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Reshaping Skills, Industrial Relations and Social
Protection for the Knowledge Economy: Evidence from
Germany

Sebastian Diessner, Niccolo Durazzi and David Hope

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Abstract

Technological change has meant that university-educated workers have become crucial to the production strategies of ICT-intensive, high-end exporting firms in the knowledge economy. We argue that the centrality of high skills in manufacturing has weakened the traditional institutional complementarity between specific skills, regulated industrial relations, and generous social protection in coordinated market economies. In fact, the liberalization of industrial relations and social protection has been instrumental for firms to concentrate wages and benefits on increasingly important high-skilled workers. To test our alternative perspective, we leverage the critical case of German manufacturing. We find strong evidence in support of our argument through an analysis of descriptive data, elite interviews, and industry surveys and reports. Our paper provides important insights for the nascent CPE literature theorizing the adjustment of advanced capitalist economies to the knowledge economy.

Keywords

Knowledge economy, ICT, technological change, liberalization, varieties of capitalism, labor economics, critical case study design, Germany, manufacturing

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Introduction

The transition from Fordism to the knowledge economy has seen extensive structural and institutional change in the advanced democracies. It has been characterized by deindustrialization, the rise of mass systems of higher education, greater female labor force participation, more dynamic and differentiated product markets, and a weakening of unions and collective bargaining.¹ In the nascent comparative political economy (CPE) literature on the knowledge economy, this transformation has thus far almost exclusively been equated – explicitly or implicitly – with a shift out of manufacturing and into high value-added service sectors.²

In this paper, we argue that the transition to the knowledge economy has had a far more profound impact, fundamentally transforming advanced manufacturing sectors as well. The increasing importance of information and communications technology (ICT) to products and production processes in manufacturing means the sector has changed beyond recognition in recent decades. Take the global automobile industry as an example. While the ICT equipment and software in a typical car contained around 100 lines of computer code in the 1970s, that figure is close to *10 million* today. It is also estimated that ICT now contributes 30-40% of total value added in automobile construction.³ The changes on the production side have been no less dramatic, with the rapid proliferation of automation in the sector; between 2012 and 2017 alone, industrial robot sales to the global automotive industry increased by 14% *per year* on average.⁴

It is difficult to reconcile the transformative changes that have taken place in the manufacturing sector with current CPE theorizations of the adjustment of advanced capitalist economies to the knowledge economy (see the next section). In this paper, we propose an alternative approach that seeks to address this shortcoming of the existing literature. Our approach embeds theories of technological change from labor economics into recent CPE frameworks on the transition to the knowledge economy.⁵ In particular, we argue that 1) a surge in the ICT-intensity of manufacturing has shifted the skills needs of manufacturing firms towards workers with tertiary education, especially in STEM (Science, Technology, Engineering and Mathematics) subjects; 2) the increased centrality of high-level general skills in advanced manufacturing has weakened the traditional institutional complementarity between specific skills, regulated industrial relations, and generous social protection in coordinated market economies (CMEs); and 3) liberalization across

the industrial relations and social protection arenas has been instrumental for high-end exporting firms in CMEs to concentrate wages and benefits on highly-educated workers.

To test our argument, we leverage the *critical* case of German manufacturing. Germany is the archetypal CME in Peter Hall and David Soskice's varieties of capitalism framework,⁶ and its export profile has changed little over the past two decades.⁷ Given that the German manufacturing sector is where we would least expect to find transformative institutional change, it provides a particularly tough test of our argument. We explore changes in the manufacturing sector and three key spheres of the German political economy (skill formation, industrial relations, and social policy) by drawing on descriptive statistics, industry reports and surveys, and a set of 20 semi-structured, elite interviews. We find strong evidence in support of our argument. Our research design and findings suggest that our alternative perspective will hold across the CMEs. In fact, we see there being a single logic of adjustment to the knowledge economy across the advanced capitalist countries, which is characterized by simultaneous and mutually-reinforcing processes of liberalization *and* technological change. In introducing this new logic of adjustment, our paper seeks to provide the basis for a new research agenda in CPE.

The paper proceeds as follows. In the next section, we present the existing literature in greater detail and develop our argument. We then discuss our research design and data collection methods, before presenting the empirical evidence in support of our argument. We first trace the changes that have taken place in the German manufacturing sector, with a specific focus on the increase in ICT-intensity. We then move on to examine institutional and policy changes in the three key spheres of skill formation, industrial relations and labor markets, and social protection. Lastly, we discuss the implications of our research and provide concluding remarks.

The Transition to the Knowledge Economy: Current CPE Perspectives and our Alternative Approach

Since the 2000s, advanced capitalist democracies have transitioned into knowledge-based economies,⁸ characterized – according to the OECD – by “greater dependence on knowledge, information and high skill levels, and the increasing need for ready access to all of these by the business and public sectors”.⁹ A growing body of work in CPE seeks to better understand this transition and the associated changes in political-economic institutions. Existing theorizations of

the adjustment of advanced capitalist democracies to the knowledge economy can be broadly divided into two camps: those arguing that different logics of adjustment are at play across different political economies, and those that identify a uniform trajectory of institutional change.

The common point of reference for scholars arguing in favor of distinct logics of adjustment is the Varieties of Capitalism (VoC) framework and the dichotomy between Liberal Market Economies (LMEs) and Coordinated Market Economies (CMEs).¹⁰ In particular, the LME trajectory (typified most commonly by the US) is characterized by general skills, deregulated labor markets, scant social protection, and economic specialization in radically innovative sectors (e.g. high-technology manufacturing and high value-added services). On the other hand, CMEs (typified by Germany in particular) are expected to specialize in incrementally innovative sectors (e.g. traditional manufacturing) owing to a specifically-skilled workforce and a set of institutional incentives nurtured by – *inter alia* – more regulated labor markets and relatively generous social protection systems.¹¹

Recent contributions departing from this tradition have favored a more dynamic approach to the VoC framework, by shedding light on the political coalitions that underpin different transitions to the knowledge economy and by introducing more nuanced typologies beyond the CME-LME dichotomy.¹² Kathleen Thelen’s work has been central to these newer approaches.¹³ Her argument does not challenge VoC as far as LMEs are concerned, but it proposes a distinct assessment of CMEs’ transition into the knowledge economy. In particular, she identifies divergent trajectories between continental European CMEs (such as Germany) and Scandinavian CMEs (such as Denmark).

Continental European CMEs are commonly characterized by a process of dualization in which the manufacturing core is still reliant on much the same coordinating institutions championed by the VoC framework, while the service sector has expanded in a considerably more deregulated and liberalized fashion.¹⁴ Scholars point at the organization of producer groups along sectoral lines as a crucial ingredient for the establishment of a cross-class coalition promoting continuity in the core manufacturing sector, alongside an increasingly deregulated periphery characterized by many of the features traditionally associated with labor markets in LMEs (such as precarious employment and low pay). Scandinavian CMEs, on the other hand, have been subject to a broader re-orientation, referred to as ‘embedded flexibilisation’. These are thought to have radically restructured their production regimes veering toward high-technology manufacturing and high-

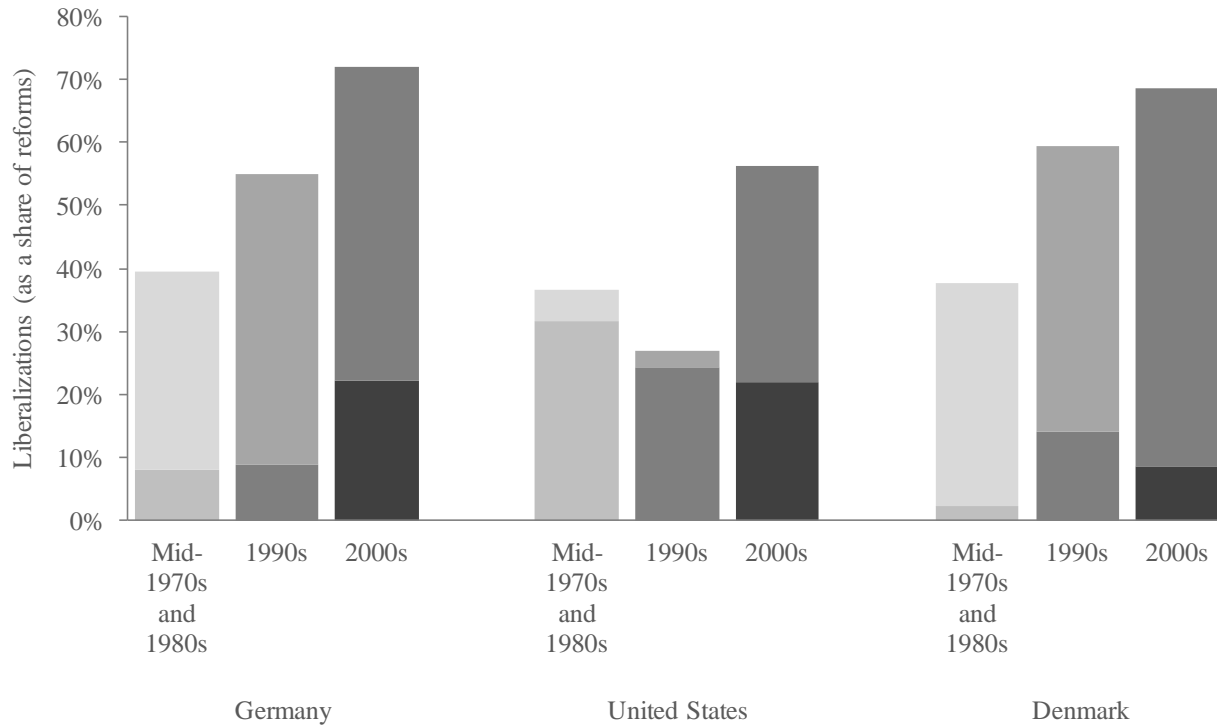
value added services while retaining their traditional egalitarian features, for instance, through the systematic deployment of training and re-training programmes. Strong and encompassing producer group coalitions have been identified as key to the reorientation of production and the conversion of institutions in this sub-type of CMEs.¹⁵

