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Abstract

We investigate the consequences of structural change for workers displaced from the manufacturing sector. Manufacturing establishments traditionally employed low- and high-wage workers in similar proportions and paid substantial wage premiums to both types of workers. Structural change has led to the disappearance of these jobs, particularly for low-wage workers. Decomposing displacement wage losses, we show that low-wage workers suffer considerable losses in establishment premiums following displacement, whereas high-wage workers tend to fall down the match quality ladder. With ongoing structural change, losses in wages and establishment premiums have increased over time, especially for low-wage workers, in part because they are increasingly forced to switch to low-knowledge service jobs where establishment premiums are low. Our findings further highlight that structural change and layoffs in manufacturing have significantly contributed to job polarization and the rise in assortative matching of workers to firms.

Keywords: structural change, manufacturing decline, displaced workers, cost of job loss, human capital, firm rents

JEL Classification: J22, J24, J31, J63

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1. Introduction

Most industrialized countries have experienced substantial changes in the structure of employment over recent decades, marked by significant shifts of employment away from the manufacturing sector. In the US, the share of workers employed in manufacturing declined from around 20 percent in the early 1980s to less than 10 percent by 2010. Germany, the third-largest exporter of manufactured goods, has also experienced a pronounced decline, though manufacturing continues to account for 20 percent of jobs in the country. Historically, the manufacturing sector has provided high-wage employment opportunities for both low- and high-skilled workers (see e.g., Gould, 2021). As manufacturing jobs have disappeared, workers have become increasingly more likely to be employed in the expanding service sector. The service sector, however, is much more segmented than the manufacturing sector. While low-knowledge service industries (e.g., retail and hospitality) are typically found at the lower end of the wage distribution, providing jobs for which few skills are needed, high-knowledge service industries (e.g., software development, finance, and insurance) are typically well-paid jobs that require higher levels of skill.

While part of the decline in manufacturing employment has been absorbed by fewer young workers entering than older workers retiring from the sector, a considerable share of prime-age workers has separated from manufacturing establishments in recent decades (11 percent per year over the 1988-2007 period).[1] More than half of these transitions out of manufacturing were into unemployment and thus likely involuntary. The decline in manufacturing will continue and might even accelerate as technological change continues. For example, the transition from the combustion engine to electric vehicles is predicted to put up to 400,000 manufacturing jobs in Germany at risk (Financial Times, 2020).

In this paper, we investigate the consequences of structural change for workers who are directly affected by it—that is, workers who have lost their manufacturing job, with a focus on mass layoffs, which can be considered as exogenous from the worker's viewpoint. Our paper is the first to examine the implications of structural change for displacement effects of different types of workers, and over time. We address the following questions: have the costs of job loss increased over time as manufacturing jobs have become scarcer? Given the segmentation of the expanding service sector, are the costs of job loss higher for less-skilled workers? What are the sources of wage losses caused by displacement, do they differ by worker type and have they changed over time? And how have structural change and layoffs in the manufacturing sector affected job polarization and the wage structure?

[1] Own calculations based on the Sample of Integrated Labour Market Biographies, 1975-2010.

Our analysis of wage components that drive displacement wage losses combines several factors emphasized by the literature on job displacement. One strand of the literature focuses on losses in workers' human capital following displacement. Displaced workers lose acquired skills that are specific to the firm as well as occupation- and industry-specific skills if they switch occupations or industries (e.g., Topel, 1990, Jacobson, LaLonde and Sullivan, 1993, Neal, 1995, Poletaev and Robinson, 2008, or Huckfeldt, 2022). Displaced workers' skills may also depreciate during a period of unemployment, leading to losses in general human capital, which is equally valued across jobs. In addition, displaced workers can lose valuable match-specific capital, since their search for a good match with a firm may need to start from scratch after displacement (e.g., Jacobson et al., 1993, Lachowska, Mas and Woodbury, 2020, Burdett, Carillo-Tudela and Coles, 2020, or Jarosch, 2023).

The more recent literature has focused on the importance of losses in wage premiums that firms or establishments pay to all their workers (e.g., Lachowska et al., 2020, and Moore and Scott-Clayton, 2021, for the US; Fackler, Mueller and Stegmaier, 2021, and Schmieder, von Wachter and Heining, 2023, for Germany; and Bertheau et al., 2022, in a cross-country analysis). Losses in establishment premiums following displacement, then, can be thought of as a fall down the "establishment premium ladder" as workers move up to higher-paying establishments with time in the labor market, either within or between industries.

Structural change can amplify displacement losses in establishment premiums and general and specific human capital. Workers faced with a shrinking number of manufacturing jobs may be forced into the lower-paying service sector, experience longer job searches and time out of work, and be more likely to switch occupations.

We make three important contributions to the literature. First, we provide a systematic analysis on how the magnitude and sources of displacement wage losses differ across worker types. While some papers have documented differences in earnings and wage losses by worker skill after displacement (e.g. Hijzen et al., 2010), they do not explicitly study the drivers behind these differences. We disentangle the sources of displacement wage losses by differentiating between general, occupation- and establishment-specific human capital losses on the one hand, and losses in establishment premiums and match quality on the other hand. Understanding the sources of displacement wage losses by worker type is important to design targeted policy responses. For example, re-training policies are unlikely to remedy lost establishment premiums but can be effective to the extent that displacement costs are due to losses in human capital.

Second, to our knowledge, this paper is the first to investigate general time trends in the cost of job displacement and its sources in the manufacturing sector, and to link these to structural change. In contrast, existing studies, including the recent work by Schmieder et al. (2023), have mostly

focused on the evolution and drivers of displacement effects over the business cycle (see also Davis and von Wachter, 2011, and Farber, 2004, 2017, for the US).

Third, our paper connects the changing and heterogeneous costs of job displacement to important long-term trends in the labor market observed in many developed countries: job polarization (Autor and Dorn, 2013) and the rise in wage inequality, in particular the increased sorting of high-wage workers into high-wage firms (e.g., Card, Heining and Kline, 2013, Song, Price, Guvenen, Bloom and von Wachter, 2019).

Specifically, we study trends in wage losses and their sources among workers displaced from the manufacturing sector over two decades between 1988 and 2007, with a focus on differences by worker type and over time. Our empirical design combines matching with an event study approach to flexibly compare the labor market careers of displaced workers with otherwise identical workers. We draw on four decades of administrative data from Germany that links information on workers with information on establishments, allowing us to observe an individual's job and occupational history for at least 15 years prior to a layoff. Consistent with the existing literature on job displacement, our analysis is restricted to male workers, who make up over 70 percent of the manufacturing workforce and who have been hit particularly hard by the decline of manufacturing jobs.[2] To disentangle the various sources of displacement wage losses (i.e., losses in general, occupation, and firm-specific human capital as well as losses in match quality and firm premiums), we estimate the different components using extended regressions based on the Abowd, Kramarz, and Margolis (AKM) model (Abowd, Kramarz and Margolis, 1999).[3]

Our first set of results provides a comprehensive analysis of the consequences of job displacement in the manufacturing sector by worker type. We distinguish between low- and high-wage workers, defined as workers in the bottom and top terciles of the distribution of estimated AKM worker fixed effects. We show that even though high-wage workers on average experience somewhat larger wage losses upon displacement, low-wage workers suffer a substantially larger loss in establishment premiums. Six years after the layoff, nearly 80 percent of the overall wage loss of low-wage workers can be attributed to declines in the establishment premium, compared to only 25 percent for high-wage workers. This finding indicates that low-wage workers have a harder time finding jobs in high-paying establishments after displacement than high-wage workers. We further show that movements out of the manufacturing sector—where establishment premiums are high—and into the low-knowledge service sector—where establishment premiums are particularly low—

[2] The existing literature almost exclusively studies the labor market outcomes of men. Exceptions are Illing, Schmieder and Trenkle (2022) and Bertheau et al. (2022).

[3] Gulyas and Pytka (2021) and Schmieder et al. (2023) provide alternative approaches for disentangling displacement wage losses. An advantage of our approach is that it is grounded in a statistical model of wage determination, allowing us to decompose wage losses formally based on jointly estimated returns to specific human capital and establishment premiums.

are more common for low-wage workers. Such differences in post-displacement sectoral switching can account for around 50 percent of the differential losses in establishment premiums by worker type. The remainder is explained by low-wage workers facing larger losses even when staying in the manufacturing sector. While the patterns and magnitudes of human capital losses are largely similar for both types of workers, high-wage workers face considerably larger losses in match quality.

These findings are consistent with the notion that over the life cycle low-wage workers predominantly move to better-paying establishments, while high-wage workers move to establishments that offer better matches, in line with the findings by Haltiwanger, Hyatt and McEntarfer (2018). The heterogeneous impact across worker types also helps to reconcile somewhat contradictory findings in the recent literature on post-displacement establishment premium losses. The lower establishment premium losses and higher match quality losses estimated by Lachowska et al. (2020) compared to those of other papers in the literature (such as Schmieder et al., 2023, and Bertheau et al., 2022) are likely a result of the more high-skilled sample used in their analysis.

In the second part of the paper, we investigate whether structural change that has shifted employment away from manufacturing into the service sector has increased the costs of displacement, with particularly severe consequences for low-wage workers. We find that low-wage workers indeed face increasingly large costs following displacement. Not only are low-wage workers increasingly less likely to be re-employed after displacement, but they also suffer increasingly large wage losses, both in absolute terms and relative to high-wage workers. Whereas low-wage workers laid off at the end of the 1980s experienced wage losses of less than 5 percent three years after displacement, losses increased to nearly 15 percent by the mid-2000s. In contrast, wage losses of high-wage workers have remained roughly stable over the same period. Losses in the establishment premium are by far the most important driver behind these increasing displacement wage losses of low-wage workers, accounting for more than two-thirds of the increase in their overall wage loss. Reduced opportunities to accumulate general human capital contribute an additional 17 percent, in line with the finding that low-wage workers are increasingly less likely to be employed after displacement.

We rule out that these trends reflect changes in the composition of displaced workers. Instead, they are related to reduced job opportunities for low-wage workers in the high-paying manufacturing sector: low-wage workers are increasingly less likely to be re-employed in manufacturing and increasingly more likely to move to the low-paying low-knowledge service sector after displacement. About half of the increased establishment premium losses over time can be explained by such *between*-sector movements; the remaining half arises because workers fall further down the establishment premium ladder *within* the manufacturing sector, likely because establishment premiums have become more dispersed over time. We further show that the cost of job displacement from the manufacturing sector has increased for both workers in production and service occupations.

The increase in displacement costs is therefore not solely a consequence of domestic outsourcing of jobs from the manufacturing to the service sector but affects all low-wage workers in manufacturing.

Overall, our findings suggest that the decline of manufacturing jobs and the rise of the service sector have hit low-wage workers much harder than high-wage workers. Not only has the share of high-wage workers in the manufacturing sector increased over time, but the rise of the high-knowledge service sector has provided new job opportunities for high-wage workers in establishments that pay relatively high wage premiums. Low-wage workers, in contrast, are increasingly forced to switch to low-knowledge service sector jobs following displacement, which are characterized by lower establishment premiums. Structural change has thus contributed to the rise in displacement wage losses experienced by low-wage workers over time.

In the third part of the paper, we explore the link between the changing and heterogeneous displacement wage losses on the one hand and job polarization and increased wage inequality on the other hand. Our findings support the notion that the disappearance of manufacturing jobs due to structural change can partially explain the employment polarization observed in many developed countries (e.g., Autor and Dorn, 2013, Goos, Manning and Salomons, 2014), as proposed by Bárány and Siegel (2018, 2020). The empirical evidence provided in our paper extends this literature by emphasizing the role of structural change and establishment premiums for job polarization. Specifically, our findings suggest that the disappearance of jobs in the middle of the wage distribution reflects not only a shift from routine to manual and abstract tasks, as emphasized in the literature, but also a shift away from low-skilled but "good" manufacturing jobs with high establishment premiums to low-skilled service sector jobs with low establishment premiums. In line with this hypothesis, we document that manufacturing jobs of low-wage workers were indeed concentrated in the middle of the occupational wage distribution, whereas low-knowledge service sector jobs of low-wage workers and high-knowledge service sector jobs of high-wage workers are overrepresented at the bottom and at the top of the wage distribution, respectively.

The decline of the manufacturing sector is also an important driver of the rise in wage inequality and assortative matching between workers and firms observed in Germany and other countries (e.g., Dustmann, Ludsteck and Schönberg, 2009, Card et al., 2013, Song et al., 2019). We find that the increase in wage inequality (measured as the change in the variance of log wages) and in assortative matching (measured as the covariance between worker and establishment fixed effects) between 1988 and 2007 would have been 15 and 22 percent lower if the broad sectoral structure—manufacturing, low-knowledge services and high-knowledge services—by worker type (low-, medium- and high-wage) had remained at its 1988 level. Moreover, we show that up to 10 percent of the increase in sorting of workers to firms can be attributed to layoffs from the manufacturing sector alone. This effect is primarily driven by layoffs that result in a transition to the service sector.

