investment for the profitability of your firm and production site, and Austrian manufacturing in general?

5.) Which effects on work have you seen and which do you expect in the course of further automation?

6.) Which economic or technological problems are to be solved through automation/ robot use?

7.) How do automation strategies differ in the automotive industry?

8.) Which concerns would you like to see addressed given a higher automation of your production site?

9. Which limits and barriers exist in your firm fort he further automation of production? Which parts of production have not or cannot be automated?

10.) How will the use of robots change the automotive industry over the next 10 years? Do you think fully-automated manufacturing is feasible?

Table 15: Regression Output Model Variant 1

Regression results (unbalanced sample): Lag=1

	Dependent variable:							
	Dependent Variable: Labour productivity							
	Manufacturing (without Auto)				Automotive			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
lag(log_HHI, 1)	-0.092***				0.099***			
	(0.032)				(0.031)			
lag(log_C3, 1)		-0.148***				0.451***		
		(0.034)				(0.074)		
lag(log_C10, 1)			-0.208***				0.641***	
			(0.060)				(0.078)	
lag(log_C30, 1)				-0.229***				0.805***
				(0.065)				(0.191)
lag(log_rob_dens_hrs, 1)	0.069**	0.068**	0.069**	0.072**	-0.114***	-0.120***	-0.118***	-0.112***
	(0.029)	(0.030)	(0.032)	(0.033)	(0.008)	(0.009)	(0.008)	(0.010)
Country FE	✓	✓	✓	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓	✓	✓	✓
Obs.:	197	197	197	197	198	198	198	198
R-squared	0.123	0.107	0.101	0.093	0.133	0.216	0.181	0.148
Adj. R-squared	-0.054	-0.073	-0.081	-0.09	-0.048	0.052	0.01	-0.029
Note:					*p<0.1; **p<0.05; ***p<0.01			

Table 16: Regression Output Model Variant 3

Regression results (unbalanced sample): Lag=1

	Dependent variable:							
	Dependent Variable: Robot Density							
	Manufacturing (without Auto)				Automotive			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
lag(log_HHI, l)	0.087^{**}				-0.0005			
	(0.038)				(0.043)			
lag(log_C3, l)		0.125^{***}				0.024		
		(0.040)				(0.177)		
lag(log_C10, l)			0.198^{**}				0.106	
			(0.081)				(0.196)	
lag(log_C30, l)				0.211^{**}				-0.449^{**}
				(0.095)				(0.193)
lag(log_labprod_hrs, l)	0.850^{***}	0.827^{***}	0.826^{***}	0.800^{***}	-0.260^{**}	-0.267^{*}	-0.276^{**}	-0.230^{**}
	(0.207)	(0.209)	(0.212)	(0.221)	(0.123)	(0.145)	(0.132)	(0.110)
Country FE	✓	✓	✓	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓	✓	✓	✓
Obs.:	197	197	197	197	198	198	198	198
R-squared	0.108	0.104	0.105	0.104	0.017	0.017	0.018	0.022
Adj. R-squared	-0.073	-0.077	-0.076	-0.077	-0.188	-0.188	-0.187	-0.182
Note:						*p<0.1; **p<0.05; ***p<0.01		

Table 17: Regression Output Model Variant 4

Regression results (unbalanced sample): Lag=1

	Dependent variable:							
	Dependent Variable: Concentration measures							
	HHI (Manu)	C3 (Manu)	C10 (Manu)	C30 (Manu)	HHI (Auto)	C3 (Auto)	C10 (Auto)	C30 (Auto
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
lag(log_rob_dens_hrs, l)	0.099	0.056	0.040^{*}	0.024	0.036	0.014	0.010	-0.003
	(0.092)	(0.046)	(0.024)	(0.015)	(0.027)	(0.023)	(0.006)	(0.005)
lag(log_labprod_hrs, l)	-0.791^{**}	-0.509^{***}	-0.391^{***}	-0.282^{***}	0.326^{**}	0.185^{**}	0.102^{**}	0.040
	(0.361)	(0.177)	(0.083)	(0.055)	(0.151)	(0.081)	(0.040)	(0.028)
Country FE	✓	✓	✓	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓	✓	✓	✓
Obs.:	197	197	197	197	198	198	198	198
R-squared	0.063	0.084	0.099	0.073	0.035	0.039	0.048	0.012
Adj. R-squared	-0.127	-0.102	-0.084	-0.115	-0.166	-0.162	-0.15	-0.194
Note:						*p<0.1; **p<0.05; ***p<0.01		

Table 18: Comparion Panels

ıtrol Panel					***Balanced Panel***					***Unbalanced Panel***				
lprod=conc+robden	Conc	Manu	Sig	Neg	V1: lprod=conc+robden	Conc	Manu	Nsig	Neg	V1: lprod=conc+robden	Conc	Manu	Sig	Neg
		Auto	Nsig	Pos			Auto	Sig	Pos			Auto	Sig	Pos
	Robden	Manu	Sig	Pos		Robden	Manu	Sig	Pos		Robden	Manu	Sig	Pos
		Auto	Sig	Neg			Auto	Sig	Neg			Auto	Sig	Neg
					V2: lprod=conc+robden	Conc	Manu	Nsig	Neg	**V2: lprod=conc+robden+capint**	Conc	Manu	Sig	Neg
							Auto	Sig	Pos			Auto	Sig	Pos
						RobDen	Manu	Sig	Pos		RobDen	Manu	Sig	Pos
							Auto	Sig	Neg			Auto	Sig	Neg
						CapInt	Manu	Nsig	Pos		CapInt	Manu	Sig	Neg
							Auto	Sig	Neg			Auto	Sig	Neg
					V3: robden=conc+lprod	Conc	Manu	Sig~	Neg	V3: robden=conc+lprod	Conc	Manu	Sig	Pos
							Auto	Sig~	Neg			Auto	Nsig	Pos
						Lprod	Manu	Sig	Pos		Lprod	Manu	Sig	Pos
							Auto	Nsig	Neg			Auto	Sig~	Neg
					V4: conc=robden+lprod	Robden	Manu	Sig~	Neg	V4: conc=robden+lprod	Robden	Manu	Nsig	Pos
							Auto	Nsig	Mix			Auto	Nsig	Pos
						Lprod	Manu	Nsig	Neg		Lprod	Manu	Sig	Neg
							Auto	Sig~	Pos			Auto	Sig	Pos