Despite their superior capacity to account for *within*-CME diversity, these newer approaches have been challenged on the grounds of overemphasizing both the institutional stability in continental CMEs' core sectors and the persistence of social solidarity in Scandinavian CMEs.¹⁶ Above all, a growing collection of work which can broadly be categorized as 'liberalization scholarship' has argued forcefully that CMEs' institutional supply has been radically transformed in a decidedly liberal direction across the board. Employers are found to be at the heart of this "common neoliberal trajectory",¹⁷ as they vehemently lobbied to liberalize labor markets in both continental European and Scandinavian CMEs, pushing for a weakening of collective bargaining institutions and a retrenchment of social protection schemes.¹⁸ Both theoretically and empirically, the focus of the liberalization literature has been on the low-end of the labor market. Scholars focused in particular on how liberalization created growing segments of the labor market characterized by in-work poverty and casual employment and by harsh workfare measures in lieu of generous unemployment benefits.¹⁹ Employers' aggressive pro-liberalization stance has often been explained in terms of cutting labor costs to ensure competitiveness of exports in increasingly globalized markets.²⁰

We agree with this view, but we submit that it is incomplete. As hypothesized by liberalization scholars, processes of liberalization have indeed been profound across the advanced capitalist countries. Figure 1 provides strong evidence in this respect as it takes three countries often assumed in the literature as different models of capitalism and shows that all three have been subject to a liberalizing trend in industrial relations and social protection since the 1980s.^{21,22}

Figure 1. Share of liberalizing reforms in industrial relations and social policy across different models of capitalism from the mid-1970s to the 2000s

Darker parts of bars show proportion of major liberalizations



Source: Authors' calculations using data from the Liberalization Database; Armingeon et al. (2019). Available at liberalization.org.

Note: Data combines reforms in five policy fields: Employment protection legislation (epi), industrial relations (ir), active labour market policies (almp), non-employment benefits (neb), and pension policies (pen). Major liberalizations are those that score above 1 on the liberalization incisiveness index (lib). Full definitions of policy fields and variables are available in the codebook, which is available at liberalization.org.

However, liberalization is not the only phenomenon that swept across advanced capitalist countries during this period. In parallel to the sustained process of liberalization captured by Figure 1, the last two decades were also characterized by a common trend toward knowledge-based growth.²³ This is shown in Table 1, which reports the proportion of working-age individuals with tertiary education, increases in number of researchers, and gross R&D expenditure across different models of capitalism since the early 2000s.

Table 1. The shift into knowledge-based growth across different models of capitalism, 2000-16

		2001	2016	Change 2001-16
Percentage of 24-65 year-olds with tertiary education	Germany	23.2	28.3	+5.1
	United States	37.5	45.7	+8.2
	Denmark	28.4	38.2	+9.8
Researchers (per 1,000 employed)	Germany	6.6	9.2	+2.6
	United States	7.3	8.9	+1.6
	Denmark	7.0	15.6	+8.6
Gross domestic spending on R&D (% of GDP)	Germany	2.4	2.9	+0.5
	United States	2.6	2.8	+0.2
	Denmark	2.3	3.1	+0.8

Source: OECD (2020), indicators for researchers, gross domestic spending on R&D, and adult education level (accessed 05 Jan 2020). Available from data.oecd.org.

Note: Full variable definitions available from data.oecd.org under the Education and Innovation & Technology headings.

Taken together, Figure 1 and Table 1 strongly suggest that the transition into a post-Fordist era cannot simply be captured through the lens of liberalization. Rather, it requires understanding how liberalization and knowledge-based growth co-developed over the last two decades.²⁴ To this end, our argument integrates theories of technological change from labor economics into recent CPE frameworks on the transition to the knowledge economy.²⁵ The dominant theories of technological change in labor economics—skill-biased technological change (SBTC) and routine-biased technological change (RBTC)—both argue that the adoption of ICT in workplaces has asymmetric effects on workers. They posit that ICT is complementary to high-skilled workers, as it enables them to do their jobs more effectively, whereas it substitutes for workers lower down the skill distribution. Technological change therefore increases the relative demand for high-skilled labor, which leads *ceteris paribus* to an increase in the wage premia for university-educated workers.²⁶

SBTC and RBTC differ in their predictions of which workers will lose out most from technological change. SBTC hypothesizes that low-skilled workers are most at danger of being substituted by technology, whereas RBTC hypothesizes that it is workers performing routine (i.e. easily codifiable) tasks, who are typically located in the middle of the skill and income distribution.²⁷ A large empirical literature has emerged, however, that shows that while the effects

of ICT on the top of the labor market are common across the advanced capitalist countries, the effects of ICT on the bottom and middle of the labor market are not. Whether national trends fit better with SBTC (i.e. upgrading) or RBTC (i.e. polarization) depends on a variety of national-level factors such as labor market institutions and changes in labor supply (including immigration patterns).²⁸ In our theorization, we therefore focus on the effect of technological change that holds consistently across the OECD economies: the rise in the relative demand for high-skilled (i.e. university educated) workers.

More specifically, we argue that technological change has played a crucial role in transforming advanced manufacturing in recent decades. A surge in the ICT intensity of advanced manufacturing has shifted the skills needs of manufacturing businesses towards workers with tertiary education, especially in STEM (Science, Technology, Engineering and Mathematics) subjects. Theorizing the complementarity between high skills and technology in the manufacturing sector brings a critical new insight into CPE theories that have so far focused near-exclusively on the spread of ICT in high value-added service sectors and largely ignored the transformative effects of ICT on the manufacturing sector.²⁹ In a context of liberalization *and* technological change, institutional change across the industrial relations and social protection arenas has been instrumental for business to concentrate wages and non-wage benefits on highly-educated workers.

Hence, one of our core contentions is that employers' preferences are likely to be more nuanced than hypothesized by the liberalization literature: on one hand, employers do push for deregulation and retrenchment in industrial relations and social protection but, at the same time, they seek to re-deploy these institutions to be able to reward and retain the highly skilled workers that are increasingly vital for their production strategies in the era of knowledge-based growth. In our view, the transition to the knowledge economy is therefore best explained by taking into account the effects of technological change in increasingly liberalized political economies. This argument stands apart from both of the dominant theorizations in the CPE literature, i.e. dualization and liberalization. Table 2 provides an overview of the main differences between our approach and the dualization and liberalization approaches, summarizing the observable implications of each theory for the three sub-spheres of the political economy which have been of central concern to CPE scholarship,³⁰ and which will be analyzed in this article in depth, namely skill formation, industrial relations and labor markets, and social protection.