2. Motivating Evidence

As in other developed countries, there has been a substantial drop in manufacturing employment in Germany over the last few decades. Whereas nearly 45 percent of male workers were employed in the manufacturing sector in 1975, this share had fallen to 35 percent by 2014 (Panel A of Figure 1). Meanwhile, employment in low-knowledge service sectors such as retail, lodging, and hospitality or logistics, and high-knowledge service sectors such as software development, finance, insurance, and advertising increased steadily over the same period.[4]

In Panel B of Figure 1, we explore changes in the employment structure by worker type. To this end, we estimate augmented AKM-style wage regressions, described in more detail in Section 4.2, that include worker as well as establishment fixed effects (Abowd et al., 1999). We then differentiate between low- and high-wage workers, by defining workers who fall into the bottom third of the distribution of AKM worker fixed effects as low-wage workers and those in the top third as high-wage workers.

A remarkable picture emerges. Over our estimation period from 1988 to 2007, the decline in the share of manufacturing employment is considerably more pronounced for low- than for high-wage workers (10 percentage points vs. 3 percentage points). Low-wage workers are also increasingly likely to be employed in the low-knowledge service sector, while high-wage workers are increasingly likely to work in high-knowledge service jobs.

Panel C of Figure 1 shows that the majority of low-wage workers in manufacturing are production workers (72 percent), while service occupations account for less than 20 percent. These shares have remained largely stable over time, implying that most low-wage manufacturing sector jobs lost are production jobs.[5]

Further differentiating sectors by the average AKM establishment premiums they pay, manufacturing jobs are characterized by exceptionally high establishment premiums: they are on average nearly 18 percent higher than in the low-knowledge service sector, and nearly 4 percent higher than in the high-knowledge service sector (Panel A of Table 1).[6]

These differences in establishment premiums across sectors are highly persistent over time. In fact, as Panel A of Figure 2 shows, gaps in establishment premiums between the manufacturing and

[4] We use the definitions provided in Grupp, Jungmittag and Schmoch (2000) to define the low- and high-knowledge service sectors. A small share of industries employing around 10 percent of the workforce can be classified as neither manufacturing nor low- or high-knowledge services.

[5] Our definition of production occupations is broad and also includes craft occupations for example. Only around 7 percent of low-wage manufacturing workers work in typical domestic outsourcing occupations as defined by Goldschmidt and Schmieder (2017) (food processing, cleaning, security, and logistics).

[6] We think of establishment fixed effects as premiums paid to all employees, holding worker quality constant. Establishment and worker fixed effects shown in Table 1 are demeaned such that their averages in the economy are zero.

low-knowledge sector have increased over time (from 17 percent in 1988 to 23 percent in 2007), whereas gaps between the manufacturing and high-knowledge service sector have declined somewhat (from 6 percent in 1988 to 3 percent in 2007). Panel B of Figure 2 further highlights that establishment premiums have become more dispersed over time in all sectors, suggesting that the scope for falling down the establishment premium ladder upon displacement has risen over time both within and across sectors.[7]

At the same time, the manufacturing sector has historically provided job opportunities for all types of workers. Average establishment premiums in the manufacturing sector are high for both low- and high-wage workers, indicating that the two types of workers are employed by similar types of establishments (Table 1, Panel A). Instead, in the two service sectors, differences in average establishment premiums between low- and high-wage workers are larger, pointing to a higher degree of sorting of high-wage workers to high-wage establishments in these sectors. Moreover, the average worker fixed effect and the education distribution across sectors suggest that workers in manufacturing are neither negatively nor positively selected, while the low- and high-knowledge sectors are characterized by a negative and positive selection of workers, respectively (Panel B).

While it is beyond the scope of this study to offer a full explanation of why establishment premiums are particularly high in the manufacturing sector, in Table 2 we consider two potential explanations: productivity differences (i.e., higher total job surplus in the manufacturing sector) and rent-sharing (i.e., workers capture a larger share of the total job surplus). In line with the latter explanation, union coverage rates—the share of workers covered by either sectoral or firm-specific union agreements—are higher in the manufacturing than in the low-knowledge service sector, but not dramatically so. Union coverage rates are lowest in the high-knowledge service sector, where workers are more likely to negotiate wages individually. Furthermore, work councils—workers' representation at the establishment level—are more common in manufacturing than in either service sector. In line with the productivity explanation, value added per worker appears to be highest in the high-knowledge service sector, followed by the manufacturing sector.

Overall, Table 2 suggests that the higher establishment premiums in the manufacturing sector relative to the low-knowledge service sector may stem from a combination of better worker representation, and higher productivity. In contrast, the difference in the establishment premiums between the high- and low-knowledge service sectors appears to be a result of productivity differences.

[7] These trends occur even though establishment premiums are constant over time within establishments (see Section 4.2 for the estimation). The trends are therefore driven by selective entry and exit and differential employment growth of continuing establishments.

3. Data and Sample

3.1. Data

Our analysis uses data from German Social Security Records (the so-called *Beschäftigtenhistorik*) spanning nearly four decades, from 1975 to 2014. These data include the population of workers and establishments covered by the social security system, comprising roughly 80 percent of the German workforce. Self-employed workers, civil servants, and military personnel are not included in the dataset. We observe workers' main employment relationships as of June 30 of each year, in addition to individual characteristics such as sex, age, education, and citizenship.

We restrict our analysis to West Germany, as this allows us to analyze how the wage effects of job displacement have evolved over time, and because East German workers are only consistently included in the data from 1992 onwards. We further exclude all irregular, marginal, and seasonal employment relationships. Since the definitions of occupations are only consistent until 2010, we discard observations after that year.

Unique establishment identifiers allow us to match individuals to the establishments where they work and to track workers over time across different establishments. These two features, combined with observing all workers covered by the social security system, make the data uniquely suited for our analysis. Occupation identifiers further allow us to observe occupation switches. We compute establishment and occupation tenure in years and cap both types of tenure at ten years, since we do not observe workers' full employment history in the earlier data windows.[8] Increasing the cap to 12 or even 15 years has little impact on our findings but does reduce the time window over which we can estimate displacement effects.

The wage variable records the daily wage in the establishment at which the worker was employed as of the reference date, averaged over the entire period the employee worked for the establishment during that year. As is typical for social security data, our wage variable is right-censored at the social security limit. We impute censored wages under the assumption that the error term in the log-wage regression is normally distributed, by following the procedure proposed by Card et al. (2013). We deflate wages to 1995 prices using the consumer price index.

When investigating the employment effects of displacement, we consider both part- and full-time employment, and assign values of 0 for non-employment, 0.5 for part-time employment and 1 for full-time employment. In the absence of detailed information on hours worked, we focus on full-time employment when studying the wage effects of displacement.

[8] If a worker is employed part-time on June 30, we assume that occupation and establishment tenure increase by half a year during that year.

3.2. Displacement Definition and Sample

Following the existing literature, we define a worker as displaced if he is separated from the establishment because of a mass layoff. Such separations are likely to be involuntary from the worker's point of view and not caused by his behavior. We define mass layoffs as events where at least 30 percent of workers are separated from the establishment from one year to the next, and establishment employment is depressed by 30 percent or more for at least two consecutive years. To ensure that we capture a true mass layoff and not merely a change in the establishment identifier or a spin-off, we follow Hethey and Schmieder (2010) by eliminating cases in which 30 percent or more of those leaving the mass layoff establishment go to a single other establishment. To rule out breakups into multiple establishments, we require that not more than 70 percent of those leaving the mass layoff establishment go to the same three establishments. We further impose that mass layoff establishments must have between 30 and 500 employees in the year before the mass layoff event. The minimum size restriction is standard in the literature and makes it unlikely that large employment fluctuations due to general turnover are misclassified as a mass layoff. The maximum size restriction ensures that the mass layoff event does not affect the region more broadly, for example through spillover effects on other firms (see Gathmann, Helm and Schönberg, 2020).

To be able to compare our estimates with findings from the existing literature, we restrict our sample of displaced workers to male, prime-aged, high-tenure workers. Specifically, we require that workers are between 25 and 50 years old and employed full-time at the mass layoff establishment for at least four years at displacement. Our sample excludes recalled workers, who were laid off but are observed again in the mass layoff establishment within six years of the layoff.

We then construct two samples. In the "pooled" sample, we consider workers displaced from a manufacturing establishment between 1990 and 2004—84,268 laid-off workers in total. In this sample, we are able to follow workers for at least six years before and after the layoff, and to observe workers' establishment and occupation history for at least ten years before the first year of our event study period (six years before the mass layoff). We use the larger "time-series" sample to investigate whether displacement effects have changed over time, focusing on medium-term displacement effects three years after the mass layoff relative to our baseline period (four years prior to the mass layoff), allowing us to consider mass layoffs that occurred between 1988 and 2007—101,557 layoffs in total.

Our analysis focuses on low- and high-wage workers. These are defined as workers in the bottom and top terciles of the distribution of worker fixed effects estimated in augmented AKM regressions based on the universe of West German male full-time workers aged 16 to 65 (see Section 4.2). In the pooled sample, 32,333 and 21,960 are low- and high-wage workers, respectively. In the time-series sample, 38,879 are low- and 26,442 are high-wage workers.

4. Estimating Displacement Wage Losses and their Sources

In this section, we first provide a statistical model of wage determination to illustrate the reasons why wages may decline following job displacement (Section 4.1). We then propose an augmented version of the AKM model to estimate the different components that determine wages (Section 4.2). Finally, we outline our empirical strategy to estimate the cost of job loss and explain how we decompose displacement wage losses into its components (Section 4.3).

4.1. A Statistical Model of Wage Determination

Assume that log wages are determined by the following relationship:

$$\ln(w_{it}) = \underbrace{\alpha_i}_{\text{worker quality}} + \underbrace{\psi_{J(i,t)}}_{\text{establishment premium}} + \underbrace{f_{1i}(ActExp_{it})}_{\text{general HC}} + \underbrace{f_{2i}(OccT_{it})}_{\text{occ.-spec. HC}} + \underbrace{f_{3i}(EstT_{it})}_{\text{est.-spec. HC}} + \underbrace{m_{iJ(i,t)}}_{\text{match quality}} + \underbrace{\omega_t}_{\text{year effects}} + \underbrace{r_{it}}_{\text{residual component}} \quad (1)$$

Here, α_i denotes worker quality, which captures differences in worker productivity that are constant over time and across establishments, and $\psi_{J(i,t)}$ denotes establishment premiums, which capture the wage premiums that establishments pay to all their employees independent of worker quality and characteristics. $ActExp_{it}$, $OccT_{it}$, and $EstT_{it}$ denote general, occupation- and establishment-specific human capital, measured as actual experience, occupation and establishment tenure, respectively; $m_{iJ(i,t)}$ denotes the quality of the match between the worker and the establishment; ω_t refers to calendar year fixed effects; and r_{it} reflects the residual component of wages.

These different components of wage determination capture the potential sources of wage losses following job displacement and therefore determine the severity of wage losses. To illustrate this, consider a worker who has been displaced for exogenous reasons from the manufacturing sector and contrast their wage loss with the wage change experienced by a "twin" control worker with the same worker characteristics who was employed in an identical job prior to the layoff.

First, the displaced worker may face losses in establishment premiums ($\psi_{J(i,t)}$). Such losses can be conceptualized as a fall down the "establishment premium ladder". Workers may move up from lower to higher-paying establishments with time in the labor market. Upon displacement, they are then forced to start searching for "good" establishments from scratch (e.g., Burdett et al., 2020, and Jarosch, 2023). The fall down the establishment premium ladder may occur either within the manufacturing sector or across sectors, as displaced workers are forced to transition into the service sector, where establishment premiums are, in general, lower (see Table 1). As such, establishment premium losses may partly reflect losses in sectoral or industry wage premiums (as explored in Dickens and Katz, 1987, Krueger and Summers, 1988, Katz and Summers, 1989, among others),

stemming from higher average productivity and rents in the manufacturing sector (see Table 2). Structural change may therefore amplify displacement losses in establishment premiums as fewer and fewer high-wage manufacturing jobs are available.

A second potential reason for displacement wage losses is reduced general human capital that is equally valued across establishments and sectors (e.g., Mincer, 1974). Displaced workers may not immediately find new employment after being laid off. Any time out of work means fewer opportunities for accumulating valuable general human capital and may lead to a depreciation of acquired skills. This factor may be particularly important for workers displaced from the manufacturing sector if these workers search longer for a new job after displacement in the hope of securing another high-wage manufacturing job.

Third, displaced workers may suffer wage losses because of losses in occupation-specific human capital (e.g., Poletaev and Robinson, 2008, or Kambourov and Manovskii, 2009). When displaced workers switch occupations, they are no longer rewarded for their acquired occupation-specific skills and need to start accumulating skills afresh in their new occupation. Any time out of work further prevents workers from accumulating such skills. A switch out of the manufacturing sector may often involve a change in occupation, further amplifying the displacement wage loss over and above the loss in establishment wage premiums.