Table 19: Regression Output Model Variant 1

Regression results (unbalanced sample): Lag=1

	Dependent variable:							
	Dependent Variable: Labour productivity							
	Manufacturing (without Auto)				Automotive			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
lag(log_HHI, l)	-0.092***				0.099***			
	(0.032)				(0.031)			
lag(log_C3, l)		-0.148***				0.451***		
		(0.034)				(0.074)		
lag(log_C10, l)			-0.208***				0.641***	
			(0.060)				(0.078)	
lag(log_C30, l)				-0.229***				0.805***
				(0.065)				(0.191)
lag(log_rob_dens_hrs, l)	0.069**	0.068**	0.069**	0.072**	-0.114***	-0.120***	-0.118***	-0.112***
	(0.029)	(0.030)	(0.032)	(0.033)	(0.008)	(0.009)	(0.008)	(0.010)
Country FE	✓	✓	✓	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓	✓	✓	✓
Obs.:	197	197	197	197	198	198	198	198
R-squared	0.123	0.107	0.101	0.093	0.133	0.216	0.181	0.148
Adj. R-squared	-0.054	-0.073	-0.081	-0.09	-0.048	0.052	0.01	-0.029
Note:						*p<0.1; **p<0.05; ***p<0.01		

Table 20: Regression Output Model Variant 3

Regression results (unbalanced sample): Lag=1

	Dependent variable:							
	Dependent Variable: Robot Density							
	Manufacturing (without Auto)				Automotive			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
lag(log_HHI, l)	0.087**				-0.0005			
	(0.038)				(0.043)			
lag(log_C3, l)		0.125***				0.024		
		(0.040)				(0.177)		
lag(log_C10, l)			0.198**				0.106	
			(0.081)				(0.196)	
lag(log_C30, l)				0.211**				-0.449**
				(0.095)				(0.193)
lag(log_labprod_hrs, l)	0.850***	0.827***	0.826***	0.800***	-0.260**	-0.267*	-0.276**	-0.230**
	(0.207)	(0.209)	(0.212)	(0.221)	(0.123)	(0.145)	(0.132)	(0.110)
Country FE	✓	✓	✓	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓	✓	✓	✓
Obs.:	197	197	197	197	198	198	198	198

R-squared	0.108	0.104	0.105	0.104	0.017	0.017	0.018	0.022
Adj. R-squared	-0.073	-0.077	-0.076	-0.077	-0.188	-0.188	-0.187	-0.182
Note:								*p<0.1; **p<0.05; ***p<0.01

Table 21: Regression Output Model Variant 4

Regression results (unbalanced sample): Lag=1

	Dependent variable:							
	Dependent Variable: Concentration measures							
	HHI (Manu)	C3 (Manu)	C10 (Manu)	C30 (Manu)	HHI (Auto)	C3 (Auto)	C10 (Auto)	C30 (Auto
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
lag(log_rob_dens_hrs, l)	0.099	0.056	0.040*	0.024	0.036	0.014	0.010	-0.003
	(0.092)	(0.046)	(0.024)	(0.015)	(0.027)	(0.023)	(0.006)	(0.005)
lag(log_labprod_hrs, l)	-0.791**	-0.509***	-0.391***	-0.282***	0.326**	0.185**	0.102**	0.040
	(0.361)	(0.177)	(0.083)	(0.055)	(0.151)	(0.081)	(0.040)	(0.028)
Country FE	✓	✓	✓	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓	✓	✓	✓
Obs.:	197	197	197	197	198	198	198	198
R-squared	0.063	0.084	0.099	0.073	0.035	0.039	0.048	0.012
Adj. R-squared	-0.127	-0.102	-0.084	-0.115	-0.166	-0.162	-0.15	-0.194
Note:								*p<0.1; **p<0.05; ***p<0.01

Table 22: Comparison panels

Control Panel					***Balanced Panel***					***Unbalanced Pa***
V1: lprod=conc+robden	Conc	Manu	Sig	Neg	V1: lprod=conc+robden	Conc	Manu	Nsig	Neg	V1: lprod=conc+
		Auto	Nsig	Pos			Auto	Sig	Pos	
	Robden	Manu	Sig	Pos		Robden	Manu	Sig	Pos	
		Auto	Sig	Neg			Auto	Sig	Neg	
					V2: lprod=conc+robden	Conc	Manu	Nsig	Neg	**V2: lprod=conc+rob**
							Auto	Sig	Pos	
						RobDen	Manu	Sig	Pos	
							Auto	Sig	Neg	
						CapInt	Manu	Nsig	Pos	
							Auto	Sig	Neg	
					V3: robden=conc+lprod	Conc	Manu	Sig~	Neg	V3: robden=con
							Auto	Sig~	Neg	
						Lprod	Manu	Sig	Pos	
							Auto	Nsig	Neg	
					V4: conc=robden+lprod	Robden	Manu	Sig~	Neg	V4: conc=robder