Table 2. Observable implications of dualization, liberalization, and our alternative approach

Theory	Institutional sphere		
	Skill formation	Industrial relations and labor markets	Social policy
Dualization	<ul style="list-style-type: none"> Continued support on behalf of employers and unions for specific skill formation through vocational training in the core manufacturing sector Lower quality forms of training in the service sector 	<ul style="list-style-type: none"> Continued support on behalf of employers and unions for collective bargaining institutions in the core manufacturing sector Labor market deregulation in the service sector 	<ul style="list-style-type: none"> Continued support on behalf of employers and unions for generous unemployment protection in the core manufacturing sector to insure the risk of investment in specific skills Scant social protection in the service sector
Liberalization	<ul style="list-style-type: none"> Employer-led de-standardization of dual training across sectors against unions' opposition 	<ul style="list-style-type: none"> Employer-led labor market deregulation across sectors against unions' opposition 	<ul style="list-style-type: none"> Employer-led retrenchment of welfare state out of cost concerns against unions' opposition
Liberalization and technological change	<ul style="list-style-type: none"> Employer-led de-standardization of dual training across sectors against unions' opposition Employers' support for higher education expansion to increase supply of workers with skills complementary to ICT 	<ul style="list-style-type: none"> Employer-led labor market deregulation across sectors against unions' opposition Employers rewarding highly skilled workers by means of higher wages and non-wage benefits 	<ul style="list-style-type: none"> Employer-led retrenchment of benefits out of cost concerns against unions' opposition Selective expansion of welfare through targeted occupational schemes to lock-in highly skilled workers

Research Design and Data Collection

Our empirical investigation is based on an in-depth case study of the German manufacturing sector. The case selection is theoretically-informed and corresponds to a critical case research design. We select a case that conforms as closely as possible to the theories that we seek to challenge and thus we “stack the cards” against our argument as much as we possibly can.³¹ The implication is that if our theoretical argument holds true under such (least likely) circumstances, it is (highly) plausible that it bears important insights for a broader universe of cases.³² Germany is the archetypal CME in Hall and Soskice’s varieties of capitalism framework and many scholars still argue that it is Germany’s traditional coordinating institutions that underpin its continued strength in export markets today.³³ Whereas it has been argued that other CMEs have moved into high-technology manufacturing and high-value added services over time,³⁴ Germany’s export model is still typically perceived to be reliant on incremental innovation in mid-high-technology manufactured goods. Therefore, if the available empirical evidence suggests that even the German manufacturing sector and the core institutions underpinning it have been transformed along the lines of our theory of institutional change, based on liberalization *and* technological change, then there are solid grounds to believe that such changes would also hold across the broader universe of CMEs.

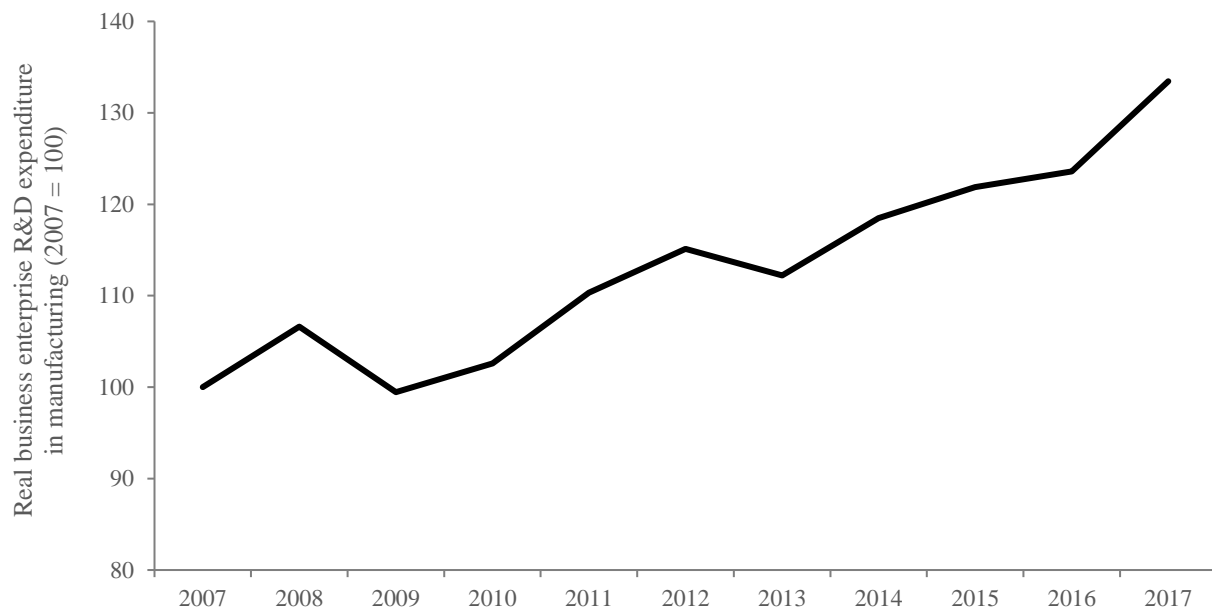
For in-depth, single-country, case study research, it is well-advised to draw on as broad a range of empirical material as possible, including statistical data, official statements and reports, and pertinent secondary sources. Where necessary and feasible, this material can be triangulated with supplementary data gathered through interviews with relevant stakeholders. This article engages all of the above, in order to investigate recent changes in the German manufacturing sector as well as those which have occurred in the key institutional spheres of skill formation, labor markets and industrial relations, and social protection. We leverage descriptive statistics from a wide range of sources, including the OECD, the Observatory for Economic Complexity, the EU KLEMS dataset, the Federal Statistical Office of Germany, the Joint Science Conference of the German regions (Länder) and Federal Government (Bund), and the German Chambers of Industry and Commerce. We complement these with qualitative data from industry surveys and reports, as well as research outputs of industry-affiliated think tanks. Lastly, we triangulate insights from these sources with primary data gathered through a set of 20 semi-structured interviews with senior stakeholders in employers’ and workers’ associations and government ministries. Details of our methodology, the selection of stakeholders, and a full list of interviewees are provided in the appendix.

German Manufacturing in The Knowledge Economy

The German export machine has been powered by a strikingly similar set of products for the past four decades.³⁵ Germany's top exports in 2017 were cars and vehicles parts, which together accounted for nearly 17% of all goods exports (by value in \$US). Germany has also maintained its global pre-eminence in the export of industrial goods, such as machinery and equipment that are used in the production of other goods.³⁶ On the surface then, the picture is one of continuity, but the stability of Germany's export profile obscures the deep and transformational changes that have taken place in the manufacturing industry during the transition to the knowledge economy. Take the German carmakers as an example, which have sharply increased expenditure on innovation in recent years, from €26.6bn in 2009 to €47.4bn in 2017.³⁷ In line with our argument on the importance of ICT to advanced manufacturing in the knowledge economy, and contrary to the expectations of the varieties of capitalism framework,³⁸ innovation in the sector has also started to shift away from incremental forms of innovation and toward more radical forms of innovation. Since the mid-2010s, German vehicle manufacturers have registered as many patents that pertain to radically innovative technologies (in the areas of digitalization, electric mobility and electronics) as those that pertain to conventional power trains (e.g., combustion engines and exhaust systems).³⁹

Against this backdrop, profound change has not been confined to the automotive sector alone, as technology has become deeply embedded across German manufacturing industries in general. Germany came top of the Bloomberg Innovation Index for the first time in 2020, owing to “top-five rankings in value-added manufacturing, high-tech density, and patent activity”.⁴⁰ German exports are heavily concentrated in advanced, high-technology goods; 52% of German exports were high-tech products in 2015, and another 31% were medium-high-tech products.⁴¹ Germany is currently ranked third in the world on the Economic Complexity Index, which measures the knowledge intensity of the products a country exports.⁴² Germany is also a leading producer of IT manufactured goods, which include computers, electronics and optical products. The OECD calculates that Germany was Europe's most ‘central’ IT manufacturing hub in 2011, highlighting its influence in global and domestic production networks for IT manufactured goods.⁴³ The importance placed on innovation of German manufacturing firms is reflected in a substantial expansion in expenditure on research and development (R&D) since the global financial crisis. Figure 2 shows real business expenditure on R&D by firms in the manufacturing sector grew by over 33% in the decade after 2007.

Figure 2. Real business enterprise R&D expenditure in manufacturing (2007 = 100) in Germany, 2007 – 2017



Source: Authors' calculations using OECD (accessed 18th October 2019).

Note: Underlying data in 2010 US dollars, constant prices and PPPs.