Fourth, displaced workers by definition lose any establishment-specific human capital (Becker, 1964); that is, skills that are valuable only in the particular establishment, such as specific knowledge about production processes or the organization.[9]

Fifth, displaced workers may lose match-specific capital—human capital that is specific to the worker-establishment match. Workers may be able to climb the "match quality ladder" with time in the labor market, improving the quality of the match as they voluntarily switch from one establishment to another. Upon displacement, displaced workers may have to search from scratch, resulting in a loss of match-specific capital (e.g., Lachowska et al., 2020).[10]

4.2. Augmented AKM Regressions

To estimate the different components of the model of wage determination presented above, we augment the AKM model first proposed by Abowd et al. (1999) by adding non-linear terms of occupation and establishment tenure to the baseline model, to capture occupation- and establishment-

[9] More generally, $f_{3i}(EstT_{it})$ in equation (1) may capture within-establishment wage growth on top of wage growth due to general and occupation-specific human capital accumulation, for example, due to the use of optimal contracts whereby establishments prefer to pay their employees initially below their marginal product followed by payments above the marginal product, as in Lazear (1979).

[10] Krolikowski (2017) and Jung and Kuhn (2019) analyze movements down the job ladder following displacement. However, neither of the two studies explicitly distinguishes between firms and jobs and hence they cannot differentiate between movements down the firm premium or the match quality ladder.

specific human capital accumulation. The aim of the extension is twofold. First, we are directly interested in the estimates of the returns to establishment- and occupation specific human capital; and second, establishment premiums ($\psi_{J(i,t)}$) and occupation and establishment tenure ($OccT_{it}$ and $EstT_{it}$) are likely to be positively correlated (i.e., workers in higher paying establishments tend to stay longer in their chosen establishment and occupation). Thus, excluding occupation and establishment tenure may result in biased estimates of establishment premiums.[11] To measure the returns to general human capital, we would ideally like to control for actual experience ($ActExp_{it}$) in the augmented AKM regression in a flexible way. This would, however, severely restrict the time window for studying displacement effects since returns to general human capital are generally less concave than returns to occupation or establishment tenure and may build up many years after labor market entry. We therefore opt to control for potential experience instead.

Due to the perfect collinearity between potential experience and time and cohort effects (captured by the worker fixed effect α_i), we adopt a two-step procedure. In a first step, we estimate returns to potential experience by regressing log wages on a cubic in potential experience, year fixed effects and establishment fixed effects.[12] We allow the returns to potential experience to vary by worker type ($WType_i$), distinguishing between low-, medium- and high-wage workers. The initial classification of worker types is based on the terciles of worker fixed effects estimated in a standard AKM model that does not control for occupation and establishment tenure. We then compute log wages net of returns to potential experience $\ln(\widetilde{w}_{it})$ and estimate the following augmented AKM regression:

$$\ln(\widetilde{w}_{it}) = \alpha_i + \psi_{J(i,t)} + \sum_g \left(\gamma_{1g} OccT_{it} + \gamma_{2g} OccT_{it}^2 + \gamma_{3g} \mathbb{I}[OccT_{it} \geq 10]\right) \mathbb{I}[WType_i = g]$$

$$+ \sum_g \left(\delta_{1g} EstT_{it} + \delta_{2g} EstT_{it}^2 + \delta_{3g} \mathbb{I}[EstT_{it} \geq 10]\right) \mathbb{I}[WType_i = g]$$

$$+ \omega_t + \epsilon_{it}. \qquad (2)$$

In equation (2), α_i denotes worker fixed effects, $\psi_{J(i,t)}$ establishment fixed effects and ω_t calendar year fixed effects. $OccT_{it}$ and $EstT_{it}$ measure an individual's (three-digit) occupation and establishment tenure, respectively. Both variables are capped at ten years of tenure, as explained in Section 3.1. We allow for a quadratic relationship between log wages and establishment and occupation tenure, and an additional effect if tenure is greater than ten years, to account for the capped

[11] Indeed, we find the contribution of losses in establishment premiums to the overall displacement wage losses to be overstated when establishment premiums are estimated using standard AKM regressions omitting occupation and establishment tenure (see Appendix A.1. and Table A.4).

[12] Potential experience is measured as age minus 16 for low-skilled workers, age minus 19 for medium-skilled workers and age minus 24 for high-skilled workers. If, by contrast, we assume that age profiles are flat at age 40 by omitting the linear age term and including a quadratic and cubic in (age-40), as in Card, Cardoso, Heining and Kline (2018), estimated establishment premiums are strongly correlated with those obtained from our preferred specification.

nature of the two variables. We further allow the returns to occupation and establishment tenure to vary by worker type, $WType_i$, again distinguishing between low-, medium- and high-wage workers.

We estimate the augmented AKM regression for the years 1984 (i.e., the first year that we are able to observe a worker's employment history for at least ten years) to 2010 (i.e., the last year that includes consistent occupation codes), using spells of all West German men in full-time employment aged 16 to 65.[13] Since a mass layoff may affect the premiums that establishments pay their employees, our sample excludes post-layoff observations of displacement establishments and displaced workers.

It should be noted that, unlike the conceptual wage regression given by equation (1), the estimated AKM regression given by equation (2) does not include a match-specific component. As is standard in the AKM literature, we assume that workers' mobility decisions are influenced by time-invariant unobserved worker heterogeneity α_i and establishment premiums $\psi_{J(i,t)}$ as well as potential experience, occupation and establishment tenure, and calendar time, but not by match quality. Thus, we assume that $\epsilon_{it} = m_{iJ(i,t)} + \varepsilon_{ijt}$, with neither $m_{iJ(i,t)}$ nor ε_{ijt} influencing mobility decisions.

It is well known that establishment and worker fixed effects estimated from an AKM regression suffer from "limited mobility bias", leading to an overestimate of the variance of establishment fixed effects and an underestimate of the covariance between worker and establishment fixed effects (e.g., Andrews, Gill, Schank and Upward, 2008, Bonhomme, Lamadon and Manresa, 2019). Various correction methods have been proposed (e.g., Kline, Saggio, and Sølvsten, 2020, Bonhomme, Holzheu, Lamadon, Manresa, Mogstad, and Setzler, 2023). The long estimation window in our 27-year analysis should reduce concerns about limited mobility bias. Moreover, as we describe in greater detail in Section 4.3.3, we use the establishment premium as a dependent variable in our regressions when investigating the extent to which losses in the establishment premium account for wage losses following displacement. Hence, any remaining measurement error in the establishment premium should not systematically bias our estimates.[14]

4.3. Empirical Strategy

Our empirical strategy combines matching with an event study approach and flexibly traces out labor market outcomes of displaced low- and high-wage workers compared to a control group of matched non-displaced workers. We next outline our matching procedure, then explain our baseline estimation regression, and finally describe how we decompose overall displacement wage losses into their various components.

[13] As a robustness check, we have also estimated augmented AKM regressions over six-year rolling windows. Estimated establishment premiums losses following displacement are very similar (see Appendix A.2., Table A.4).

[14] In Section 7, we use worker and firm fixed effects to decompose changes in the variance of (log) wages. Limited mobility bias is unlikely to pose a problem here either as the bias is largely constant over time (Bonhomme et al., 2023).

4.3.1. Matching

To ensure that we compare displaced workers with their "statistical twins" —individuals who resemble displaced workers as much as possible prior to the layoff—we match a control worker with similar observed worker and establishment characteristics pre-layoff to each displaced worker. Our sample of potential control workers consists of all workers that fulfil the same sample restrictions as the displaced workers, but are not displaced in a mass layoff in any of our sample periods (see Section 3.2).[15] We then apply coarsened exact matching (e.g. Iacus, King, and Porro, 2012) and match on the following characteristics: wage vigintiles, age deciles, two-year bins of establishment and occupation tenure, skill groups (low-, medium- and high-skilled), citizenship (German or non-German), and the broad industry of the workplace (four broad industries in the manufacturing sector). We further match on worker and establishment fixed effect terciles, as we define low- and high-wage workers according to these terciles. Our matching procedure creates a set of cells such that displaced and non-displaced workers have the exact same coarsened characteristics within each cell. For each displaced worker, we then randomly pick one non-displaced worker from the same cell as a control. If there are more displaced workers than non-displaced workers in a cell, we randomly drop displaced workers to ensure an equal number. Our matching procedure results in a balanced sample of displaced and matched non-displaced workers within each cell and effectively corresponds to one-to-one matching.

We match displaced and control workers four years before the mass layoff to allow for the possibility that the imminent job loss affects the wages of displaced workers even before the actual displacement (similar to Couch and Placzek, 2010). Such pre-displacement losses may, for example, reflect a decline in the establishment premium prior to displacement due to a negative productivity or demand shock in the establishment that ultimately leads to the layoff of a large share of its workforce. Alternatively, they may capture reduced investments into general or specific human capital by workers and establishments. A matching procedure that instead matches on characteristics one year before the mass layoff or conditions on pre-displacement wage trends, which is sometimes done in the literature, would understate the overall wage loss caused by displacement by failing to consider such pre-displacement losses.

Table 3 shows that our matching procedure works well in ensuring that for both low- and high-wage workers, displaced and non-displaced workers are nearly identical in their observed pre-layoff characteristics. While the design of the matching procedure forces displaced and matched non-displaced workers to be in the same skill group, broad sector, and have the same citizenship status

[15] Non-displaced control group workers are male, between 25 and 50 years of age, have worked full-time in the same manufacturing establishment for at least four years, and are employed in an establishment with at least 30 and no more than 500 employees. Control group workers are allowed to become non-employed or change employers in any period following the mass layoff event.

(German or non-German), the matched workers are also similar in terms of continuous characteristics like their pre-displacement wage, worker, and establishment fixed effects, age, and establishment and occupation tenure.

In contrast, both low- and high-wage displaced workers earn lower wages compared to random non-displaced workers. Mass layoff establishments further pay slightly higher establishment premiums than the establishment of a randomly chosen non-displaced worker and are more likely to be located within the investment and consumer goods industry within the manufacturing sector (columns (5) and (10) of Table 3).

4.3.2. Estimation Regression

We then compare the labor market outcomes of displaced and matched non-displaced workers in the six years before and after displacement, separately for low- and high-wage workers. Specifically, we estimate the following model:

$$Y_{ic\tau t} = \alpha_i + \sum_{\tau=-6}^{6} \beta_\tau Displ_{i,t}^{\tau} + \theta_{c\tau} + \epsilon_{ic\tau t}\,, \tag{3}$$

where the subscript τ denotes the time period relative to the year of the mass layoff. While displacement occurs between $\tau = -1$ and $\tau = 0$, we refer to the mass layoff year as $\tau = 0$. $Y_{ic\tau t}$ is the outcome variable of interest, such as whether the individual is employed, the log wage, or the establishment premium of individual i in cell c in a given calendar year t and τ periods before or after job displacement. $Displ_{i,t}^{\tau}$ denotes indicator variables equal to 1 in period τ if the individual has been displaced in a mass layoff, and 0 otherwise. Note that t and τ differ in our case because job displacement occurs in multiple years.

In regression equation (3), we control for individual fixed effects α_i as well as for cell-by-period fixed effects $\theta_{c\tau}$.[16] The inclusion of cell-by-period fixed effects recreates the idea of estimating the effects of job displacement by first differencing the outcome of interest of paired displaced and non-displaced workers within each cell and event period, and then averaging these effects across all cells for each period. This ensures that we compare the outcomes for displaced and matched control workers from the same cell in each period relative to job displacement, thus accounting for selection into work after job displacement based on matched characteristics. Worker fixed effects account for within-individual changes in outcomes before and after displacement as well as any potential selection into work after job displacement based on time-invariant worker differences within cells. Since our cells are very narrowly defined and workers barely differ within cells, the inclusion of

[16] Controlling for cell-by-period fixed effects is equivalent to controlling for cell-by-calendar year fixed effects, since cells are defined separately for each layoff year.

worker fixed effects in addition to cell-by-period fixed effects has little impact on our estimates. We cluster standard errors by cell, thus allowing for an arbitrary correlation of error terms within cells over time.

The parameters of interest in regression equation (3) are β_τ, which measure the difference in the outcome of interest between displaced and matched non-displaced workers in period τ relative to the baseline period. Since we match on pre-displacement characteristics four years prior to the mass layoff, we set the baseline period to $\tau = -4$ and exclude $\beta_{-4} Displ_{i,t}^{-4}$ from the regression. The event study specification further allows us to compare outcomes of displaced and non-displaced workers up to six years prior to displacement to assess whether displaced workers face a wage decline even before job displacement.

4.3.3. Decomposition of Displacement Wage Losses

To decompose displacement wage losses into their various components, we proceed as follows. First, to estimate the importance of losses in the establishment premium, we estimate regression equation (3) with the estimated establishment premium $\hat{\psi}_{J(i,t)}$ from the AKM wage regression (2) as the dependent variable.

Second, to investigate the role of losses in occupation and establishment tenure, we predict the returns to establishment and occupation tenure for our sample of displaced and non-displaced workers using the estimates $\hat{\gamma}_{1g}, \hat{\gamma}_{2g}$ and $\hat{\gamma}_{3g}$, as well as $\hat{\delta}_{1g}, \hat{\delta}_{2g}$ and $\hat{\delta}_{3g}$ from the AKM wage regression (2).[17] We then estimate equation (3) using predicted returns to establishment and occupation tenure as dependent variables. Importantly, as establishment premiums and returns to occupation and establishment tenure are pre-estimated, the order in which displacement wage losses from these three sources are computed does not matter.