							Auto	Nsig	Mix	
						Lprod	Manu	Nsig	Neg	
							Auto	Sig~	Pos	

Table 23: Table Output Variation 1

Dependent Var	***log LP***					
Capint Version	*capital-VA ratio*					
	Balanced		**Unbalanced**		**No Outliers**	
	Manu	Auto	Manu	Auto	Manu	Auto
Concentration	insig	pos**	neg***	neg** (HHI)	pos*	pos***
Robden	insig	insig	neg***	neg***	pos***	neg**
N	136	136	154	150	120	120
Capint Version	*capital - hours ratio*					
	Balanced		**Unbalanced**			
	Manu	Auto	Manu	Auto	**No Outliers**	
Concentration	pos**	pos*	neg***	neg** (HHI)	pos***	pos***
Robden	insig	insig	neg***	neg***	pos*	neg**
N	136	136	154	150	120	120

Table 24: Table Output Variation 2

Dependent Var	***log real va in ppp***					
Capint Version	*capital-VA ratio*					
	Balanced		**Unbalanced**		**No Outliers**	
	Manu	Auto	Manu	Auto	Manu	Auto
Concentration	insig	neg*** (HHI)	neg***	neg*** (HHI)	insig	pos** (exc. HHI)
Robden	insig	pos***	neg***	insig	pos***	pos**
N	136	136	154	150	120	120
Capint Version	*capital - hours ratio*					
	Balanced		**Unbalanced**		**No Outliers**	
	Manu	Auto	Manu	Auto	Manu	Auto
Concentration	insig	neg*** (HHI)	neg***	neg*** (HHI)	pos*	pos** (exc. HHI)
Robden	pos***	pos***	neg***	insig	pos***	pos**
N	136	136	154	150	120	120

Table 25: Table Output Variation 3

Dependent Var	***log hours worked***					
Capint Version	*capital-VA ratio*					
	Balanced		**Unbalanced**		**No Outliers**	
	Manu	Auto	Manu	Auto	Manu	Auto
Concentration	neg**	neg***	pos***	neg***	neg**	neg***
Robden	pos*	pos***	pos***	pos***	pos***	pos***
N	136	136	190	186	120	120
Capint Version	*capital - hours ratio*					
	Balanced		**Unbalanced**		**No Outliers**	
	Manu	Auto	Manu	Auto	Manu	Auto
Concentration	neg***	neg***	pos**	insig	neg**	neg***
Robden	pos***	pos***	pos***	pos***	pos***	pos**
N	136	136	190	186	120	120

Table 26: Structure of Interview Respondent Sample.

Signifier	Firm Type	Position Interviewee (Gender)	Product	GPL	Employees	Duration
E-1	Automation Technology Provider	Project Engineer and Chief Sales Officer, M	Automated Guided Vehicles	3	82	01:05:44
E-2	Automation Technology Provider	Chief Sales Officer, M	Artifical Intelligence for Manufacturing	1	7	00:29:43
E-3	Automation Technology Provider Startup	CEO, M	Artifical Intelligence for Manufacturing	1	100	00:47:08
E-4	Automation Technology Provider Startup	CEO, M	AI solutions for Robots	1	20	00:25:00
E-5	Automation Technology Provider and Systems Integrator	Sales Manager, M	Robots	60	15000	00:58:45
E-6	Automation Technology Provider and Systems Integrator	Key Account Manager	Robots	25	15000	00:54:28
E-7	Systems Integrator	CEO and Chief Engineer, M	Automation Solutions	1	/	01:11:22
E-8	Systems Integrator	Head of Business Development	Automation Solutions	1	16	01:06:05
E-9	Automation Technology Provider and Systems Integrator	Regional Sales Manager	Robots	12	5500	00:39:22
M-1	Automotive Supplier	Talent Marketing & University Relations, F	Microelectronics	23	56200	01:00:00
M-2	Automotive Supplier	Head of Digital Office, M	Glass and Aluminium Processing	40	9000	00:30:00
M-3	Automotive Supplier	Vice Presiden Production System, M	Electronic Components	4	1800	01:19:17
M-4	Automotive Supplier V	Team lead Machine Construction	Light Systems	12	10000	01:36:06
M-5	Automotive Supplier V	Lead - Strategy Industry 4.0, M	Body Exterirors, Structures, Power, Vision, Seating Systems	341	11.900	01:04:37
M-6	Automotive Supplier V	Project Lead Production, M	Body Exterirors, Structures, Power, Vision, Seating Systems	1	11.900	01:35:31
M-7	Autmotive Supplier V	CEO, M	Hinges and Glass	9	4788	Only visit
M-8	Automotive Supplier V	Group Lead Automation Technology, M	Technology Development Center (joining, welding, bonding, screwing)	341	11900	Only visit
M-9	Automotive Supplier V	CEO, M	Logistics and Warehousing for industry	40	5300	Only visit
M-10	Automotive Supplier	Group Lead Automation Technology, M	Body Exteriors, Structures, Power, Vision, Seating Systems	341	11.900	00:44:00
W-1	Automotive Supplier V	Worker Council, F	Sintered Parts, Bearings, Friction linings	29 GPL	7546	01:36:10
W-2	Automotive Supplier (OEM) V	Worker Council, M	Engines	1	4500	05:30:56
W-3	Automotive Supplier V	Worker Council, M	Rims	8 GPL	4255	02:44:24
W-4	Manufacturing Union	Union Secretary , M	/	1	/	01:39:35
W-5	Automotive Supplier V	Production Master, M	Body Exterirors, Structures, Power, Vision, Seating Systems	1	11.900	02:05:00
W-6	Automotive Supplier (OEM) V	Worker	Engines	1	11.900	/
W-7	Automotive Supplier (OEM) V	Worker	Engines	1	11.900	/
W-8	Automotive Supplier (OEM) V	Worker	Engines	1	11.900	/
W-9	Automotive Supplier (OEM) V	Worker	Engines	1	11.900	/
W-10	Automotive Supplier (OEM) V	Worker	Engines	1	11.900	/
W-11	Automotive Supplier (OEM) V	Worker	Engines	1	11.900	/
W-12	Automotive Supplier (OEM) V	Worker	Engines	1	11.900	/
W-13	Automotive Supplier (OEM) V	Worker	Engines	1	11.900	/
W-14	Automotive Supplier (OEM) V	Worker	Engines	1	11.900	/
W-15	Automotive Supplier (OEM) V	Worker	Engines	1	11.900	/
W-16	Automotive Supplier (OEM) V	Worker	Engines	1	11.900	/
W-17	Automotive Supplier (OEM) V	Worker	Engines	1	11.900	/
W-18	Automotive Supplier (OEM) V	Worker	Engines	1	11.900	/
W-19	Automotive Supplier (OEM) V	Worker	Engines	1	11.900	/
W-20	Automotive Supplier (OEM) V	Worker	Engines	1	11.900	/
W-21	Automotive Supplier (OEM) V	Worker	Engines	1	11.900	/
W-22	Automotive Supplier (OEM) V	Worker	Engines	1	11.900	/
W-23	Automotive Supplier (OEM) V	Worker	Engines	1	11.900	/
W-24	Automotive Supplier (OEM) V	Worker	Engines	1	11.900	/
R-1	Representation of Interest	Board Member and Engineering Prof., M	Socieity for Measurement- Automation and Robot Technology	Austria	/	03:58:20
R-2	Representation of Interest	CEO, M	Society for the Advancement of the digitalisation of Austrian manufacturing	Austria	/	01:23:25