Moreover, spending on innovation by the metal and electrical industries (Metall- und Elektroindustrie) now accounts for almost two-thirds of innovation spending in the German economy (62.9% in 2017, compared to 55% in 2010), as manufacturing firms grapple with the challenges and opportunities of the ICT revolution.⁴⁴ For a large number of our interviewees, for instance, the quest for “new business models” has become one of the key issues facing German industry in the digital age, with greater service-orientation and more focus on product individualization and customization being two common developments identified by interview partners.⁴⁵ In this context, manufacturers now increasingly seek employees with wider and more general skillsets in *both* mechanical or electrical engineering *and* information technology, so as to safeguard their innovative capacity.⁴⁶

Theories of technological change from labor economics would predict that the rapid diffusion of ICT during the transition to the knowledge economy would have substantial effects on the workforce in the German manufacturing sector.⁴⁷ As discussed in the theory section, we would expect to see greater demand for high-skilled workers due to their complementarity with ICT,⁴⁸ as well as a movement away from the routine tasks that can be easily replicated by computers or

machines and towards more complex, non-routine abstract and analytical tasks.⁴⁹ In line with this hypothesis, Hugh Cassidy shows through a task usage shift-share analysis that manufacturing occupations were shifting away from manual tasks and towards interactive and analytical tasks as early as the late 1980s.⁵⁰

Alongside these changes, German manufacturing firms offshored a large amount of labor-intensive upstream production activities to Central and Eastern Europe and other emerging economies during the 1990s.⁵¹ Sascha Becker, Karolina Ekholm, and Marc-Andreas Muendler study the effects of offshoring on the onshore workforce of German multinational companies and find that offshoring is associated with a significant shift toward more highly educated workers and more interactive and non-routine tasks.⁵² The manufacturing activities remaining in Germany now focus more on research and development and the non-routine aspects of the production process such as production engineering and quality services.⁵³

The rise in importance of non-routine tasks and service occupations in manufacturing workplaces has significantly altered the skill requirements of manufacturing firms. There is greater demand for workers with the high-level general skills (i.e. university education) that are complementary to ICT.⁵⁴ This chimes in with Dominik Boddin and Philipp Henze's occupational analysis of the German manufacturing sector, which finds that the most skilled occupations saw the greatest employment growth between 1975 and 2010.⁵⁵ The single biggest employment expansion was for engineers, who saw employment more than double over the period (+106%), followed by semi-professionals (+66%) and professionals (+51%) in service occupations.⁵⁶ These expansions are even more striking as they took place against a backdrop of shrinking employment in the manufacturing sector as a whole; manufacturing employment fell from 32% to 19% of total employment in Germany between 1975 and 2006.⁵⁷ It has also become more common for manufacturing workers to possess higher education; the share of workers with tertiary education in high and medium-high tech manufacturing rose from 25% in the mid-1990s to 33% in 2016.⁵⁸

Overall, ICT has increasingly become a cornerstone of the manufacturing sector in Germany. In line with theories of technological change from the realm of labor economics, the diffusion of ICT has taken place in conjunction with a shift towards high skills, service occupations, and complex, non-routine tasks. The demand for university-educated workers, especially those with engineering and IT-related degrees, has increased dramatically as a result. The transition to the knowledge economy has evidently changed German manufacturing and rendered the recruitment

and retention of high-skilled workers increasingly vital for continued success in the export of mid-high-tech and high-tech goods.

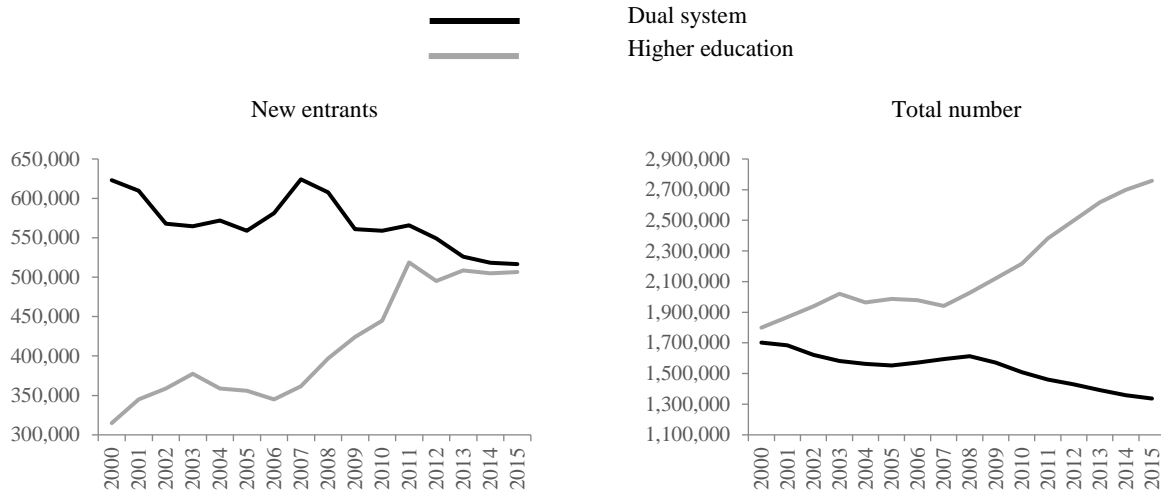
Institutional Change in German Manufacturing

This section identifies the patterns of institutional change which have occurred alongside the technological transformation of Germany's manufacturing sector since the second half of the 1990s⁵⁹ and across the three core spheres of skill formation, industrial relations and labor markets, and social policy. In particular, it assesses the extent to which the available evidence is supportive of our argument about the mutually reinforcing relationship between liberalization and technological change in the German political economy during the transition to the knowledge economy.

Skill Formation

Following on from the findings of the previous section, the widespread use of ICT in German manufacturing has altered the composition of jobs and skills in the sector. The centrality of intermediate skills has diminished in the context of the increasing importance of non-routine tasks, which called for higher level skills. Since the mid-1990s – and with a stark acceleration from the mid-2000s – higher education has become the center of gravity of the German skill formation system.⁶⁰ Enrolments at universities skyrocketed, while the number of young people in the dual apprenticeship system has decreased (see Figure 3).

Figure 3. Size of higher education and dual vocational training systems, 2000-2015



Source: Adapted from Statistisches Bundesamt.

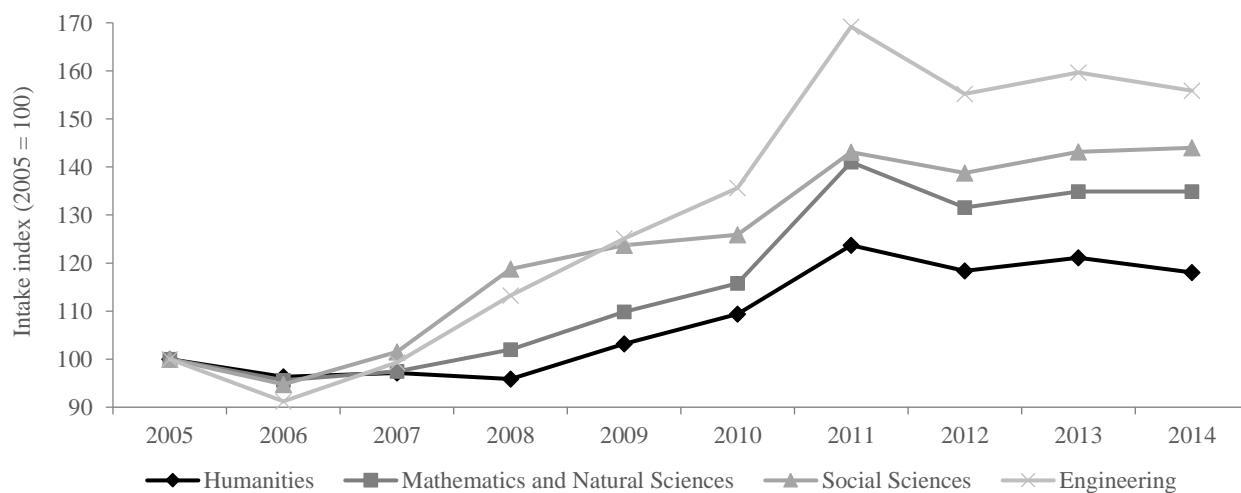
The process of expansion of higher education in Germany does not simply reflect expansion of service sector employment, as commonly assumed by the CPE literature.⁶¹ It is also intimately linked with changes in advanced manufacturing, given that “industrial production has become increasingly digitalized, decentralized, and dependent on workers with high cognitive and analytical skills, causing demand for employees with university [...] degrees to rise, while VET training has become relatively less important”.⁶² Remarkably, since the 2000s, employers in the manufacturing sector have pushed for a deregulation of the traditional apprenticeship system, which has entailed the re-introduction of shorter, two-year apprenticeships in 2003. This has been achieved against the opposition of trade unions, who feared that lowering the quality of training would facilitate segmentation among the workforce in terms of collective bargaining and wages.⁶³ Crucially, this deregulation of the apprenticeship system – which Marius Busemeyer and Christine Trampusch have termed ‘liberalization by exhaustion’⁶⁴ – originated in the core manufacturing industries, with large export-oriented firms being among its most fervent supporters.⁶⁵