Since our augmented AKM regression accounts for returns to potential experience but not actual experience, we cannot proceed accordingly to quantify the importance of losses in general human capital. Instead, we first compute residualized wages net of the establishment premium and returns to establishment- and occupation-specific human capital by deducting these returns from an individual's original log wage. We then estimate equation (3) with the residualized net log wage as dependent variable twice: once flexibly, controlling for years out of work after job displacement by including dummy variables that indicate how many years an individual has been out of work since displacement and once without controlling for years out of work. We define the difference between the estimated

[17] We display returns to establishment and occupation tenure for low- and high-wage workers based on the AKM regression equation (2) in Appendix Figure A.1. Returns to establishment tenure tend to be low for both worker groups—about 3 percent for high-wage workers and 1 percent for low-wage workers after ten years with the same establishment. Returns to occupation tenure are larger and more concave, about 7.6 percent for high-wage workers and 4.5 percent for low-wage workers after ten years in the same occupation.

effects of job displacement from these two regressions as the loss in returns to general experience, which captures both reduced opportunities to accumulate new general skills and the depreciation of existing general skills.

Finally, we interpret the residual displacement wage loss that is not accounted for by losses in the establishment wage premium, returns to occupation- and establishment-specific tenure or actual experience as a loss in match quality. In Appendix A.5, we also provide alternative estimates of the loss in match quality by explicitly estimating match quality following the approach of Lachowska et al. (2020), who build on Woodcock (2015), and show that the loss in match quality is quantitatively similar to the residual displacement wage loss.

5. Displacement Effects by Worker Type

We start by analyzing the employment and wage effects of job displacement and their sources in the pooled sample of workers displaced from the manufacturing sector between 1990 and 2004, with a focus on contrasting the magnitude and sources of displacement effects for low- and high-wage workers. For completeness, we present baseline results on the full sample of displaced workers (i.e., low-, medium- and high-wage workers combined) in Appendix A.1. Section 6 then turns the focus to changes in the cost of job displacement over time using our larger time series sample for workers displaced between 1988 and 2007.

5.1 Employment and Wage Effects

Employment Effects. In Panel A of Figure 3, we present the average employment effects of displacement by worker type. By construction, there are no differences in the probability of being employed between displaced workers and their matched counterparts in the four years prior to displacement. The employment probabilities of displaced and non-displaced low- and high-wage workers are also virtually identical five and six years before the mass layoff, corroborating that our matching procedure works well. While employment effects at layoff are large and persistent for both low- and high-wage workers, they are considerably more pronounced for low-wage workers. In the first year after the mass layoff, low-wage workers are 47 percentage points less likely to be re-employed than their matched counterparts, compared to 30 percentage points for high-wage workers. This gap reduces to 15 percentage points for low-wage and 12 percentage points for high-wage workers, respectively, six years after the mass layoff.

Wage Losses. In Panel B of Figure 3, we plot the average wage effects of displacement by worker type. The corresponding point estimates and standard errors are reported in column (1) of Appendix Tables A.2 and A.3. Workers displaced in mass layoffs face considerable and long-lasting wage

losses. Wages of displaced workers start falling already three years before the actual displacement, amounting to a total pre-displacement wage loss of 2.5 percent for low-wage workers and 3.7 percent for high-wage workers.[18] Matching on workers' wages one year (instead of four years) prior to the layoff to select the control group would therefore understate the true displacement wage loss. Upon displacement, wages then decline sharply to 9.0 and 11.8 percent total wage loss for low- and high-wage workers, respectively. While the post-displacement wages of low-wage workers recover somewhat over time, the wage losses of high-wage workers remain roughly constant around 12 percent. High-wage workers thus suffer somewhat larger wage losses than low-wage workers.

In addition, there is little evidence of wage differences between laid-off workers and the control group between six and four years prior to displacement for either low- or high-wage workers, further confirming that our matching procedure removes potential differences between displaced and non-displaced workers.

5.2 Sources of Displacement Wage Losses

Which factors account for these large displacement wage losses of both high- and low-wage workers? Do displaced workers suffer losses in establishment premiums? Or do wage losses reflect declines in general or specific human capital, or match quality? And does this differ by worker type? In this section, we decompose wage losses into their various components, as described in Section 4.3.3. The results are shown in Figure 4, where we present the absolute contribution of each component of wage loss by worker type in Panel A and the relative contribution to the overall wage effect in Panel B. Tables A.2 and A.3 report the corresponding point estimates and standard errors.

Establishment Premiums. Figure 4 shows that displacement losses in establishment premiums differ starkly for low- and high-wage workers. Even though high-wage workers suffer higher overall wage losses upon displacement, low-wage workers experience a much sharper decline in establishment premiums. Whereas low-wage workers see a drop of 7 percent in establishment premiums six years after the layoff, establishment premiums decline by only around 3 percent for high-wage workers. As a consequence, losses in establishment premiums account for a considerably larger share of the overall displacement wage loss for low-wage workers six years after the layoff (about 80 percent compared to 25 percent), indicating that low-wage workers have a harder time finding another job in a "good" high-paying establishment after displacement.

[18] Wage losses prior to displacement may reflect a decline in establishment premiums in mass layoff establishments that is not picked up in our augmented AKM regression since we estimate a single establishment premium for the whole period. Alternatively, reduced pre-layoff investment in human capital in mass layoff establishments could account for the pre-displacement wage losses. Such reduced investments are likewise not picked up in our augmented AKM regressions since we assign the same estimated returns to human capital independent of whether a layoff is imminent.

The larger establishment premium loss for low-wage workers is even more remarkable in light of the finding that high-wage workers tend to be employed in higher-paying establishments (see Table 1), and workers displaced from higher-paying establishments experience larger wage losses (see Appendix Figure A.2). Indeed, when we apply reweighting to make the establishment premium distribution of low-wage workers resemble that of high-wage workers, losses in wages and establishment premiums for low-wage workers increase (see Appendix Figure A.3).

Specific and General Human Capital. While losses in establishment premiums differ starkly for low- and high-wage workers, losses in establishment- and occupation-specific human capital are largely similar for both types of workers. Such losses are large initially, at 4.1 percent for low-wage workers and 4.5 percent for high-wage workers, thus contributing between 40 and 50 percent to the overall wage loss in the first year after the layoff. Due to their concave profiles and because displaced workers rebuild specific human capital, the effects of losses in establishment and occupation tenure become less important over time, contributing less than 10 percent to the overall wage loss six years after the mass layoff.

Losses from missed general human capital accumulation, in contrast, are initially low but increase over time for both worker types. Since low-wage workers have lower re-employment probabilities and thus spend more time out of work after displacement, losses in general human capital contribute a somewhat larger share to the overall wage loss for low- than for high-wage workers (30 vs. 15 percent six years after the layoff).

Match Quality. We attribute the residual wage loss to losses in worker-establishment match quality. For low-wage workers, losses in establishment premiums, establishment-specific, occupation-specific, and general human capital more than explain the total wage loss, indicating that low-wage workers do find jobs with similar (or even improved) match quality after the layoff. A different picture emerges for high-wage workers: losses in establishment premiums and human capital account for about 70 percent of the overall wage loss one year after the layoff and around 50 percent after six years. Thus, a much larger share of the overall wage loss remains "unexplained", suggesting that losses in valuable establishment-worker matches play a more important role for high-wage workers. We confirm this conjecture in Appendix A.5 where we estimate match quality more directly following the approach suggested in Lachowska et al. (2020).

The stark difference in the importance of establishment premiums and match quality losses between low- and high-wage workers suggests that the job ladder predominantly operates through movements to better-paying establishments for low-wage workers, while movements to establishments that offer better matches are more important for high-wage workers, in line with the findings in Haltiwanger et al. (2018).

The heterogeneous impact across worker types further helps to reconcile the recent findings on the role of establishment and firm premiums in the literature. Lachowska et al. (2020) have found a smaller role of firm premium losses and larger role of match quality losses than other papers in the literature (such as Schmieder et al., 2023, and Bertheau et al., 2022). High-wage workers are likely overrepresented in Lachowska et al. (2020) since close to 40 percent of the layoffs they examine occurred in the high-skilled finance sector. Our results highlight that high-wage workers suffer larger losses in match quality than in establishment premiums, in line with their findings. Another likely explanation is that only about 30 percent of layoffs in Lachowska et al. (2020) are from the manufacturing sector, where losses in establishment premiums are particularly pronounced, as we show in more detail in the next section.[19]

5.3 Displacement Wage Losses in the Service Sector

In Figure 5, we demonstrate that displacement wage losses are considerably larger in the manufacturing sector than in the service sector for both low- and high-wage workers. Whereas low-wage workers displaced from the manufacturing sector face a wage loss of about 7.5 percent six years after the layoff, their displacement wage loss is only around 3 percent in the service sector. Similarly, high-wage workers suffer a wage loss of about 12 percent when displaced from the manufacturing sector but only 7 percent when displaced from the service sector. These differences are largely explained by larger losses in establishment premiums, which amount to about 6 percent (for low-wage workers) and 3 percent (high-wage workers) in the manufacturing sector but are much smaller (for low-wage workers) or absent (for high-wage workers) in the service sector. Losses in human capital and match quality are largely similar across sectors for both low- and high-wage workers.

5.4 Sectoral Switching and Losses in Establishment Premiums

Why are displacement losses in establishment premiums larger in the manufacturing than in the service sector, and larger for low- than for high-wage workers? Next, we argue that this is in part due to higher establishment premiums paid in the manufacturing sector (see Table 1) and higher post-displacement switching rates out of the manufacturing sector and into the service sector for low-wage workers.

First, as Figure 6 illustrates, post-displacement transitions out of the manufacturing sector are indeed common. Low-wage workers are not only more likely to switch out of the declining manufacturing sector after displacement than high-wage workers (Panel A), but they are also more likely to move into the low-knowledge service sector where establishment premiums are particularly

[19] Bertheau et al. (2022) also find that the share of wage losses explained by establishment premium losses tends to be larger for countries with a higher share of workers laid off from the manufacturing sector.

low (Panel B). High-wage workers, in contrast, are more likely to move into the high-knowledge service sector after displacement where establishment premiums are higher than in the low-knowledge service sector.

Second, as reported in Table 4, these differences in switching patterns have considerable consequences for wage and establishment premium losses following displacement. Workers who move to the low-knowledge service sector following displacement suffer considerably larger wage losses than workers who remain employed in manufacturing or transit into the high-knowledge sector. While this is true for both low- and high-wage workers, the differences are more pronounced for low-wage workers (16.2 percent losses when transitioning to the low-knowledge service sector vs. 5.2 percent for manufacturing stayers). The larger wage losses when transitioning into the low-knowledge service sector are almost entirely explained by larger losses in establishment premiums (14.2 percent for low-wage movers into the low-knowledge service sector compared to 3.7 percent for manufacturing stayers). In contrast, other sources of displacement wage losses, such as losses in general and specific human capital, barely vary across destination sectors.

A simple back-of-the envelope calculation suggests that sectoral switching alone can account for around half of the difference in the loss of establishment premiums between low- and high-wage workers. The remainder is explained by low-wage workers facing larger losses in establishment premiums even when staying within the manufacturing sector.

5.5 Robustness

In Appendix A, we show that our main conclusions are robust a number of variations in estimation choices. In Appendix A.1, we present the results of the full sample, pooled for low-, medium- and high-wage workers, as a baseline and for completeness. Our main findings are robust to estimating establishment premiums according to standard AKM regressions that do control for establishment and occupation tenure (Appendix A.2); estimating establishment premiums using 27 six-year rolling periods rather than a single 27-year period (Appendix A.3); allowing for different establishment premiums by worker type (Appendix A.4); estimating displacement losses in match quality for each worker-establishment pair more directly, closely following Lachowska et al. (2020) and Woodcock (2015) (Appendix A.5); and restricting the sample to workers who were displaced from their firm because of a plant closure (Appendix A.6).

6. Trends in Displacement Effects over Time

Our findings thus far show that displaced low-wage workers suffer a larger decline in the establishment premium than high-wage workers, in part because they are less likely to remain

employed in the manufacturing sector where establishment premiums are high and more likely to move to the low-knowledge service sector where establishment premiums are low. Since employment opportunities in the manufacturing sector have steadily declined over time due to structural change, in particular for low-wage workers, transitions out of the manufacturing sector may have become more common over time, resulting in ever larger wage losses upon displacement. To investigate this hypothesis, we next examine how the cost of job displacement has changed over time by splitting our time series sample into ten two-year periods, starting with the 1988-1989 and ending with the 2006-2007 period. We then estimate equation (3) for each two-year period separately for low- and high-wage workers and compare employment effects, wage effects, and the sources of wage losses three years after the mass layoff across time.

6.1. Employment and Wage Effects Over Time

In Figure 7, we show that the cost of displacement from the manufacturing sector has indeed increased over time, particularly for low-wage workers. Low-wage workers are increasingly less likely to be re-employed three years after the mass layoff, both in absolute terms and relative to high-wage workers (Panel A). While there is a clear cyclical component in the probability of re-employment, the linear trend lines indicate that the likelihood of working three years after the mass layoff drops by around 13 percentage points for low-wage workers (from 13 to 25 percentage points) from the late 1980s to the mid-2000s, compared to a 4-percentage point reduction for high-wage workers.