Table 27: Sectoral Characteristics 2008 to 2021. Source: Austrian Statistics Agency

Number of Firms	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Automotive Sector	294	290	296	329	310	305	317	235	228	227	226	229	233	242
Total Manufacturing (excl. Auto)	26016	25633	25439	25273	24768	24583	25330	25387	25031	25369	25115	25121	25232	31708
Average (excl. Auto)	1131,1	1114,5	1106,0	1098,8	1076,9	1068,8	1101,3	1103,8	1088,3	1103,0	1092,0	1092,2	1097,0	1378,6
Total Manufacturing	26310	25923	25735	25602	25078	24888	25647	25622	25259	25596	25341	25350	25465	31950
Auto % of Total (excl. Auto)	1,1	1,1	1,2	1,3	1,2	1,2	1,2	0,9	0,9	0,9	0,9	0,9	0,9	0,8
Total Employees in Thsd.														
Automotive Sector	32,3	29,2	29,4	31,5	31,5	30,6	31,1	31,6	31,9	35,7	38,9	38,7	37,1	36,2
Total Manufacturing (excl. Auto)	596,0	559,4	568,4	580,9	582,4	580,6	584,5	588,8	594,1	606,6	619,2	624,7	613,7	632,5
Average (excl. Auto)	25,9	24,3	24,7	25,3	25,3	25,2	25,4	25,6	25,8	26,4	26,9	27,2	26,7	27,5
Total Manufacturing	628,3	588,6	597,8	612,4	613,9	611,3	615,6	620,3	625,9	642,4	658,1	663,4	650,8	668,7
Auto % of Total (excl. Auto)	5,1	5,0	4,9	5,1	5,1	5,0	5,1	5,1	5,1	5,6	5,9	5,8	5,7	5,4
Total Hours Worked in Mio.														
Automotive Sector	54,5	45,5	48,1	49,9	51,2	49,5	49,8	50,5	51,6	54,9	62,4	63,2	56,1	56,9
Total Manufacturing (excl. Auto)	963,2	881,9	891,1	913,3	918,5	915,6	913,2	913,0	918,8	931,6	948,6	958,7	900,3	945,4
Average (excl. Auto)	41,9	38,3	38,7	39,7	39,9	39,8	39,7	39,7	39,9	40,5	41,2	41,7	39,1	41,1
Total Manufacturing	1.017,7	927,4	939,2	963,3	969,7	965,1	963,0	963,4	970,4	986,4	1.011,0	1.022,0	956,4	1.002,3
Auto % of Total (excl. Auto)	5,4	4,9	5,1	5,2	5,3	5,1	5,2	5,2	5,3	5,6	6,2	6,2	5,9	5,7
Total Technical Production in Bio. Euro														
Automotive Sector	11973,0	8568,5	10833,8	12415,7	12230,0	13019,9	13287,6	13399,0	13822,3	14295,3	16332,0	17286,1	13980,2	15320,7
Total Manufacturing (excl. Auto)	119257,7	101131,2	110695,3	122241,6	122834,0	122965,0	124269,3	126352,3	129409,2	137262,0	145531,1	147639,9	137471,6	160725,7
Average (excl. Auto)	5185,1	4397,0	4812,8	5314,9	5340,6	5346,3	5403,0	5493,6	5626,5	5967,9	6327,4	6419,1	5977,0	6988,1
Total Manufacturing	131230,7	109699,7	121529,1	134657,3	135064,0	135984,9	137556,8	139751,3	143231,6	151557,3	161863,1	164926,0	151451,9	176046,4
Auto % of Total (excl. Auto)	9,12	7,81	8,91	9,22	9,05	9,57	9,66	9,59	9,65	9,43	10,09	10,48	9,23	8,70

Table 28: Automotive Characteristics 2008-2021. Source: Austrian Statistics Agency