Yet, manufacturing employers not only campaigned for – and eventually obtained – a deregulation of the apprenticeship system in the 2000s, but also mobilized in favor of an expansion of higher education, and an expansion in the provision of STEM skills in particular.⁶⁶ Employers ran public campaigns emphasizing the urgency of creating a plentiful and stable supply of high-level skills to sustain the backbone of the export-oriented German economy,⁶⁷ with the influential

metalworking employers’ association (Gesamtmittel) and the employers’ peak association (BDA) funding bi-annual studies to monitor the supply of STEM skills (so-called STEM Trend Reports).⁶⁸ Similarly, the National Academy of Science and Engineering (acatech) – a publicly-funded organization advising policy-makers on innovation policy and technological developments including ‘Industrie 4.0’ – has been at the very forefront of research on skills needs in the transition to the knowledge economy. The supply of STEM skills has been a central concern of acatech’s activities, including the publication of a yearly report co-commissioned by the entrepreneurs’ foundation Körber Stiftung and marketed as a ‘Barometer of Young Talents in STEM Subjects’. According to interviewees, at the heart of these efforts was the motivation to increase the supply of high-level skills in order to ensure that German companies reap the benefits associated with technological change,⁶⁹ which eventually led employers’ associations to become “massively engaged in higher education reform”.⁷⁰

Consequently, German higher education policy has come to reflect demands for an increased supply of STEM skills.⁷¹ The federal government launched the Higher Education Pact (HEP) in 2007 to fund the expansion of the university sector, tying the disbursement of funds to the promotion of STEM subjects in particular, as these were perceived as pivotal for a successful transition to the knowledge economy.⁷² As a result, since the launch of the pact, intakes in engineering have—in relative terms—outstripped intakes in any other discipline (see Figure 4).

Figure 4. Relative intake of students by discipline, 2005-2014



Source: GWK 2016, 11.

In some *Länder*, the HEP has also been used to fund so-called ‘dual study programmes’.⁷³ Within these, students obtain regular university degrees (typically at undergraduate level), but also gain extensive work experience in firms which enter a cooperation agreement with higher education institutions (usually universities of applied sciences). One of the main reasons for employers to sponsor dual study programmes is to tie students to the firm early on in order to minimize the risk of future skill shortages.⁷⁴ Looking at the distribution of students in dual study programmes, engineering stands out as the most popular discipline.⁷⁵ This is particularly reflective of business preferences for certain graduate skills, given that firms—not universities—get to decide in which disciplines these degrees will be offered.⁷⁶ At present, around 100,000 students are enrolled in dual study programs, thus accounting for a relatively limited share of students across the German higher education sector.⁷⁷ Yet, the rapid proliferation of dual study degrees over the last decade and their emphasis on engineering provides some additional evidence for the vital importance of this particular set of higher-level general skills in the German political economy.

Taken together, recent developments in the realm of skill formation corroborate the argument of an employer-led de-standardization. However, manufacturing employers not only worked toward the liberalization of the traditional apprenticeship system, but also developed a keen interest in higher education policy. As ICT alters production processes in manufacturing in favor of non-routine jobs, skill formation is ‘moving up’ to a higher level. Universities are today at the core of skill formation in Germany and policy-makers—following business’ demands—have encouraged the higher education sector to provide the skills (STEM and engineering in particular) which are considered crucial for businesses to succeed in advanced, ICT-intensive manufacturing.

Industrial Relations and Labor Markets

Moving on to the realm of industrial relations, there is broad consensus that the traditional German system of coordination has become substantially more decentralized since the end of the 1980s.⁷⁸ The extent of the liberalization is clear to see in the headline data; trade union density fell from 31% in 1990 to 17% in 2016, while collective bargaining coverage dropped from 85% to 56% over the same period.⁷⁹ These changes coincided with a steady decline in sectoral (i.e. industry-level) collective agreements between trade unions and employers’ associations that were long considered the cornerstone of the German industrial relations system.⁸⁰

There is mounting evidence that these trends have been observed in the industrial core, as well as the service sector periphery. For instance, Oberfichtner and Schnabel analyze firm-level data from the Federal Employment Agency's IAB Establishment Panel and find that the proportion of manufacturing firms covered by collective bargaining agreements fell from 90% to 67% in Western Germany and from 69% to 46% in Eastern Germany between 1996 and 2015.⁸¹ They also highlight the countervailing rise in establishments without any collective agreement at all.

Employers in the manufacturing sector have actively pushed for this transformation. The metalworking employers' association (Gesamtmetall), for instance, lobbied heavily for the liberalization of industrial relations during the 2000s, not least through its pro-reform think-tank Initiative Neue Soziale Marktwirtschaft (INSM). Daniel Kinderman suggests that, in contrast to the expectations of the varieties of capitalism framework, German manufacturing employers did *not* defend traditional coordinated institutions during this period.⁸² Instead, they fought to give employers more discretion in labor relations. Beyond lobbying, Gesamtmetall took concrete steps that further eroded collective bargaining institutions, such as introducing a new membership option called 'Ohne Tarifbindung' (OT), which offers the full range of services to employers without the obligation to comply with the conditions set out in the sectoral agreement. The option has been popular; nearly one half of all Gesamtmetall members (representing about 20% of employees) are now 'OT' members.⁸³

Employers in manufacturing have gained both flexibility and discretion from the significant changes that took place in the industrial relations sphere from the mid-1990s. Two prominent trends that followed were the greater use of agency workers and the rise of domestic outsourcing.⁸⁴ Agency workers are more insecurely employed and typically earn 25-30% less than regular staff.⁸⁵ They are also disproportionately located in the manufacturing sector in Germany (unlike in other countries, such as the US, where they are more concentrated in the service sector) and are predominantly unskilled, male workers.⁸⁶ Alongside employing more agency workers in low-skilled positions, German manufacturing firms began to increasingly rely on the outsourcing of services provided by low-skilled labor, such as cleaning, food, and security. Deborah Goldschmidt and Johannes Schmieder calculate that outsourced workers in Germany see a drop in wages of around 10%.⁸⁷

What lies behind the dramatic changes that have been observed in industrial relations in the core manufacturing sectors since the mid-1990s? The CPE literature has almost exclusively

focused on the desire of export sector firms to cut unit labor costs to safeguard their competitiveness on world markets.⁸⁸ While this is clearly an important part of the story, it is hard to reconcile with the empirical evidence that this period saw wage growth in manufacturing strongly outstrip that in the non-tradeable sectors,⁸⁹ as well as a rise in the wage premia of workers in exporting (over non-exporting) firms.⁹⁰ What is missing from existing CPE explanations, then, is proper consideration of how high-skilled workers were affected by the transformation of the industrial relations system. We argue that the liberalization of industrial relations has provided manufacturing firms with the scope to concentrate their resources on the recruitment and retention of high-skilled workers, who have become central to the production strategies of export sector firms in the knowledge economy.

Table 3 draws on the EU KLEMS dataset to show how the share of total labor compensation by skill group changed between 2002 and 2015 in the manufacturing sector. We can see that compensation was re-orientated over this period, with skilled workers gaining at the expense of unskilled workers. University educated workers gained the most, with their share of total compensation rising 4.2 percentage points to 35%. Workers with intermediate skills also saw their share of labor compensation rise, but not as significantly as that of high-skilled workers. That workers with intermediate skills saw a moderate increase in their share of total labor compensation suggests that the flexibilization of labor relations in manufacturing has also benefitted mid-skilled workers. Fabian Ochsenfeld provides a potential explanation for this.⁹¹ He uses linked employer–employee panel data to explore the effects of subcontracting on the wages of core workers without a college education and finds the effects to be positive or neutral. Thus, the adjustments in labor relations in German manufacturing since the mid-1990s have allowed manufacturing firms to protect and reward their core mid-skilled workforce, alongside shifting resources toward ever more important highly-skilled university graduates. This also chimes in with recent empirical literature that finds that changes in the German wage and employment structure since the 1990s better fit with theories of technological change from labor economics predicting occupational upgrading (i.e. SBTC) than those predicting polarization (i.e. RBTC).⁹²

Table 3. Share of total labor compensation by skill group in German manufacturing, 2002 & 2015

Educational attainment	2002	2015	Change 2002 – 2015 (percentage points)
No formal qualifications	12.5%	6.3%	-6.2%
Intermediate	56.7%	58.7%	+2.0%
University graduates	30.8%	35.0%	+4.2%

Source: EU KLEMS Growth and Productivity Accounts 2012 and 2017; O'Mahony and Timmer 2009; Jäger 2018.

Note: University graduates refer to those with educational attainment at ISCED levels 5 and 6.