Not only are low-wage workers increasingly less likely to be re-employed after displacement, they also face increasing wage losses, both in absolute terms and relative to high-wage workers (Panel B). Whereas the wage losses of high-wage workers have remained largely stable over time, at about 10 to 13 percent three years after displacement, the wage losses of low-wage workers increased from about 3 percent in the mid-1980s to 15 percent by the mid-2000s.[20]

6.2. Sources of Displacement Wage Losses over Time

Which factors explain the increasing post-displacement wage losses among low-wage workers, both in absolute terms and relative to high-wage workers? As Panel C of Figure 7 shows, losses in establishment premiums play a key role. The figure displays losses in the establishment premium three years after displacement separately for low- and high-wage workers. According to the linear trend line, low-wage workers displaced from manufacturing establishments in the late 1980s suffered a decline in the establishment premium of only 3 percent, whereas in the mid-2000s, the reduction

[20] While our focus is on trends in displacement wage losses, Panel B of Figure 7 further shows that wage losses appear to be larger in recessions, in line with the findings of Schmieder et al. (2023).

exceeds 10 percent. In contrast, over the same time period losses in the establishment premium increased only slightly for high-wage workers, from about 2 to 3 percent.

We provide a more detailed analysis of the changing sources of displacement wage losses in Figure 8. In Panels A.1 and B.1, we show absolute wage losses over time due to losses in establishment premiums, losses in general and specific human capital, and losses in match quality (i.e., the residual component) by worker type. In Panels A.2 and B.2 of the figure, we instead display the change in the overall displacement wage loss between the first two and last two two-year periods as well as the changes in wage losses due to each of the five factors that we consider. Among low-wage workers (Panel A), losses in the establishment premium are by far the most important driver behind the increasing displacement losses over time, accounting for two thirds of the increase in the overall wage loss. Missed opportunities for general human capital accumulation account for an additional 15 percent, in line with our finding that low-wage workers are increasingly less likely to be employed after a mass layoff. In contrast, changes in the returns to occupation and establishment tenure play only a minor role, indicating that there are no changes in the frequency with which displaced workers switch occupations or establishments after displacement. The much smaller increase in the wage losses of high-wage workers can likewise be primarily attributed to losses in establishment premiums and general human capital (Panel B).

The increasing losses in establishment premiums among low-wage workers could, in principle, simply reflect changes in the composition of displaced workers or displacing establishments. For example, high-wage establishments may account for an increasingly large share of mass layoff establishments over time, resulting in larger displacement wage losses over time. In Appendix A.7, we show that such compositional changes are small in magnitude and do not drive our findings, using a reweighting approach based on firm and worker fixed effects, as well as an alternative approach modelling the individual wage loss and then controlling for composition effects in a unified regression as suggested by Schmieder et al. (2023).

6.3. Structural Change and Losses in Establishment Premiums over Time

Post-displacement Sectoral Switching. Has structural change and the decline in job opportunities in the manufacturing sector contributed to these increasing establishment losses? We report evidence in line with this hypothesis in Figure 9, Panel A. While there is a strong cyclical component in the propensity to switch sectors after displacement, especially among low-wage workers, low-wage workers are also increasingly less likely to remain employed in the manufacturing sector after displacement and increasingly more likely to be re-employed in the low-knowledge service sector. The share of displaced low-wage workers who transitioned out of manufacturing increased from 25 percent in the 1988-1989 period to 38 percent in the 2006-2007 period. In turn, the share of low-wage

workers who moved into the low-knowledge service sector increased by 12 percentage points, from 15 to about 27 percent. In contrast, the sectoral switching patterns of high-wage workers have remained roughly constant over time.

Establishment Premium Losses by Destination Sector. Low-wage workers also suffer increasingly large losses in establishment premiums conditional on their post-displacement sector, particularly if they transition to the low-knowledge service sector (Panel B of Figure 9). For these workers, losses in establishment premiums almost tripled over our sample period from 7 to 21 percent. This finding is in line with increasing gaps in establishment premiums between the manufacturing and the low-knowledge service sector and increasing dispersion in premiums particularly in the low-knowledge service sector, as discussed in Section 2 (see Figure 2). While high-wage workers also experience increasing losses in establishment premiums conditional on moving to the low-knowledge service sector, the increase is considerably less pronounced than for low-wage workers.

Establishment Premium Losses Within and Between Sectors. In order to quantify to what extent structural change has contributed to the increase in establishment premium losses of low-wage workers over time, we decompose the increase into a within and between sector component (see Appendix B for details). We display our findings in Table 5. About half of the increase in establishment premium losses over time occurs between sectors (3.7 percent of a total increase of 7.4 percent), while losses within the manufacturing sector account for the remaining half. Further decomposing the between-sector component into a component capturing increased sectoral switching and a component capturing increased sectoral wage premiums (i.e., increased gaps in establishment premiums between the manufacturing and service sectors), we find that increased sectoral wage premiums account for around two thirds of the increase (2.4 percent of 3.7 percent), while increased sectoral switching explains the remaining third (1.3 percent of 3.7 percent).

Structural change has thus shifted low-wage workers away from high-paying jobs in the manufacturing sector into increasingly low-paying jobs in the low-knowledge service sector and therefore significantly contributed to the increased establishment premium losses following job displacement. Yet, low-wage workers are also increasingly falling down the establishment premium ladder over time even when they remain employed in the manufacturing sector possibly because establishment premiums have become more dispersed over time in all sectors (see Figure 2 Panel B).

Production Jobs vs. Service Jobs. A recent literature has documented large wage losses that stem from losses in firm-specific rents for (mostly low-wage) workers whose jobs have been outsourced, typically from firms in the manufacturing sector to firms in the low-knowledge service sector (e.g., Goldschmidt and Schmieder, 2017). It is important to emphasize that the patterns we document—

increasingly large displacement wage losses driven by increasingly large losses in establishment premiums—are not confined to low-wage workers at risk of domestic outsourcing but affect all low-wage workers in the manufacturing sector. We have already documented in Section 2 that the majority of low-wage jobs lost in the manufacturing sector are jobs in production occupations rather than in service occupations (see also Figure 1, Panel C). In Figure 10, we further show that low-wage workers displaced from production jobs and low-wage workers displaced from jobs in service occupations both suffer increasingly large wage losses over time and that for both groups a similar share of these increasing wage losses can be explained by losses in establishment premiums.

7. Structural Change, Job Polarization, and the Wage Structure

We have documented considerable increases in establishment premium losses following job displacement that are, at least in part, the result of structural change in the labor market. These findings have important implications for the drivers behind the rise in wage inequality and the job polarization observed in several developed countries, which we discuss next.

7.1. Structural Change and Job Polarization

Job polarization—whereby employment in occupations located in the middle of the wage distribution has declined relative to employment in occupations located at the bottom or top of the wage distribution—has increased across developed countries (e.g., Autor and Dorn, 2013 and Goos et al., 2014). The polarization literature thus far emphasized the importance of tasks and technological change in accounting for this pattern. Our results instead point to the importance of firms. We provide support for this hypothesis in Figure 11 where we rank occupations according to their median wage in 1988 (the "occupational wage percentile") and plot, separately for low- and high-wage workers, the share of workers employed in each occupational wage percentile in the manufacturing sector at the beginning of our analysis period (1988) and in the low- or high-knowledge service sector at the end of our analysis period (2007). Among low-wage workers, manufacturing jobs—which pay particularly high establishment premiums and have disproportionally disappeared over time—are indeed overrepresented in the middle of the occupational wage distribution at the beginning of our sample period (Panel A). In contrast, low-knowledge service jobs—which pay particularly low establishment premiums and have gained importance over time for low-wage workers—are overrepresented in the bottom of the occupational wage distribution at the end of our sample period. Relatedly, among high-wage workers, high-knowledge service jobs—which have become more important for high-wage workers—are overrepresented at the top of the occupational wage distribution at the end of our sample period (Panel B).

7.2. Structural Change and the Wage Structure

Our findings further point toward the importance of structural change as a driver of the increase in wage inequality, and in particular the rise in the sorting of high-wage workers to high-wage firms observed in many developed countries (e.g., Card et al., 2013; Song et al., 2019). Panel A of Table 6 shows the variance of log daily wages among West German men nearly doubled over our sample period (from 0.14 in 1988 to 0.26 in 2007), as did the variance of establishment premiums (from 0.028 in 1988 to 0.053 in 2007). Similarly, (two times) the covariance between worker and establishment fixed effects—a commonly used measure to quantify the degree of assortative matching of workers to firms—increased considerably from close to zero in 1988, to 0.022 in 2007.[21] Because worker and establishment fixed effects are constant throughout the sample period, the increase in the dispersion of establishment premiums and the assortative matching of workers to establishments solely reflect selective establishment entry and exit and the reallocation of workers among continuing establishments.

In a first step, we ask what the increase in wage inequality, the dispersion in establishment premiums and the covariance between worker and establishment effects would have been if the broad sectoral structure—manufacturing, low-knowledge services and high-knowledge services—by worker type (low-, medium-, and high-wage) had remained at its 1988 level. To compute the counterfactual wage structure, we adopt the reweighting method proposed by DiNardo, Fortin and Lemieux (1996). The results are striking: changes in the broad sectoral structure alone can account for about 15 percent of the increase in wage dispersion between 1988 and 2007, 16 percent of the increase in the dispersion of establishment premiums and more than 20 percent of the increase in the covariance between worker and establishment fixed effects (see Table 6, Panel B).

In a second step, we aim to quantify the effects of layoffs in the manufacturing sector on the wage structure more directly. To this end, we identify all workers in our sample who have worked in the manufacturing sector for at least two consecutive years and who separate from the manufacturing sector through an unemployment transition – likely an involuntary separation. For each post-unemployment job spell, we then reassign these workers the establishment premium of the pre-unemployment manufacturing establishment and a counterfactual wage based on this pre-unemployment premium and calculate the counterfactual dispersion in wages, establishment

[21] Note that our estimated worker and firm fixed effects differ from Card et al. (2013). Our worker and establishment fixed effects are estimated conditional on firm and occupation tenure (by worker type). In Card et al. (2013) returns to tenure are instead loaded on the fixed effects. If we estimate worker and establishment fixed effects as in Card et al. (2013), the increase in the variance of wages, the establishment premium and the covariance is similar to the increase in Card et al. (2013). Card et al. (2013) further estimate fixed effects over 6-year windows, while our fixed effects are estimated over a single 27-year period (see Section 4.2).

premiums and the covariance between worker and establishment fixed effects.[22] In Panel C.1 of Table 6, we assign counterfactual wages and establishment premiums only for those workers who transition into the service sector after the unemployment spell; in Panel C.2, we assign counterfactual wages and establishment premiums also for workers who remain employed in the manufacturing sector. This exercise indicates that about 6 percent of the increase in wage dispersion, 12 percent of the increase in the dispersion of establishment premiums and 10 percent of the increase in assortative matching between workers and establishments can be attributed to layoffs from manufacturing alone. These results are primarily driven by layoffs that result in switches into the service sector.

8. Conclusion

In this paper, we provide novel evidence on the consequences of structural change in employment away from manufacturing and towards the service sector. To this end, we focus on workers in manufacturing who lose their jobs due to a mass layoff. We present two main sets of results. First, we show that the sources of wage loss are markedly different for low- and high-wage workers. Most importantly, displaced low-wage workers suffer substantially larger losses in establishment premiums, which is in part explained by a higher propensity to move out of the manufacturing sector (where establishment premiums are high) and into the low-knowledge service sector (where establishment premiums are low). For high-wage workers, in contrast, declines in worker-establishment match quality are an important driver of overall wage losses. These findings are consistent with the notion that movements up the job ladder predominantly operate through improvements in match quality for high-wage workers, but through improvements in establishment quality or rents for low-wage workers.

Second, we document that structural change in the labor market that shifts workers away from the manufacturing sector into the service sector, has particularly severe consequences for low-wage workers. For low-wage workers, the costs of job displacement have dramatically increased over time, both in absolute terms and relative to high-wage workers. Not only are low-wage workers increasingly less likely to be re-employed after displacement, they also suffer increasingly larger wage losses. This increase in wage losses is driven to a large extent by greater declines in establishment premiums over time, which in part reflect increased sectoral reallocation: low-wage workers are increasingly less likely to remain employed in the manufacturing sector and increasingly more likely to move to the low-paying low-knowledge service sector after displacement. These findings underscore the growing difficulty encountered by low-wage workers in securing

[22] The counterfactual (log) wage is calculated as the actual (log) wage plus the difference between the current and the pre-unemployment establishment premium.

employment in establishments that pay equally high wage premiums as their pre-displacement establishments, in part because of dwindling employment opportunities in the manufacturing sector.

Overall, our findings demonstrate that the decline of the manufacturing and the rise of the service sector has had particularly serious repercussions for low-wage workers. As such, our findings are consistent with the idea that structural change may be one driver behind the increased sorting of high-wage workers to high-wage firms observed in several developed countries (Card et al., 2013, Song et al., 2019). Using reweighting methods, we show that structural change can account for around 20 percent of the increase in assortative matching between workers and firms between 1988 and 2007 and displacement from manufacturing can account for around half of this effect.