Totals C-29	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2015**	**2014**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Total Firms	294	290	296	329	310	305	235	317	228	227	226	229	233	242
Total Employed	31527	29174	28698	31485	30704	29851	30240	30160	31858	35749	38872	37177	35230	36187
Total Workers	19947	18124	18000	19507	18766	19028	18746	18894	19598	22675	23513	21979	20545	21066
Total Employees	9840	9383	9066	10193	10231	9120	9871	9500	10622	11401	13694	13599	13168	13597
Total Technical Production	11358069	8568494	10565394	12415662	11924173	12649279	12689230	12814848	13822333	14295296	16332030	17286068	13252088	15320686

Table 29: Growth of Austrian Automotive Industry Metrics

Growth Between 2008 and 2021	
Total Firms	-17,7
Total Employed	14,8
Total Workers	5,6
Total Employees	38,2
Total Technical Production	34,9

Table 30: Automotive Characteristics sorted by Firm Size. Source: Austrian Statistics Agency. Own Calculation

H.v. Kraftwagen und -teilen <C29>	**2020**		
			%
Investitionen insgesamt in 1.000 EUR	0 bis 9 Beschäftigte	1046	0,19
	10 bis 19 Beschäftigte	2877	0,52
	20 bis 49 Beschäftigte	3816	0,69
	50 bis 249 Beschäftigte	60756	11,03
	250 und mehr Beschäftigte	482376	**87,57**
	Total	550871	
Umsatzerlöse in 1.000 EUR	0 bis 9 Beschäftigte	44461	0,28
	10 bis 19 Beschäftigte	105309	0,66
	20 bis 49 Beschäftigte	91736	0,57
	50 bis 249 Beschäftigte	1370158	8,54
	250 und mehr Beschäftigte	14436656	**89,96**

	Total	16048320	
Anzahl der Unternehmen	0 bis 9 Beschäftigte	115	49,57
	10 bis 19 Beschäftigte	34	14,66
	20 bis 49 Beschäftigte	19	8,19
	50 bis 249 Beschäftigte	37	15,95
	250 und mehr Beschäftigte	27	**11,64**
	Total	232	
Beschäftigte - insgesamt	0 bis 9 Beschäftigte	342	0,91
	10 bis 19 Beschäftigte	471	1,25
	20 bis 49 Beschäftigte	637	1,69
	50 bis 249 Beschäftigte	4923	13,05
	250 und mehr Beschäftigte	31340	**83,10**
	Total	37713	

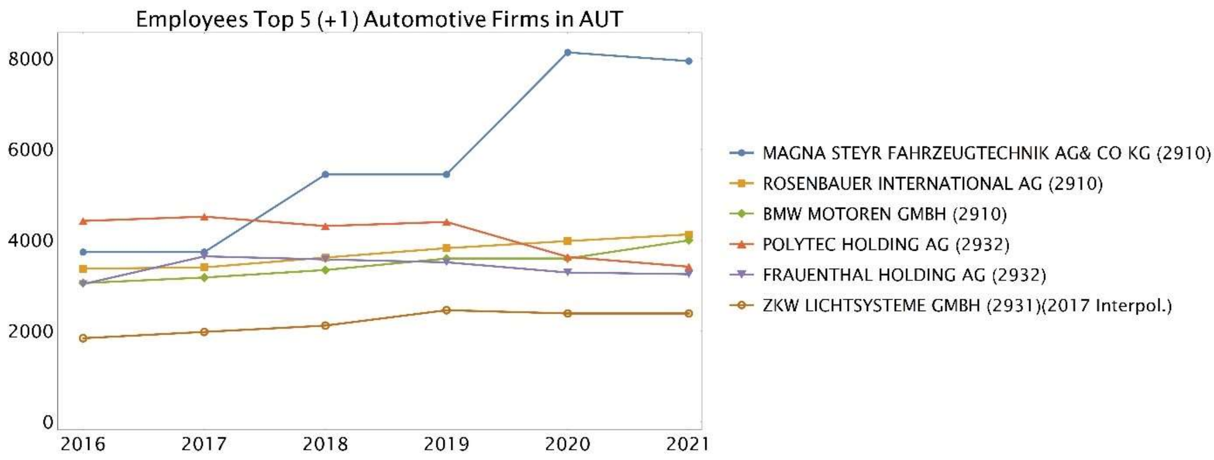

Figure 22:Employees Top 6 Austrian Automotive Firms. Source: Orbis Bureau Van Dijk.

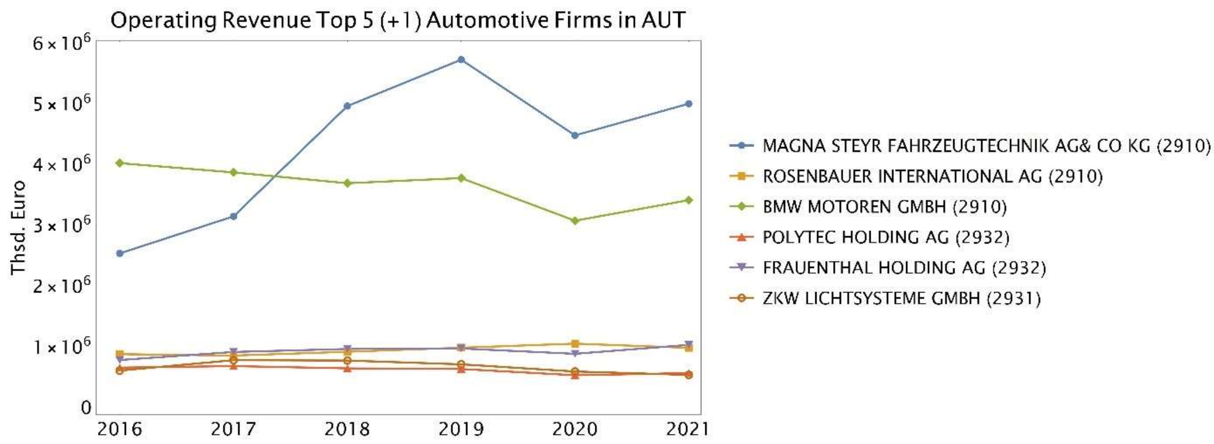

Figure 23: Operating Revenue Top 6 Austrian Automotive Firms. Source: Orbis Bureau Van Dijk.