These dynamics are further reflected in the emerging literature on changes in the wage distribution in the German manufacturing sector. Philipp Henze shows that the gap between the upper and lower quartile of real wages has risen over time and that a key driver of this trend is the shift *within* the manufacturing sector into service occupations (which draw heavily on high-level, general skills that are complementary to ICT).⁹³ We have also seen rising wage premia for workers with STEM qualifications,⁹⁴ as well as high-skilled employees in exporting firms.⁹⁵ The developments within manufacturing mirror developments across the wider German labor market. A number of recent contributions have documented *both* the large rise in wage inequality at the top of the distribution in Germany since the mid-1990s *and* the central importance of technological change in driving this trend.⁹⁶

Consequently, the solidarity among workers of different skill levels in German manufacturing has been severely endangered by the transition to the knowledge economy. High-skilled workers clearly stand apart from workers with lower levels of skill. Brett Meyer and Thomas Biegert show that the greater the workforce skill polarization resulting from technological change, the lower the participation in collective agreements at both the firm- and industry-level in Germany.⁹⁷ They put this down to technology generating more demand for high-skilled workers (e.g. programmers, engineers, managers etc.), which endows them with a great deal of individual bargaining power and moves their interests in wage bargaining away from those of low-skilled workers. This suggests that the liberalization of industrial relations and the technologically-driven increase in earnings dispersion observed in the German manufacturing sector have been mutually reinforcing.

The rise in bargaining power of high-skilled workers in German manufacturing and the freedom afforded to employers through the liberalization of industrial relations has culminated in a major change in focus for employers, who are increasingly directing their efforts and resources toward the hiring and retention of university-educated workers. Werner Eichhorst argues that firms are increasingly competing with one another to recruit and retain high-skilled workers and that entry level wages for skilled graduates in shortage occupations, such as engineering, have improved markedly in the post-financial crisis period.⁹⁸ The competition among employers is also increasingly stretching beyond remuneration, with firms competing on non-monetary benefits including flexible working time⁹⁹ and occupational welfare (as discussed further in the next subsection).¹⁰⁰

In its regular survey of 20,000 German businesses, the Association of Chambers of Industry and Commerce (Deutscher Industrie- und Handelskammertag, DIHK) finds that a growing number of employers aim to recruit and retain skilled workers by improving employer attractiveness in terms of both pay and job quality.¹⁰¹ Among manufacturing businesses in particular, the survey charts an increase from 31% to 42% of those striving to increase employer attractiveness between 2011 and 2014 alone,¹⁰² leading the DIHK to conclude that “the situation on the labor market is turning around – employers are now competing more and more for scarce and well-qualified employees”.¹⁰³ Interviewees acknowledge this “war for talent” and suggest that skilled applicants “know their worth and thus make higher demands”,¹⁰⁴ indicating that “the balance of power is tilting”,¹⁰⁵ to an extent that “employees are dominating the labor market” for STEM skills.¹⁰⁶

The use of pecuniary and non-pecuniary benefits can be seen as an attempt by employers to solve the “new poaching problem” they face in the knowledge economy, which is to keep hold of their high-skilled, university-educated workers.¹⁰⁷¹⁰⁸ Holding onto STEM graduates is a particular challenge for manufacturers. These workers are not only highly skilled but also exceptionally mobile as their skills are prized in both high value-added manufacturing and high value-added service sectors (e.g. finance, consultancy etc.).¹⁰⁹ In contrast to the varieties of capitalism view of the German economy, where solving the poaching problem for mid-skilled workers relies on coordinated wage bargaining,¹¹⁰ solving the poaching problem in the knowledge economy is not reliant on the presence of traditional coordinating institutions. Rather, it appears to rely on the gradual *erosion* of those very institutions in order to make it possible for employers to attract, reward and retain highly-skilled workers as they deem fit.

In summary, the industrial relations system has become substantially more liberalized in the German manufacturing sector since the mid-1990s. Given the rapid pace of technological change, manufacturing firms have taken advantage of the greater discretion liberalization has offered by shifting labor compensation away from low-skilled workers (temporary workers, outsourcing etc.) and toward high-skilled workers, who have become indispensable in the knowledge economy. The combination of liberalization and the changing skills requirements in the manufacturing sector as a result of technological change has driven up wage inequality, particularly at the top of the distribution, and has weakened solidarity among workers of different skill levels.

Social Policy

Comprehensive change has not been limited to the skill formation and industrial relations arenas. The realm of social protection has also been subject to radical transformation, most prominently since the early-2000s. The parallels between social protection and industrial relations in terms of both outcomes and underlying political agency—namely on behalf of employers’ associations spearheaded by manufacturing employers—are striking. Despite its reliance on social insurance as the archetypal Bismarckian welfare state, the German social protection system reached ‘quasi-universalism’ in its post-war settlement and ensured high replacement rates for both unemployed and pensioners.¹¹¹ The quasi-universalist principles were, however, increasingly challenged during the 1990s, and ultimately dismantled in the 2000s. As in the case of industrial relations and labor market policy, employers emerged as the key actors behind the liberalization of the social protection system.

Business lobbying in favor of welfare state retrenchment was primarily targeted at unemployment benefits and pensions, two of the largest items of German public spending. Timo Fleckenstein and Soohyun Christine Lee demonstrate how the peak employer association BDA formulated an increasingly hostile stance toward unemployment benefits through the second half of the 1990s.¹¹² Manufacturing employers, through the Gesamtmetall-funded think-tank INSM, were equally aggressive in heralding the need “for far-reaching market-oriented reforms” to be achieved with or without unions’ consent, as well as forcefully advocating for the “necessary retrenchment of the unaffordable welfare state”.¹¹³ Employers targeted both the duration and the generosity of unemployment benefits, which they argued should be curtailed. Business preferences

eventually came to dominate the Hartz commissions in charge of designing far-reaching labor market reforms, with employers' representatives outnumbering unions' representatives.¹¹⁴ Accordingly, the Hartz reforms of 2003/04 led to a profound reconfiguration of the German unemployment insurance system. Maximum duration was shortened from 32 to 18 months and the long-term unemployed became "only entitled to a means tested transfer at the level of social assistance, leading to a reduction in the net replacement rate from 54 per cent to 17 for a single with a previous average wage".¹¹⁵

Retrenchment had a discernible impact on both labor market insiders and outsiders—despite the latter being more strongly affected¹¹⁶—and its most fervent supporters were employers in core sectors.¹¹⁷ Strikingly, as in the case of industrial relations, much of the employers' offensive against the generosity of unemployment benefits originated from the manufacturing sector, with the INSM think tank once again being pivotal in the business campaign for benefit retrenchment. This poses a direct challenge to received wisdom in CPE, which suggests that the manufacturing sector, "with its reliance on industry-specific skills, should have been the one least interested in dismantling the German model and its social insurance system".¹¹⁸ As such, business preferences do not lend support to the proposition of dualization. Much rather, employers' behavior in the late-1990s and early-2000s matches more closely with the expectations of liberalization theories, challenging predictions of institutional stability in Germany's core industrial sectors.

As far as pensions are concerned, an analogous development can be seen throughout the 1990s. Employers strongly advocated in favor of cuts to the public pension system, arguing that costs had reached unsustainable levels which would hamper German competitiveness in global export markets. By the end of the decade, and similar to the case of unemployment benefits, employers had emerged as the single most forceful actor setting the agenda for comprehensive retrenchment of the public pension system.¹¹⁹ Despite unions' vocal opposition in parliamentary hearings and beyond,¹²⁰ employers dominated the public debate around the 2001 pension reform, which effectively slashed net replacement rates from 70% to 52%.¹²¹

It is here that the parallels with the dynamic witnessed in the sphere of industrial relations become most evident. On the one hand, and as expected from a liberalization perspective, employers in core sectors stood behind welfare state retrenchment, which was chiefly motivated by concerns around rising costs negatively affecting German firms' competitiveness.¹²² On the other hand, however, a simple cost-cutting story provides an incomplete picture once again.