Our findings also have important implications for the literature on job polarization (e.g., Autor and Dorn, 2013, Goos et al., 2014). While this literature has thus far emphasized the importance of technological change and tasks, our results point to the importance of firms. Specifically, our findings are consistent with the notion that the disappearance of jobs in the middle of the wage distribution is a consequence of the decline of the manufacturing sector, which has historically provided "good" jobs characterized by high establishment premiums for both high- and low-skilled workers. In line with this hypothesis, we document that manufacturing jobs of low-wage workers are concentrated in the middle of the occupational wage distribution, whereas low-knowledge service sector jobs of low-wage workers and high-knowledge service sector jobs of high-wage workers are overrepresented at the bottom and top of the wage distribution, respectively.

Currently, one of the most important active labor market policy tools to cushion the adverse effects of displacement in particular and structural change more generally are training and retraining programs that are, in part, designed to equip workers with specific skills required in the service sector. Germany, for example, spent EUR 11.2 billion in 2019 on such policies (Weber, Hausner and Engelhard, 2020). Our findings, however, imply that training programs are not sufficient to buffer the effects of structural change, especially for less skilled workers, as lost establishment premiums account for a considerably larger share of the overall displacement wage loss than losses in specific skills.

Recognizing that the manufacturing sector generally provides high-paying jobs for less skilled workers, and that such jobs are becoming rarer, some policymakers have pushed to bring back manufacturing jobs, for example through industrial policy. It is unclear, however, whether such policies can be successful or are even desirable. The challenge is thus to turn low-wage jobs, especially in the low-knowledge service sector, into higher-paying jobs. While minimum wage legislation and policies that strengthen unions and work councils, as currently discussed in several countries such as the US and Germany, are likely to play an important role, fostering productivity growth in the low-knowledge service sector is also important.

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Tables and Figures

Table 1: Establishment Premium and Worker Quality by Sector

	Manufacturing	Service Sector	
		Low-knowledge	High-knowledge
Panel A: Establishment Premium			
All Workers	0.077	-0.109	0.034
	(0.139)	(0.210)	(0.191)
Low-wage Workers	0.052	-0.151	-0.008
	(0.139)	(0.226)	(0.201)
High-wage Workers	0.101	-0.068	0.060
	(0.140)	(0.202)	(0.187)
Panel B: Worker Quality			
Worker Fixed Effect	0.002	-0.024	0.085
	(0.165)	(0.180)	(0.223)
Skill Groups			
Low Skilled	0.181	0.171	0.072
	(0.385)	(0.377)	(0.259)
Medium Skilled	0.719	0.742	0.653
	(0.450)	(0.438)	(0.476)
High Skilled	0.100	0.087	0.275
	(0.300)	(0.282)	(0.447)

Notes: The table shows means and standard deviations of establishment premiums (Panel A) and worker quality (Panel B) by sector for full-time male workers in West Germany over the period 1988 to 2007. Establishment premiums and worker quality correspond to the establishment and worker fixed effects estimated in an AKM-style wage regression (see equation (2) in Section 4.2). Both establishment and worker fixed effects are demeaned by the average fixed effect in the economy. Low-skilled individuals are those without a high school (*Abitur*) or vocational degree, medium-skilled are those with a high school or vocational degree, and high-skilled are those with a college or university degree.

Table 2: Establishment Characteristics by Sector

	Manufacturing	Service Sector	
		Low-knowledge	High-knowledge
Union Coverage	0.798	0.752	0.608
Presence of a Works Council	0.741	0.508	0.529
Value Added per Worker	78,967	71,407	81,472

Notes: The table reports average union coverage rates, work council presence and value added by sector for West German firms over the period 1995-2007. Data are drawn from the German IAB Establishment Panel, and averages are weighted using survey weights multiplied by the number of male workers in the firm, to make results representative for male workers. Union coverage refers to either a firm- or industry-wide collective bargaining agreement. Value added per worker is yearly and is calculated as revenues minus intermediate inputs in EUR.

Table 3: Displaced vs. Control Workers by Worker Type

	Low-wage Workers					High-wage Workers				
	Displaced Workers (Treatment)	Non-Displaced (Matched Control)	Non-Displaced (Random Control)	Treatment vs. Matched Control	Treatment vs. Random Control	Displaced Workers (Treatment)	Non-Displaced (Matched Control)	Non-Displaced (Random Control)	Treatment vs. Matched Control	Treatment vs. Random Control
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: Worker Characteristics										
Wage	4.269	4.271	4.295	-0.001	-0.027***	4.657	4.659	4.682	-0.002	-0.028***
Worker Fixed Effect	-0.126	-0.125	-0.128	-0.001**	0.003***	0.142	0.154	0.169	-0.012***	-0.028***
Firm Tenure	7.414	7.379	7.291	0.034	0.058**	7.157	7.125	7.426	0.031	-0.347***
Occupation Tenure	7.687	7.657	7.393	0.029	0.245***	7.689	7.679	7.800	0.010	-0.164***
Age	35.950	35.927	35.431	0.022	0.459***	35.540	35.522	35.737	0.018	-0.267***
Low Skilled	0.307	0.307	0.279	0.000	0.028***	0.027	0.027	0.044	0.000	-0.017***
Medium Skilled	0.688	0.688	0.707	0.000	-0.019***	0.793	0.793	0.754	0.000	0.041***
High Skilled	0.005	0.005	0.014	0.000	-0.009***	0.179	0.179	0.202	0.000	-0.024***
Non-German	0.193	0.193	0.160	0.000	0.034***	0.038	0.038	0.049	0.000	-0.012***
Panel B: Firm Characteristics										
Establishment Wage Premium	-0.005	-0.008	-0.011	0.003***	0.006***	0.017	0.016	0.014	0.001	0.003***
Sector:										
Food and Beverage	0.071	0.071	0.087	0.000	-0.017***	0.061	0.061	0.073	0.000	-0.012***
Consumer Goods	0.210	0.210	0.180	0.000	0.032***	0.158	0.158	0.156	0.000	0.003
Producer Goods	0.267	0.267	0.292	0.000	-0.026***	0.186	0.186	0.223	0.000	-0.038***
Investment Goods	0.452	0.452	0.441	0.000	0.011***	0.596	0.596	0.549	0.000	0.048***
N	38879	38879	608586	77758	650254	26442	26442	510811	52884	538832

Notes: The table reports summary statistics for male workers displaced from the manufacturing sector between 1988 and 2007 as well as matched and random control workers separately by worker type. Low- and high-wage workers are defined as workers with worker fixed effects in the bottom and top terciles of the estimated AKM worker fixed effects distribution, respectively. Wages are log average daily wages in EUR adjusted to 1995 prices. Establishment premiums and worker fixed effects are demeaned to have zero mean over the sample period (see equation (2) in Section 4.2). Tenure variables are reported in years and are capped at ten years. The random control group represents a 10 percent random sample of manufacturing workers. Both displaced and control workers are males aged 25-50 with at least four years establishment tenure and employed in establishments with at least 30 and a maximum of 500 employees in West Germany. Levels of significance are * p<0.10, ** p<0.05, *** p<0.01.

Table 4: Sectoral Transitions and Displacement Losses

	Manufacturing	Service Sector	
		Low-knowledge	High-knowledge
Panel A: Low-wage Workers			
Transition Likelihood	-0.349	0.235	0.054
Wage	-0.052	-0.162	-0.079
Establishment Premium	-0.037	-0.142	-0.065
Returns to Experience	-0.015	-0.021	-0.016
Returns to Occup. Tenure	-0.013	-0.015	-0.015
Returns to Estab. Tenure	-0.006	-0.006	-0.008
Match Quality	0.019	0.023	0.025
Panel B: High-wage Workers			
Transition Likelihood	-0.286	0.140	0.097
Wage	-0.110	-0.185	-0.105
Establishment Premium	-0.021	-0.079	-0.016
Returns to Experience	-0.014	-0.019	-0.016
Returns to Occup. Tenure	-0.012	-0.015	-0.014
Returns to Estab. Tenure	-0.009	-0.010	-0.011
Match Quality	-0.054	-0.062	-0.049

Notes: The table reports estimates of the effects of job displacement on wages and its sources by destination sector and worker type three years after the layoff. Panel A reports the estimates for low-wage workers and Panel B for high-wage workers. Estimates are based on equation (3). The establishment wage premium refers to the AKM establishment fixed effect as estimated in equation (2) in Section 4.2. For the procedure to estimate wage losses due to occupation and establishment tenure and experience, see Section 4.3.3. The sample consists of male workers displaced between 1990 and 2004 and their matched control workers. Both displaced and control workers are aged 25-50 with at least four years establishment tenure in the year of layoff. Levels of significance are * p<0.10, ** p<0.05, *** p<0.01.

Table 5: Within-Between Decomposition of Establishment Premium Losses over Time

	Absolute	Share
Change in Total Establishment Premium Loss	-0.074	1.000
Within Manufacturing	-0.037	0.501
Between - Total	-0.037	0.499
Between - Sectoral Premium Component	-0.024	0.646
Between - Switching Component	-0.013	0.354

Notes: The table presents results of a within-between decomposition of changes in establishment premium losses for displaced low-wage workers over time. Changes are measured as average losses between the first two two-year periods in the sample (1988-1989 and 1990-1991) and the final two two-year periods (2004-2005 and 2006-2007). The decomposition is explained in more detail in Appendix B.

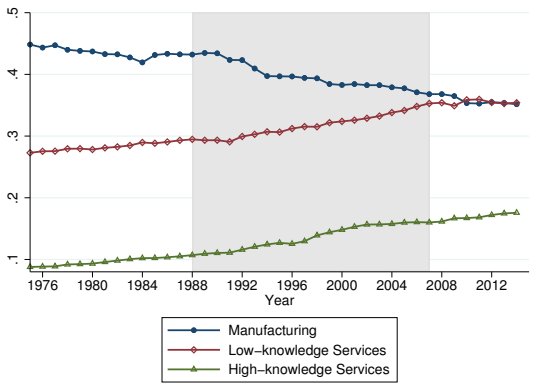
Table 6: Structural Change and Changes in the Wage Structure

	1988	2007	Change from 1988 to 2007	Explained (in %)
Panel A: Observed				
Variance of Wages	0.144	0.264	0.120	
Variance of Establishment Premiums	0.028	0.053	0.025	
2 x Cov. (Worker Fixed Effect, Estab. Premium)	0.005	0.024	0.019	
Panel B: DFL-method, reweight to 1988 sectoral composition				
Variance of Wages	0.144	0.245	0.101	0.152
Variance of Establishment Premiums	0.028	0.049	0.021	0.160
2 x Cov. (Worker Fixed Effect, Estab. Premium)	0.005	0.019	0.015	0.223
Panel C: Unemployment Transition, Assign Establishment Premium of Last Manufacturing Job				
Panel C.1: Counterfactual I, Reassign Only if in Service Sector				
Variance of Wages	0.144	0.257	0.112	0.059
Variance of Establishment Premiums	0.028	0.050	0.022	0.116
2 x Cov. (Worker Fixed Effect, Estab. Premium)	0.005	0.022	0.018	0.081
Panel C.2: Counterfactual II, Reassign if in Any Sector				
Variance of Wages	0.144	0.256	0.112	0.066
Variance of Establishment Premiums	0.028	0.050	0.022	0.128
2 x Cov. (Worker Fixed Effect, Estab. Premium)	0.005	0.022	0.017	0.090

Notes: Panel A shows the observed variances of (log) wages and establishment fixed effects, as well as the covariance between establishment and worker fixed effects in 1988 and 2007. Panel B displays the counterfactual variances and covariances based on DFL reweighting methods that would have prevailed if the sectoral composition by worker type (i.e., manufacturing, low-knowledge and high-knowledge services and other) had remained at its 1988 level. Panels C.1 and C.2 show instead a counterfactual where we first identify workers who transitioned from manufacturing into unemployment and then assign the establishment premiums of the manufacturing job before unemployment to their post-unemployment jobs. In Panel C.1, we do so only if the worker is employed in the service sector after the unemployment spell. In Panel C.2, we assign the pre-unemployment establishment premium to post-unemployment spells also if the worker is reemployed in the manufacturing sector. The sample contains all West German male workers aged 25 to 50. Wages are log average daily wages in EUR adjusted to 1995 prices.