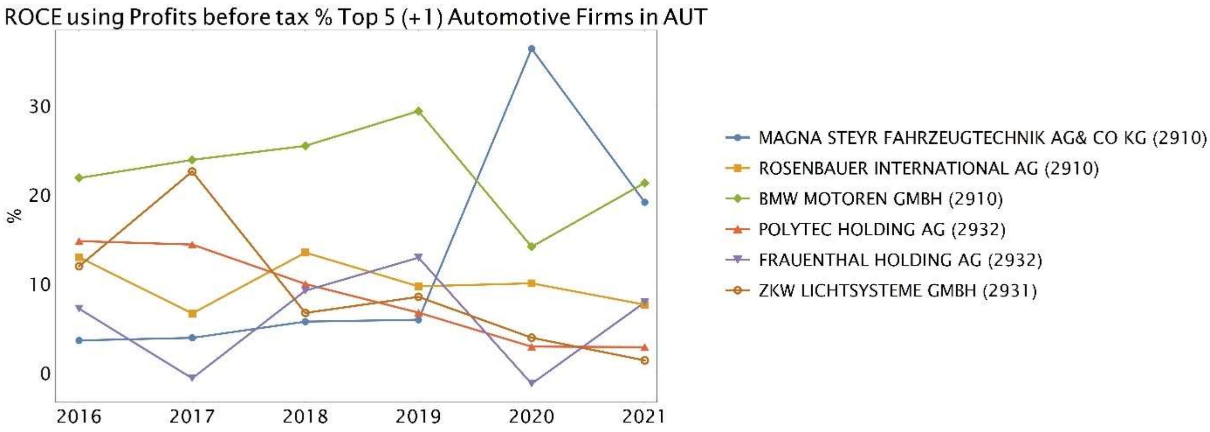

Figure 24: ROCE Profits Before Tax. Source. Orbis Bureau Van Dijk. Own Figure

Table 31: Number of Employees Austrian Automotive Firms. Source. Orbis Bureau Van Dijk

Number of Employees	NACE Rev. 2	2021	2020	2019	2018	2017	2016
MAGNA STEYR FAHRZEUGTECHNIK AG & CO KG	2910	7947	8138	5450	5450	3740	3740
ROSENBAUER INTERNATIONAL AG	2910	4130	3984	3828	3621	3405	3375
BMW MOTOREN GMBH	2910	4000	3600	3600	3347	3182	3059
POLYTEC HOLDING AG	2932	3420	3636	4406	4315	4522	4427
FRAUENTHAL HOLDING AG	2932	3255	3292	3517	3580	3648	3036
ZKW LICHTSYSTEME GMBH	2931	2390	2390	2462	2123	n.a.	1845
OPEL WIEN GMBH	2910	600	600	1000	1497	1497	1600
GF CASTING SOLUTIONS ALTENMARKT GMBH & CO KG	2932	550	512	545	600	600	555
STIWA ADVANCED PRODUCTS GMBH	2932	536	543	464	420	400	400
HELLA FAHRZEUGTEILE AUSTRIA GMBH	2931	460	463	432	400	400	420
KTM COMPONENTS GMBH	2932	441	429	430	461	461	420
ASPOECK SYSTEMS GMBH	2931	360	368	375	318	295	302
GFOELLNER FAHRZEUGBAU UND CONTAINERTECHNIK GMBH	2920	283	278	n.a.	n.a.	n.a.	n.a.
KROMBERG & SCHUBERT AUSTRIA GMBH & CO. KG	2931	248	248	239	229	n.a.	220
ASTOTEC AUTOMOTIVE GMBH	2932	219	n.a.	n.a.	1	1	n.a.
HANS BRANTNER & SOHN FAHRZEUGBAUGESELLSCHAFT M.B.H.	2920	191	182	182	157	146	163
GD EUROPEAN LAND SYSTEMS - STEYR GMBH	2910	132	144	144	141	150	240
RESSENIG FAHRZEUGBAU GMBH	2920	131	131	143	143	n.a.	n.a.
WECUBEX FERTIGUNGSTECHNIK GMBH	2920	130	165	159	130	101	n.a.
WALSER GMBH	2920	130	130	130	151	151	151
AL-KO TECHNOLOGY AUSTRIA GMBH	2932	123	137	n.a.	142	152	243
OTTO WOHLGENANNT GESELLSCHAFT M.B.H.	2920	120	129	129	128	119	92
TCG UNITECH SYSTEMTECHNIK GMBH	2932	104	100	112	113	117	110
TROPPER MASCHINEN UND ANLAGEN GMBH.	2920	100	89	90	89	75	70
KMB METALLTECHNIK GMBH	2932	80	87	94	94	77	77
FRITZMEIER GESELLSCHAFT M.B.H.	2920	71	77	77	78	79	100
Total 2021		30151	29852	28008	27728	23318	24645
Share Top 5		75,46018374	75,87431328	74,26806627	73,25807848	79,32498499	71,56421181
Share top 6		83,38695234	83,88047702	83,05841188	80,91459896	79,32498499	79,05051735

Table 32: Operating Revenue Austrian Automotive Firms. Source: Orbis Bureau Van Dijk.