Following the 2001 pension reforms, retrenchment in the public scheme was coupled with selective expansion of occupational pension plans—i.e., pension schemes provided directly by employers. Occupational pension plans differ crucially from statutory public pensions insofar as businesses have much greater control over their design and coverage, as they can “determine the conditions of such schemes or abstain from them”.¹²³ As such, occupational pensions increase employers’ discretion and can be deployed far more selectively. Importantly, occupational pensions developed unevenly across skill-levels and have benefitted skilled workers more than unskilled workers and, among skilled workers, those with a tertiary degree more than those without.¹²⁴ Tobias Wiß’s detailed analysis of occupational pensions across countries and sectors—including German manufacturing—suggests that, in sectors relying on high skills, workers “can transfer their human capital into economic individual power, thereby negotiating generous occupational pensions with their employers which are in need of these skills (e.g. in finance and insurance and manufacturing)”.¹²⁵ This conjecture is confirmed by interviewees, suggesting that the most highly-prized workers in the knowledge economy, such as information technologists and data scientists, can “literally choose where to go”,¹²⁶ and under what conditions.¹²⁷

While unions voiced concern over the uneven development of occupational pensions, employers did not perceive such heterogeneity in coverage to be much of an issue.¹²⁸ To the contrary, the BDA and BDI openly promote the selective nature of occupational pensions as a strategic device to “attract and retain” highly skilled workers,¹²⁹ and particularly those with STEM skills.¹³⁰ Similarly, major insurance companies increasingly advertise occupational pension schemes to German employers (especially in the *Mittelstand*) as a means to target much-needed skilled personnel,¹³¹ often in the form of comprehensive packages including additional, targeted benefits such as occupational healthcare and accident insurance. In this vein, despite occupational welfare offerings being a universal right for German employees, manufacturing employers have become those to advertise them most proactively.¹³²

In sum, German employers have vigorously mobilized against generous social protection delivered through social insurance, while simultaneously increasing the selective provision of occupational welfare. As others have noted,¹³³ the withdrawal of employers’ support for unemployment protection directly contradicts theories that posit continuity in the German political economy based on the persistent complementarity, at least in core sectors, between unemployment protection and investment in specific skills. Yet, employers’ support for occupational welfare in

the manufacturing industries does not fit with an unequivocal liberalization story either. Rather, it can best be understood in light of the argument we put forward in this paper: as the centrality of highly-specialized but mobile workers—such as STEM graduates—increased, employers became supporters of selective social policies conducive to “locking-in” their highly-skilled personnel.¹³⁴ Thus, employers’ preferences toward social protection in the context of the knowledge economy are less concerned with incentivizing individuals to invest in specific skills and more concerned with selectively rewarding and retaining tertiary-educated workers with high-level general skills. As such, forms of occupational and company-based welfare—characterized by higher employer discretion¹³⁵—have become more widespread, while relatively more encompassing forms of social insurance have been increasingly challenged.

Conclusion

The question of how advanced democracies have transitioned from Fordism to the knowledge economy has been of growing interest to comparative political economists in recent years. This article set out to make a novel contribution to this debate, by providing an original theorization of the transition of CMEs into the knowledge economy and by testing it empirically through the critical case of the German manufacturing sector. We conceptualized the transition to the knowledge economy as a process shaped by both liberalization *and* technological change. This approach differs from the “varieties” arguments insofar as we accommodate in our framework increasing evidence that liberalization has not spared CMEs’ core sectors. But differently from the liberalization literature, we also integrate theories of technological change from labor economics into a political economy explanation. We argue in particular that technological change has meant that highly-skilled workers, especially in STEM subjects, have become vital to the production strategies of advanced manufacturing firms. The centrality of this group of workers—highly specialized, but also highly mobile—has weakened CMEs’ traditional complementarity between specific skills, regulated industrial relations, and generous social protection. In this context, liberalization in the industrial relations and social protection arenas has been instrumental for business not only to cut costs at the low end of the skill distribution—as demonstrated by the liberalization literature—but also to concentrate wages and benefits on increasingly important high-skilled workers.

We tested this theoretical argument by leveraging the case of German manufacturing. Triangulating data from elite interviews, descriptive statistics, and industry surveys and reports, we found strong empirical support for our argument. We first documented how the German manufacturing sector has undergone a deep transformation toward high-tech exports. In line with the central expectation of theories of technological change from labor economics, as ICT has become an ever more crucial ingredient of production processes in advanced manufacturing, highly skilled workers—especially in STEM subjects—have become increasingly sought after. In this context, business informed government policy in higher education, which led to an increase in STEM graduates, and of engineers in particular. In parallel, we found that liberalization in industrial relations and labor market policy has been conducive to rewarding highly-skilled workers, whose wage share in the manufacturing sector increased significantly in recent years. Similarly, while employers lobbied aggressively in favor of welfare state retrenchment since the mid-1990s, we also found compelling evidence that occupational social policies have been selectively deployed by manufacturing firms to reward and retain highly-skilled workers.

A key implication for future research which our analysis brings to bear is that one of the main political-economic logics behind CMEs' transition to the knowledge economy can be found in an implicit alliance between business and high-skilled workers—who increasingly stand apart from the rest of the workforce—, which has grown in the shadow of two major structural developments: liberalization *and* technological change. This may prove useful to students of the coalitional politics underpinning advanced capitalist economies' transition to the era of knowledge-based growth, as it points to a different coalitional logic compared to both the dualization literature (which stresses the persistence of a cross-class coalition in core sectors) and liberalization scholarship (which pits capital against labor at large). Our research design—based on the critical case of German manufacturing—suggests that analogous developments can be expected to have occurred in other CMEs as well. At the same time, specific outcomes are likely to be mediated by socio-economic and socio-political variables that differ across countries. Our findings, therefore, open up a fruitful research agenda which can subject the argument developed in this article to systematic scrutiny across the entire universe of CMEs, so as to gain a more thorough understanding of how the logic of transition to the knowledge economy that we have theorized is mediated by different institutional contexts.

Appendix

Fieldwork and Elite Interviews

We conducted a total of 20 semi-structured elite interviews, carried out over two rounds of fieldwork. Interviews were semi-structured in so far as each was conducted with the help of a pre-specified set of questions inquiring about issues of innovation and technological change, skill requirements and skill formation systems, labor markets and industrial relations, or social protection and occupational welfare, while leaving room for discussion of adjacent subjects where need be. The first round of fieldwork was carried out in 2016 with six preliminary interviews focusing on questions about skill requirements and higher education reform in Germany in particular. Following descriptive data and document collection and analysis, a second larger round of fieldwork was carried out in 2019, yielding 14 in-depth interviews on questions of innovation, labor markets and industrial relations, and social protection and welfare. Where possible, interviews were conducted in person (11), with the remainder set up over the telephone. Most interviewees were contacted and acquired directly by authors, with a smaller number of initiations being the result of snowballing (recommendation and referral on behalf of other interviewees).

Interviewees were selected on the basis of three main criteria – affiliation, expertise, and seniority – until a point of saturation was reached for each. As regards affiliation, the focus was on organizations at the highest level of aggregation – i.e., industry associations, social partners, as well as their umbrella organizations –, in order to seek out interviewees with as far-reaching perspectives on their fields of expertise as possible. These included several industry associations of the German manufacturing sector, employers’ associations and labor unions, and affiliated think tanks and networks, complemented by the relevant ministries. With a view to expertise, we sought to obtain insights especially from those representatives who were put in charge of questions of innovation and industrial transformation in their respective organizations. Lastly, in terms of seniority, a key objective was to acquire senior and long-serving interview partners in particular, so as to be able to shed light on the changes which have been witnessed in their fields of expertise over time. Ethics approval and consent were sought before interviews, while recordings and notes were transcribed thereafter. The full list of interviewees together with codes, affiliations (with short explanations), places, and dates, is produced in Table A1 below.

Table A1. List of interviewees

Code	Interviewee affiliation (translation/explanation)	Place	Date
1	BDA – Bund der Deutschen Arbeitgeberverbände (Umbrella organization of German employers' associations)	Berlin (in person)	05.04.2016
2	Stifterverband (Employers' & donors' organization for research and education)	Berlin (in person)	22.04.2016
3	BMBF – Bundesministerium für Bildung und Forschung (Federal ministry of education and research)	Berlin (in person)	10.05.2016
4	KMK – Kultusministerkonferenz (Assembly of ministers of education of the German states)	Bonn (telephone)	26.05.2016
5	BDA – Bund der Deutschen Arbeitgeberverbände	Berlin (in person)	17.06.2016
6	VDMA – Verband Deutscher Maschinen- und Anlagenbau (Mechanical engineering industry association)	Frankfurt (telephone)	27.10.2016
7	Plattform Industrie 4.0 (State-funded, employer-led network on industrial innovation)	Hannover (in person)	04.04.2019
8	VDMA – Verband Deutscher Maschinen- und Anlagenbau	Hannover (in person)	04.04.2019
9	ZVEI – Zentralverband Elektrotechnik- und Elektronikindustrie (Electrical and electronic manufacturers' association)	Hannover (in person)	05.04.2019
10	BITKOM – Bundesverband Informationswirtschaft, Telekommunikation und neue Medien (Federal association for information technology, telecommunications and new media)	Hannover (in person)	05.04.2019
11	IW – Institut der deutschen Wirtschaft (Employers' economic think tank)	Cologne (in person)	15.04.2019
12	BVDW – Bundesverband Digitale Wirtschaft (Federal association for the digital economy)	Berlin (telephone)	17.04.2019
13	DGB Nordrhein-Westfalen – Deutscher Gewerkschaftsbund (Umbrella organization of unions, North Rhine-Westphalia)	Düsseldorf (in person)	26.04.2019
14	IG Metall Baden-Württemberg – Industriegewerkschaft Metall (Industrial union of metalworkers, Baden-Wuerttemberg)	Stuttgart (telephone)	26.04.2019
15	IG Metall Deutschland – Industriegewerkschaft Metall	Berlin (in person)	02.05.2019