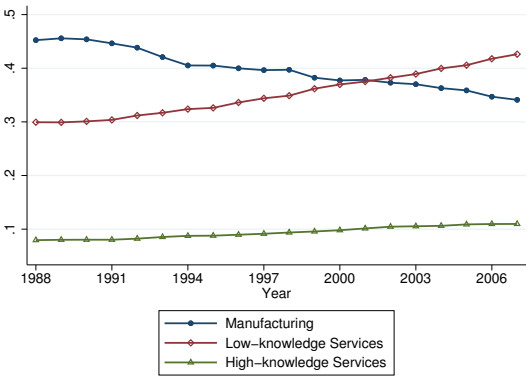
Figure 1: Employment Shares by Sector

Panel A: All Workers

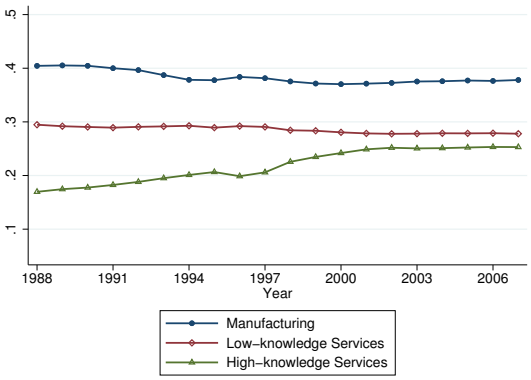


Panel B: By Worker Type

B.1 Low-wage Workers

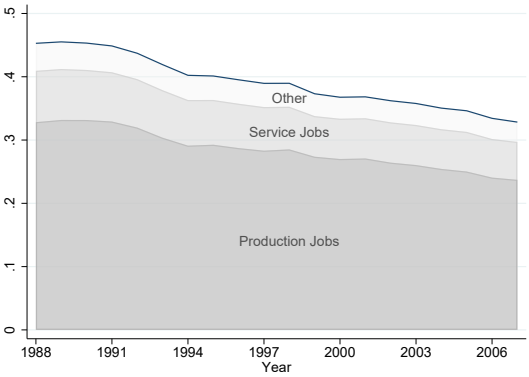


B.2 High-wage Workers

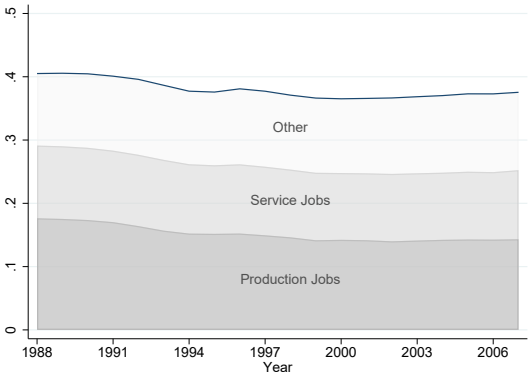


Panel C: Job Types in Manufacturing

C.1 Low-wage Workers

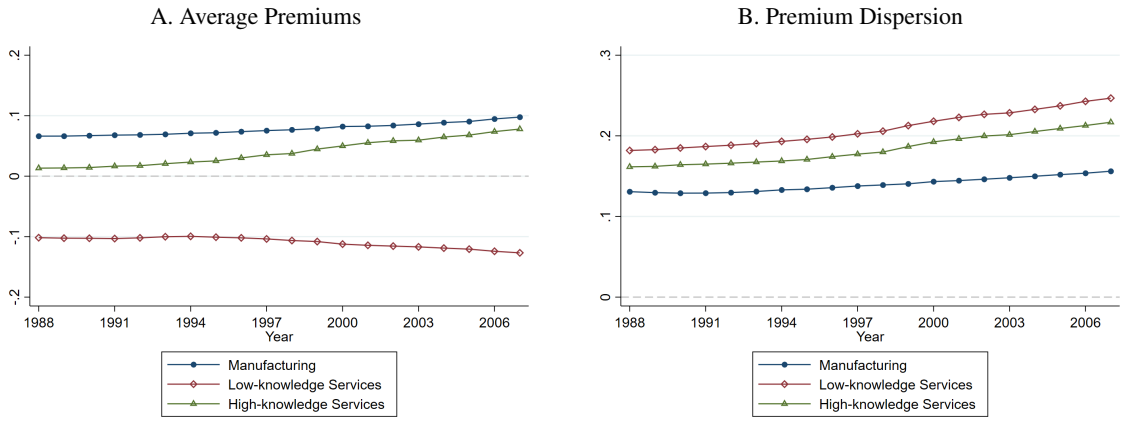


C.2 High-wage Workers



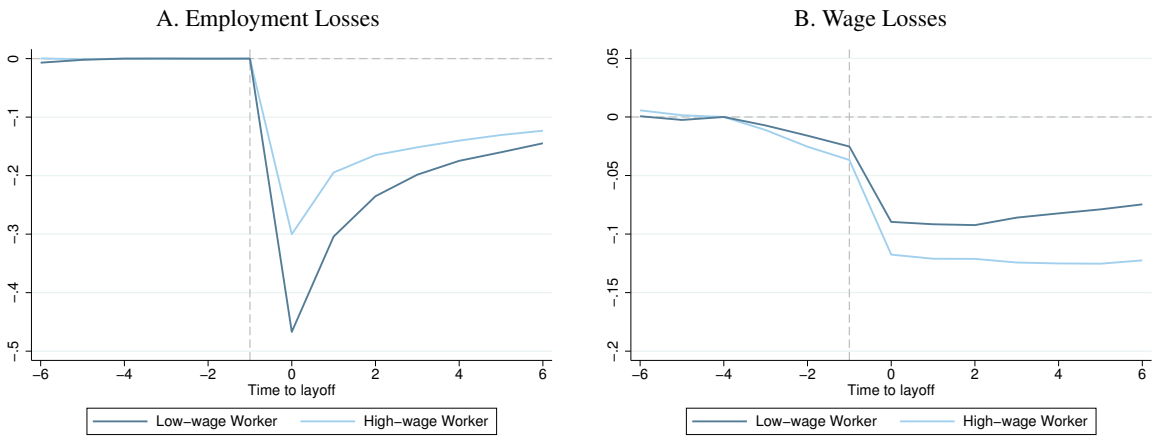
Notes: The figure shows the evolution of employment shares of the manufacturing, the low-knowledge and the high-knowledge sectors for male workers in West Germany in Panel A, and by worker type in Panel B. Panel C shows the evolution of employment shares by job type in the manufacturing sector for low- and high-wage workers. Low-wage workers are defined as workers whose worker fixed effect falls into the bottom tercile and high-wage workers as workers whose worker fixed effects fall into the top tercile of the distribution of worker fixed effects. In Panel C, "Other" refers to jobs that cannot be assigned to service or production jobs, most importantly agricultural jobs and jobs in mining.

Figure 2: Establishment Premiums by Sector over Time



Notes: The figure shows the evolution of establishment premiums in the manufacturing, the low-knowledge and the high-knowledge sectors for male workers in West Germany. Panel A shows average establishment premiums and Panel B the standard deviation of premiums.

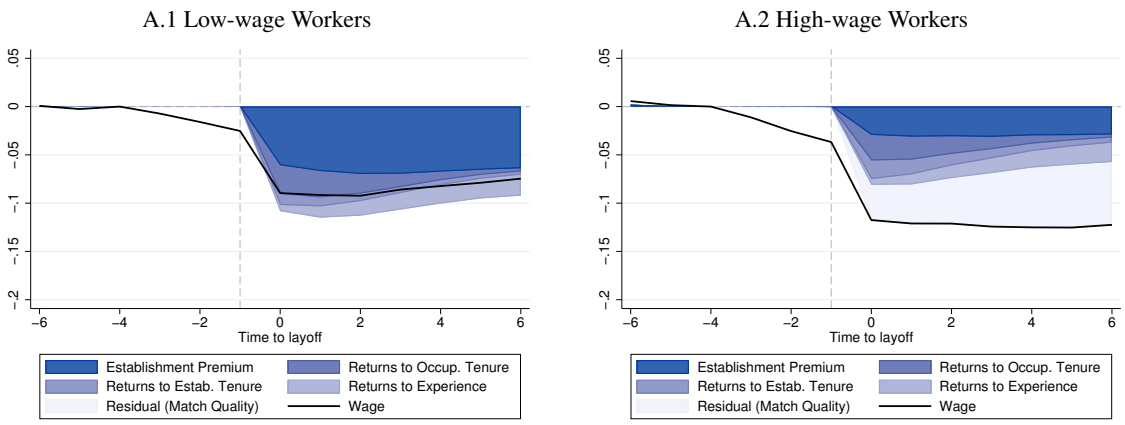
Figure 3: The Effects of Job Displacement by Worker Type



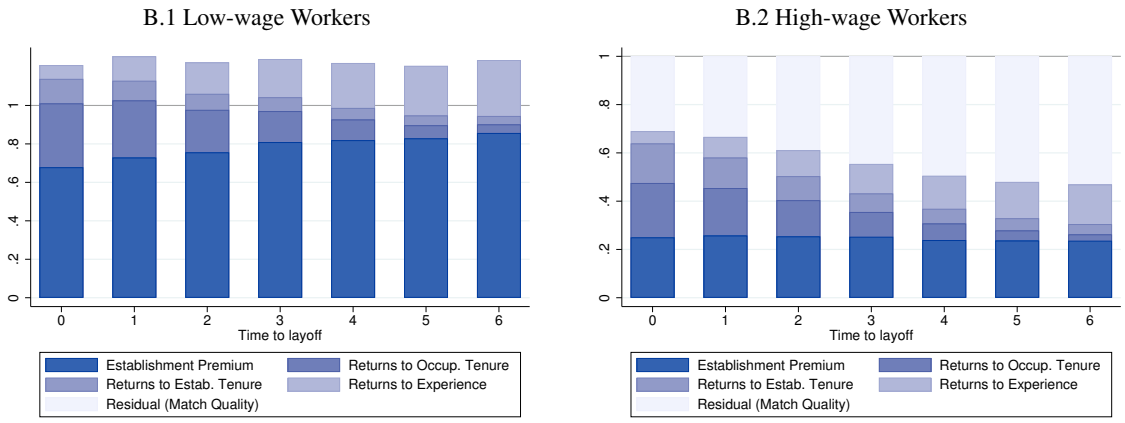
Notes: The figure reports event study estimates of the effects of job displacement by worker type on the probability of being employed in Panel A and on wages conditional on employment in Panel B. Estimates are based on equation (3). Low-wage and high-wage workers are defined as workers with worker fixed effects in the bottom and top terciles of the estimated AKM worker fixed effects distribution, respectively; see equation (2) and Section 4.2. The sample consists of low- and high-wage male workers displaced between 1990 and 2004 and their matched control workers. Both displaced and control workers are aged 25-50 with at least four years establishment tenure in the year of layoff.