Operating Revenue in th Euro	NACE Rev. 2	2021	2020	2019	2018	2017	2016
MAGNA STEYR FAHRZEUGTECHNIK AG & CO KG	2910	5001206	4479820	5725976	4962394	3146235	2536131
BMW MOTOREN GMBH	2910	3413697	3074707	3776199	3691991	3869638	4022194
KROMBERG & SCHUBERT AUSTRIA GMBH & CO. KG	2931	1066707	942234	1177238	1185932	1116486	1043562
FRAUENTHAL HOLDING AG	2932	1030097	882920	970069	963013	913262	780477
ROSENBAUER INTERNATIONAL AG	2910	981445	1050205	983455	916564	854111	877538
POLYTEC HOLDING AG	2932	565258	530388	632655	643561	680605	655645
ZKW LICHTSYSTEME GMBH	2931	535845	591768	709598	772200	778444	606678
KTM COMPONENTS GMBH	2932	181080	142832	169801	193669	182022	168031
GF CASTING SOLUTIONS ALTENMARKT GMBH & CO KG	2932	165742	133239	142001	167174	162219	171104
ASPOECK SYSTEMS GMBH	2931	162524	116511	138696	133785	114798	99700
STIWA ADVANCED PRODUCTS GMBH	2932	139623	102389	123139	137009	106851	83976
ASTOTEC AUTOMOTIVE GMBH	2932	116258	n.a.	n.a.	n.a.	n.a.	n.a.
HELLA FAHRZEUGTEILE AUSTRIA GMBH	2931	110076	92019	104962	105771	91145	90276
KAESSBOHRER TRANSPORT TECHNIK GMBH	2920	94786	136134	181015	155749	n.a.	n.a.
OPEL WIEN GMBH	2910	86416	105084	14231	232452	14525	187518
TCG UNITECH SYSTEMTECHNIK GMBH	2932	64282	58515	78377	79120	74376	74575
AL-KO TECHNOLOGY AUSTRIA GMBH	2932	48987	38186	38851	42314	42770	n.a.
GD EUROPEAN LAND SYSTEMS - STEYR GMBH	2910	43562	25373	58547	41980	29654	28381
GFOELLNER FAHRZEUGBAU UND CONTAINERTECHNIK GMBH	2920	41934	52210	46050	48740	n.a.	n.a.
VNT AUTOMOTIVE GMBH	2932	41037	34264	55822	73349	72138	55774
WILLI MEINGAST GESELLSCHAFT M.B.H. & CO. KG.	2920	9395	9509	n.a.	9000	n.a.	n.a.
SCHUH KAROSSERIEBAU GMBH	2920	6000	6000	n.a.	15333	6130	6000
STEYR TRUCKS SALES AND SERVICES INTERNATIONAL GMBH	2920	4600	4600	n.a.	n.a.	5500	5500
JOSEF RINNER KG.	2920	2900	n.a.	n.a.	n.a.	n.a.	n.a.
MARIO JOSEF EGGER	2920	2130	n.a.	n.a.	n.a.	n.a.	n.a.
JOHANNES LEOPOLD SCHMALZL	2920	1980	n.a.	n.a.	n.a.	n.a.	n.a.
WEINMANN KG	2920	1833	2000	2500	2500	2500	2500
Total 2021		13919399	12610907	15129182	14573600	12263410	11495560
Share Top 5		82,56931382	82,70527719	83,50046797	80,41865841	80,72577072	80,55198639
Share top 6		86,63025072	86,91106506	87,68215485	84,83459541	86,27565469	86,25544935

Table 33: Profit before Tax Austrian Automotive Firms. Source: Orbis Bureau Van Dijk.