16	Südwestmetall – Verband der Metall- und Elektroindustrie (Employers' association in the metal and electrical engineering industries, Baden-Wuerttemberg)	Stuttgart (telephone)	02.05.2019
17	Acatech – Deutsche Akademie der Technikwissenschaften (National academy of sciences and engineering)	Munich (telephone)	13.05.2019
18	BDA – Bund der Deutschen Arbeitgeberverbände	Berlin (telephone)	11.12.2019
19	Südwestmetall – Verband der Metall- und Elektroindustrie	Stuttgart (telephone)	11.12.2019
20	Gesammetall – Gesamtverband der Arbeitgeberverbände der Metall- und Elektroindustrie (Federation of employers' associations in the metal and electrical engineering industries)	Berlin (telephone)	18.12.2019

Notes

- ¹ Kathleen Thelen, ‘Transitions to the Knowledge Economy in Germany, Sweden, and the Netherlands’, *Comparative Politics* 51, no. 2 (2019): 295–315; Torben Iversen and David Soskice, ‘Democratic Limits to Redistribution: Inclusionary versus Exclusionary Coalitions in the Knowledge Economy’, *World Politics* 67, no. 2 (April 2015): 185–225; Torben Iversen and David Soskice, *Democracy and Prosperity: Reinventing Capitalism through a Turbulent Century* (Princeton University Press, 2019).
- ² See, for example, Ben Ansell and Jane Gingrich, ‘A Tale of Two Trilemmas: Varieties of Higher Education and the Service Economy’, in *The Political Economy of the Service Transition*, ed. Anne Wren (Oxford University Press, 2013); Anne Wren, Mate Fodor, and Sotiria Theodoropoulou, ‘The Trilemma Revisited: Institutions, Inequality, and Employment Creation in an Era of ICT-Intensive Service Expansion’, in *The Political Economy of the Service Transition*, ed. Anne Wren (Oxford University Press, 2013); David Hope and Angelo Martelli, ‘The Transition to the Knowledge Economy, Labor Market Institutions, and Income Inequality in Advanced Democracies’, *World Politics* 71, no. 2 (2019): 236–88.
- ³ fortiss, ‘The Software Car: Information and Communication Technology (ICT) as an Engine for the Electromobility of the Future’ (fortiss GmbH, 2011), 4.
- ⁴ International Federation of Robotics, ‘World Robotics Report 2018’, 2018, 16.
- ⁵ Daron Acemoglu and David Autor, ‘Chapter 12 - Skills, Tasks and Technologies: Implications for Employment and Earnings’, in *Handbook of Labor Economics*, ed. David Card and Orley Ashenfelter, vol. 4 (Elsevier, 2011), 1043–1171; C. D. Goldin and L. F. Katz, *The Race between Education and Technology* (Harvard University Press, 2008); Niccolo Durazzi, ‘The Political Economy of High Skills: Higher Education in Knowledge-Based Labour Markets’, *Journal of European Public Policy* 26, no. 12 (2 December 2019): 1799–1817; Peter A. Hall, ‘The Electoral Politics of Growth Regimes’, *Perspectives on Politics*, 2019, 1–15; Hope and Martelli, ‘The Transition to the Knowledge Economy, Labor Market Institutions, and Income Inequality in Advanced Democracies’; Iversen and Soskice, *Democracy and Prosperity: Reinventing Capitalism through a Turbulent Century*.
- ⁶ Peter A. Hall and David Soskice, ‘An Introduction to Varieties of Capitalism’, in *Varieties of Capitalism: The Institutional Foundations of Comparative Advantage* (Oxford University Press, 2001), 1–68.
- ⁷ Thelen, ‘Transitions to the Knowledge Economy in Germany, Sweden, and the Netherlands’.
- ⁸ Hall, ‘The Electoral Politics of Growth Regimes’; Hope and Martelli, ‘The Transition to the Knowledge Economy, Labor Market Institutions, and Income Inequality in Advanced Democracies’; Iversen and Soskice, ‘Democratic Limits to Redistribution’; Iversen and Soskice, *Democracy and Prosperity: Reinventing Capitalism through a Turbulent Century*; Thelen, ‘Transitions to the Knowledge Economy in Germany, Sweden, and the Netherlands’.
- ⁹ OECD, ‘The Measurement of Scientific and Technological Activities: Guidelines for Collecting and Interpreting Innovation Data: Oslo Manual, Third Edition’ (Prepared by the Working Party of National Experts on Scientific and Technology Indicators, OECD, Paris, 2005), 28.
- ¹⁰ Hall and Soskice, ‘An Introduction to Varieties of Capitalism’.

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- ¹¹ Hall and Soskice; Margarita Estévez-Abe, Torben Iversen, and David Soskice, ‘Social Protection and the Formation of Skills: A Reinterpretation of the Welfare State’, in *Varieties of Capitalism: The Institutional Foundations of Comparative Advantage* (Oxford University Press, 2001), 145–83; Torben Iversen, *Capitalism, Democracy, and Welfare* (Cambridge University Press, 2005).
- ¹² Kathleen Thelen, *Varieties of Liberalization and the New Politics of Social Solidarity* (New York: Cambridge University Press, 2014); Thelen, ‘Transitions to the Knowledge Economy in Germany, Sweden, and the Netherlands’; Karen M. Anderson and Anke Hassel, ‘Pathways of Change in CMEs: Training Regimes in Germany and the Netherlands’, in *The Political Economy of the Service Transition*, ed. Anne Wren (Oxford University Press, 2013); Ansell and Gingrich, ‘A Tale of Two Trilemmas: Varieties of Higher Education and the Service Economy’; Hall, ‘The Electoral Politics of Growth Regimes’; Wren, Fodor, and Theodoropoulou, ‘The Trilemma Revisited: Institutions, Inequality, and Employment Creation in an Era of ICT-Intensive Service Expansion’.
- ¹³ Thelen, *Varieties of Liberalization and the New Politics of Social Solidarity*; Thelen, ‘Transitions to the Knowledge Economy in Germany, Sweden, and the Netherlands’.
- ¹⁴ Anke Hassel, ‘The Paradox of Liberalization — Understanding Dualism and the Recovery of the German Political Economy’, *British Journal of Industrial Relations* 52, no. 1 (2014): 57–81; Bruno Palier and Kathleen Thelen, ‘Institutionalizing Dualism: Complementarities and Change in France and Germany’, *Politics & Society* 38, no. 1 (1 March 2010): 119–48.
- ¹⁵ Thelen, *Varieties of Liberalization and the New Politics of Social Solidarity*; Thelen, ‘Transitions to the Knowledge Economy in Germany, Sweden, and the Netherlands’; Christian Lyhne Ibsen and Kathleen Thelen, ‘Diverging Solidarity: Labor Strategies in the New Knowledge Economy’, *World Politics* 69, no. 3 (2017): 409–47.
- ¹⁶ Lucio Baccaro and Chris Howell, ‘A Common Neoliberal Trajectory: The Transformation of Industrial Relations in Advanced Capitalism’, *Politics & Society* 39, no. 4 (1 December 2011): 521–63; Lucio Baccaro and Chris Howell, *Trajectories of Neoliberal Transformation: European Industrial Relations Since the 1970s* (Cambridge University Press, 2017); Timo Fleckenstein and Soohyun Christine Lee, ‘The Politics of Labor Market Reform in Coordinated Welfare Capitalism: Comparing Sweden, Germany, and South Korea’, *World Politics* 69, no. 1 (2017): 144–83; Wolfgang Streeck, *Re-Forming Capitalism: Institutional Change in the German Political Economy* (Oxford University Press, 2009).
- ¹⁷ Baccaro and Howell, ‘A Common Neoliberal Trajectory’; Baccaro and Howell, *Trajectories of Neoliberal Transformation*.
- ¹⁸ Daniel Kinderman, ‘Challenging Varieties of Capitalism’s Account of Business Interests: Neoliberal Think-Tanks, Discourse as a Power Resource and Employers’ Quest for Liberalization in Germany and Sweden’, *Socio-Economic Review* 15, no. 3 (2017): 587–613; Fleckenstein and Lee, ‘The Politics of Labor Market Reform in Coordinated Welfare Capitalism’.
- ¹⁹ Baccaro and Howell, ‘A Common Neoliberal Trajectory’; Baccaro and Howell, *Trajectories of Neoliberal Transformation*; Fleckenstein and Lee, ‘The Politics of Labor Market Reform in Coordinated Welfare Capitalism’; Kinderman, ‘Challenging Varieties of Capitalism’s Account of Business Interests’.

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