Profit before Tax in th Euro	**NACE Rev. 2**	**2021**	**2020**	**2019**	**2018**	**2017**	**2016**
MAGNA STEYR FAHRZEUGTECHNIK AG & CO KG	2910	238527,1	812237,3	92651,4	73011,5	51689,7	66231,6
BMW MOTOREN GMBH	2910	187572,9	166674,0	258717,0	214491,0	177105,3	246206,5
ROSENBAUER INTERNATIONAL AG	2910	28871,0	51454,0	45536,0	43848,0	21127,0	44041,0
ASPOECK SYSTEMS GMBH	2931	28823,6	13001,2	16905,7	18425,1	13632,6	12362,6
GF CASTING SOLUTIONS ALTENMARKT GMBH & CO KG	2932	21841,2	14483,6	18128,6	25928,2	22134,1	18555,8
FRAUENTHAL HOLDING AG	2932	18317,0	-10814,0	28864,0	16756,0	-7291,0	9203,0
KROMBERG & SCHUBERT AUSTRIA GMBH & CO. KG	2931	14855,0	-3041,7	10092,1	16094,2	19432,9	19298,9
POLYTEC HOLDING AG	2932	9602,0	7676,0	28847,0	36801,0	52070,0	48102,0
KTM COMPONENTS GMBH	2932	8673,4	6793,8	6387,4	9253,8	8296,3	6653,5
HELLA FAHRZEUGTEILE AUSTRIA GMBH	2931	6268,8	5526,5	6615,9	7283,3	5548,3	8318,1
GD EUROPEAN LAND SYSTEMS - STEYR GMBH	2910	5927,7	154,7	3479,0	-13274,1	-659,6	-698,4
ASTOTEC AUTOMOTIVE GMBH	2932	5100,0	n.a.	n.a.	n.a.	n.a.	n.a.
AL-KO TECHNOLOGY AUSTRIA GMBH	2932	3932,9	3962,1	3247,0	4605,1	5653,0	2111,6
STIWA ADVANCED PRODUCTS GMBH	2932	3889,3	-7541,9	-3117,6	12457,9	8455,7	588,4
RESSENIG FAHRZEUGBAU GMBH	2920	3521,3	0,8	-1770,2	-337,6	n.a.	n.a.
ZKW LICHTSYSTEME GMBH	2931	3387,3	10207,5	25065,7	18515,7	57893,7	35019,4
HOLZ - WASTL HANDELSGESELLSCHAFT M.B.H.	2932	2832,7	1604,3	3046,5	1808,3	-2811,2	224,9
OPEL WIEN GMBH	2910	1836,7	2027,1	6853,6	10853,2	4984,4	-9011,2
KAESSBOHRER AUSTRIA GMBH	2910	1785,8	1482,8	1598,7	1756,0	1519,8	n.a.
HUMER - ANHAENGER, TIEFLADER, VERKAUFSFAHRZEUGE - GMBI	2920	1635,8	497,6	422,5	599,8	262,4	623,8
OTTO WOHLGENANNT GESELLSCHAFT M.B.H.	2920	1055,5	2149,0	828,9	878,3	739,3	695,3
TCG UNITECH SYSTEMTECHNIK GMBH	2932	866,1	-312,2	904,0	2913,9	3314,0	3599,0
PONGRATZ TRAILER-GROUP GMBH	2920	602,5	-692,9	-528,4	-1296,5	-596,7	-257,5
TROPPER MASCHINEN UND ANLAGEN GMBH.	2920	508,5	-183,3	688,6	548,7	396,4	915,2
HANS BRANTNER & SOHN FAHRZEUGBAUGESELLSCHAFT M.B.H.	2920	327,0	35,5	-88,4	-286,1	-671,4	110,0
KMB METALLTECHNIK GMBH	2932	131,6	116,5	107,2	211,9	284,3	131,4
WALSER GMBH	2920	-108,8	-860,2	769,7	260,4	-272,2	247,3
Total 2021		600584	1076638	554252	502107	442237	513272
Share Top 5		84,19068827	98,25492969	77,93185531	74,82544227	64,60078971	75,47604316
Share top 6		87,24055396	97,25050686	83,13959748	78,16257928	62,95212712	77,26904902

Table 34: Total Assets Austrian Automotive Firms. Source: Orbis Bureau Van Dijk.

Total Assets in th Euro	**NACE Rev. 2**	**2021**	**2020**	**2019**	**2018**	**2017**	**2016**
MAGNA STEYR FAHRZEUGTECHNIK AG & CO KG	2910	1995538	3256215	2309363	2660822	2165744	1903221
BMW MOTOREN GMBH	2910	1317888	1176428	1240156	1080441	1088171	1132227
ROSENBAUER INTERNATIONAL AG	2910	891562	909466	977498	782256	625441	650601
POLYTEC HOLDING AG	2932	568499	581504	605601	557636	516453	501448
FRAUENTHAL HOLDING AG	2932	496725	441006	442225	408069	418034	354641
KROMBERG & SCHUBERT AUSTRIA GMBH & CO. KG	2931	389302	392437	358066	365053	344999	271935
ZKW LICHTSYSTEME GMBH	2931	366762	372804	403044	405416	358301	296755
OPEL WIEN GMBH	2910	338883	366476	399518	445146	500503	487750
ASPOECK SYSTEMS GMBH	2931	137989	105127	98689	93490	77862	80355
GD EUROPEAN LAND SYSTEMS - STEYR GMBH	2910	125753	90011	51293	94154	100880	82917
GF CASTING SOLUTIONS ALTENMARKT GMBH & CO KG	2932	120344	118189	103398	135277	131210	118757
KTM COMPONENTS GMBH	2932	81892	69214	97573	85270	86307	85139
HELLA FAHRZEUGTEILE AUSTRIA GMBH	2931	57557	43208	49806	50257	44353	48974
STIWA ADVANCED PRODUCTS GMBH	2932	49212	41741	40343	42289	36708	28361
HANS BRANTNER & SOHN FAHRZEUGBAUGESELLSCHAFT M.B.H.	2920	42298	34822	31366	28803	28834	30806
KAESSBOHRER TRANSPORT TECHNIK GMBH	2920	40517	41186	55150	48312	n.a.	n.a.
ASTOTEC AUTOMOTIVE GMBH	2932	35442	64	60	55	55	54
OTTO WOHLGENANNT GESELLSCHAFT M.B.H.	2920	29883	28416	27777	27719	28500	24078
VNT AUTOMOTIVE GMBH	2932	26532	28531	31603	34195	34200	32378
AL-KO TECHNOLOGY AUSTRIA GMBH	2932	26272	23852	20739	20404	22223	20891
HOLZ - WASTL HANDELSGESELLSCHAFT M.B.H.	2932	24689	25681	26356	26025	24284	18737
WALSER GMBH	2920	20996	22212	21891	21810	22842	22023
TCG UNITECH SYSTEMTECHNIK GMBH	2932	18129	15684	20106	20197	21577	21349
RESSENIG FAHRZEUGBAU GMBH	2920	17450	12299	12274	12282	n.a.	n.a.
KAESSBOHRER AUSTRIA GMBH	2910	16273	18283	17172	20562	19650	494
PONGRATZ TRAILER-GROUP GMBH	2920	16256	12188	12776	10967	8973	8818
WECUBEX FERTIGUNGSTECHNIK GMBH	2920	12987	9214	10313	11161	7645	n.a.
Total 2021		7265630	8236260	7464156	7488068	6713748	6222707
Share Top 5		72,53620454	82,04035309	79,48533127	78,18140946	76,83996442	77,36300627
Share top 6		77,89433258	82,04035309	79,48533127	78,18140946	76,83996442	77,36300627

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