Figure 4: Decomposition by Worker Type

Panel A: Sources of Wage Losses

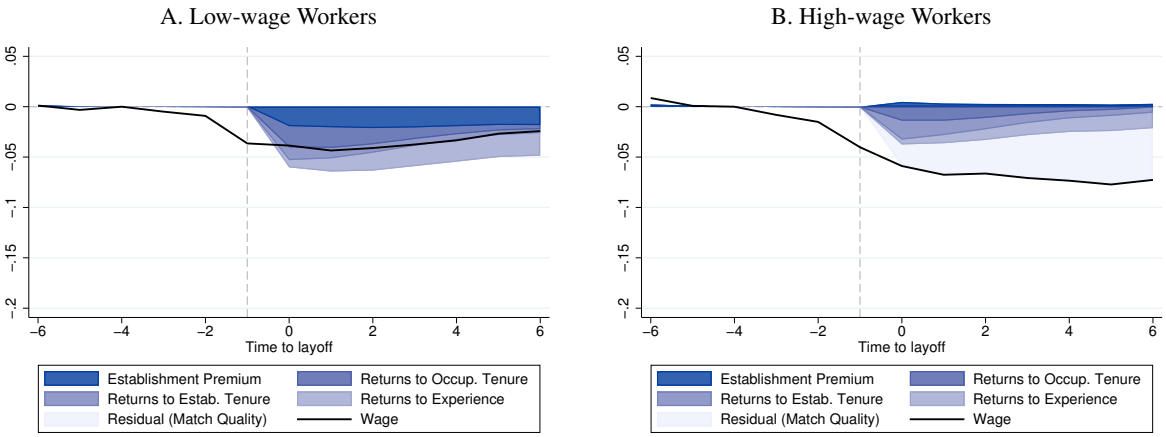


Panel B: Share of Total Wage Loss



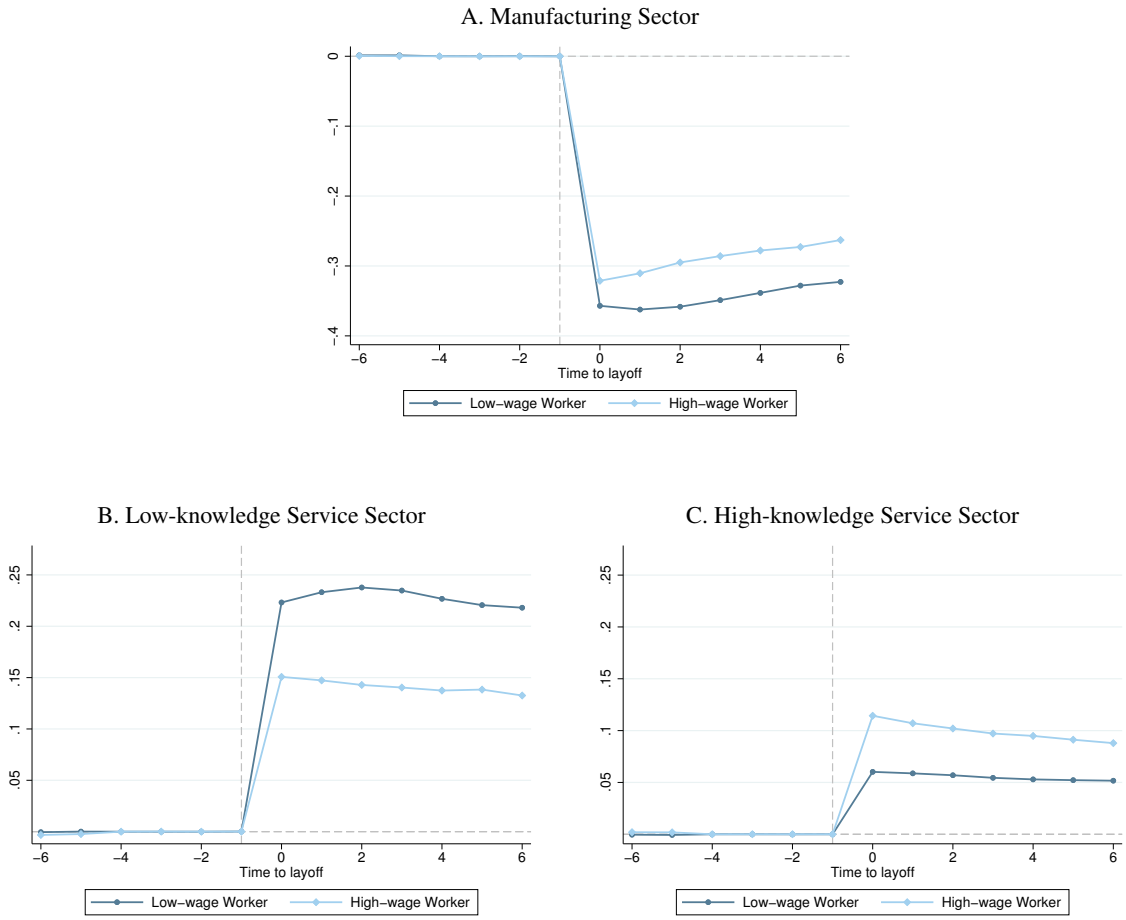
Notes: Panel A of the figure reports event study estimates of the effects of job displacement on wages, and on five potential sources of wage losses (establishment premium, returns to establishment and occupation tenure, returns to experience and match quality) by worker type. Estimates are based on equation (3), with the respective source as dependent variable. Panel B shows the contribution of each of these sources to the total wage loss by worker type. Low- and high-wage workers are defined as workers with worker fixed effects in the bottom and top terciles of the estimated AKM worker fixed effects distribution, respectively. The establishment wage premium refers to the AKM establishment fixed effect as estimated in equation (2) in Section 4.2. The returns to establishment and occupation tenure are predicted using the respective estimates from equation (2) and a worker's observed years of tenure. Tenure variables are capped at ten years of tenure. Losses in the returns to experience are estimated as described in Section 4.3.3. Losses in match quality are defined as the residual wage loss. The sample consists of low- and high-wage male workers displaced between 1990 and 2004 and their matched control workers. Both displaced and control workers are aged 25-50 with at least four years establishment tenure in the year of layoff.

Figure 5: Displacement Losses in the Service Sector



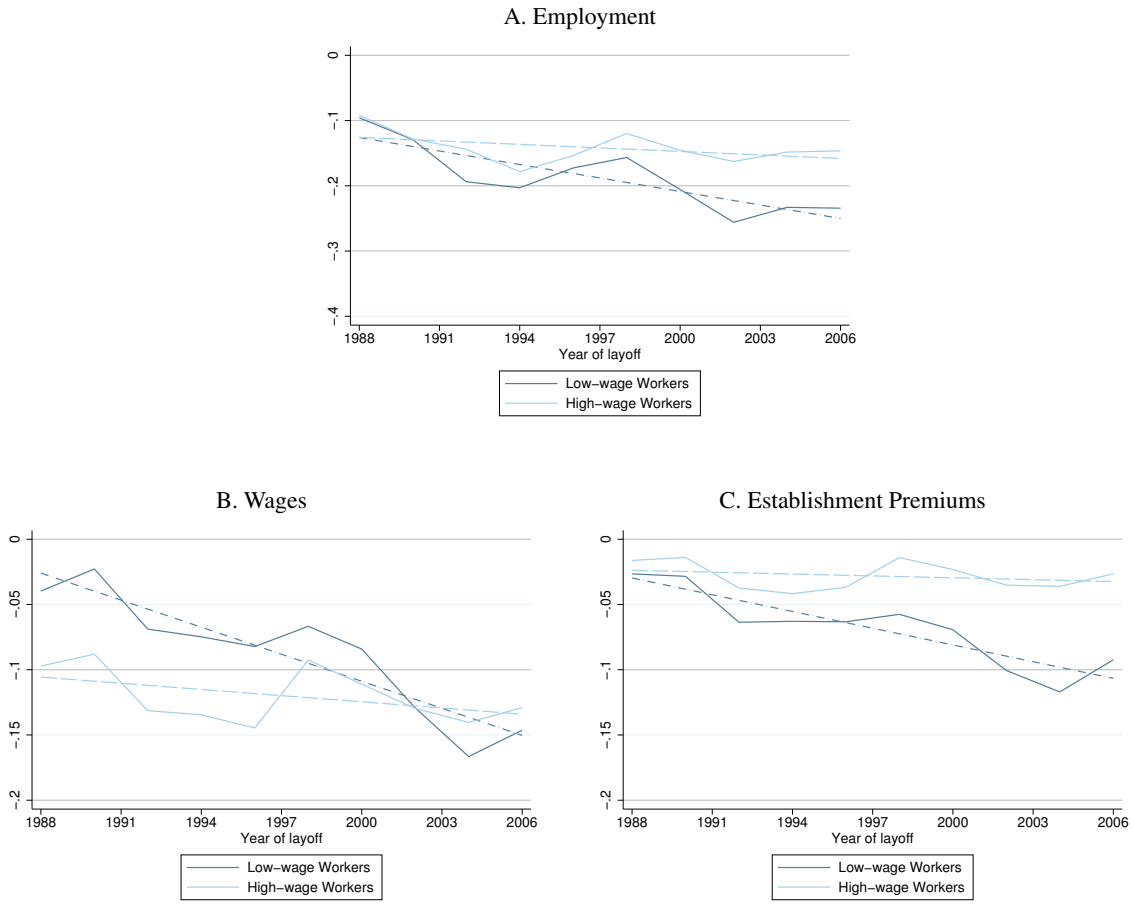
Notes: The figure reports event-study estimates of the effects of job displacement on wages and its sources for workers displaced from the service sector separately for low- and high-wage workers. Estimates are based on equation (3). The establishment wage premium refers to the AKM establishment fixed effect as estimated in equation (2) in Section 4.2. For the procedure to estimate wage losses due to occupation and establishment tenure and experience, see Section 4.3.3. The sample consists of male workers displaced between 1990 and 2004 and their matched control workers. Both displaced and control workers are aged 25-50 with at least four years establishment tenure in the year of layoff.

Figure 6: Sectoral Switching after Displacement



Notes: The figure reports event study estimates of the likelihood of being employed in the manufacturing sector (Panel A), the low-knowledge service sector (Panel B) and the high-knowledge service sector (Panel C) after displacement, conditional on being employed. Estimates are based on equation (3). Low- and high-wage workers are defined as workers with worker fixed effects in the bottom and top terciles of the estimated AKM worker fixed effects distribution, respectively. The sample consists of low- and high-wage male workers displaced between 1990 and 2004 and their matched control workers. Both displaced and control workers are aged 25-50 with at least four years establishment tenure in the year of layoff.

Figure 7: Employment, Wage and Establishment Premium Losses over Time

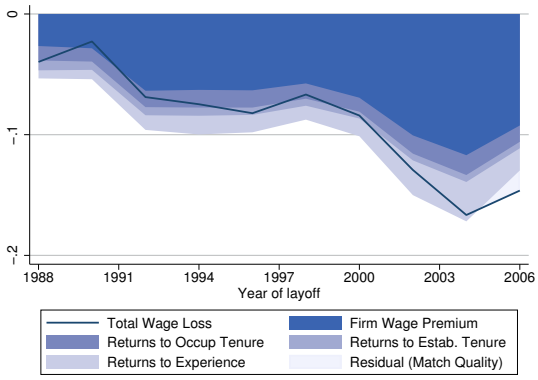


Notes: The figure reports event study estimates of the effects of job displacement by worker type on the probability of being employed in Panel A, on wages in Panel B and on the establishment premium in Panel C. Estimates are based on equation (3) estimated separately for each two-year period of layoffs taking place between 1988 and 2007. Reported coefficients are for the effects three years after displacement. Low- and high-wage workers are defined as workers with worker fixed effects in the bottom and top terciles of the estimated AKM worker fixed effects distribution, respectively. The establishment wage premium refers to the AKM establishment fixed effect as estimated in equation (2) in Section 4.2. The dashed lines present linear trends of the presented estimates for each worker type.

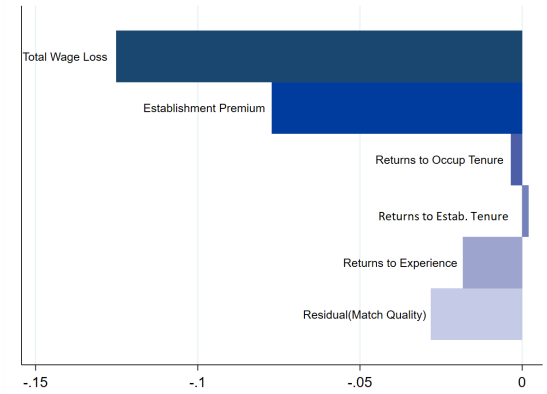
Figure 8: Decomposition of Displacement Wage Losses over Time by Worker Type

Panel A: Low-wage Workers

A.1 Decomposition

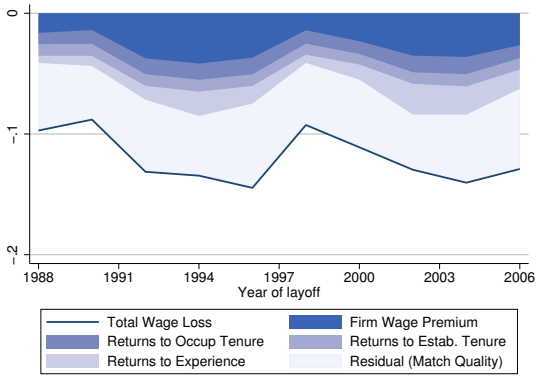


A.2 Change in Wage Loss and its Components

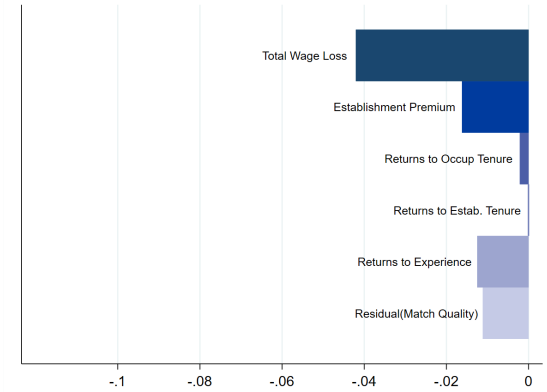


Panel B: High-Wage Workers

B.1 Decomposition



B.2 Change in Wage Loss and its Components

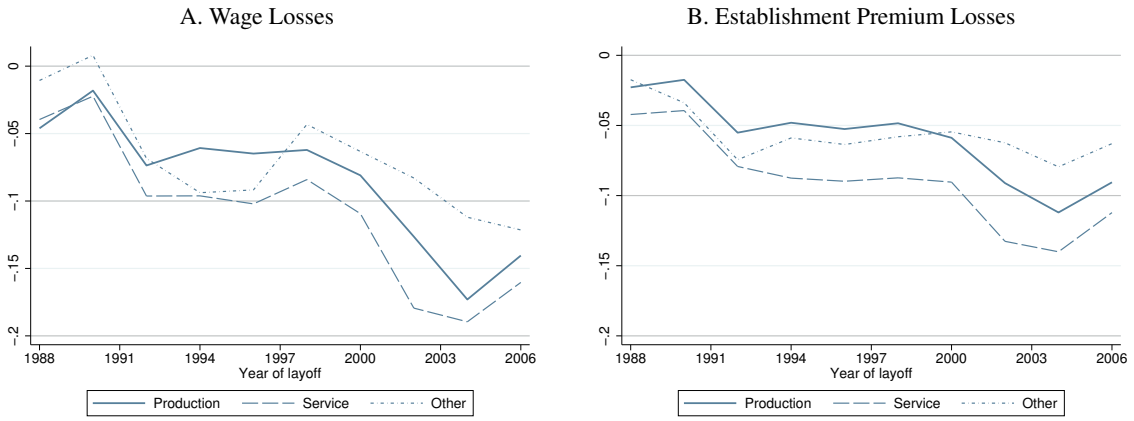


Notes: Panel A.1 and B.1 of the figure shows event study estimates of the effects of job displacement on wages, and on five potential sources of wage losses (establishment premium, returns to establishment and occupation tenure, returns to experience and match quality) by worker type estimated separately for each two-year period of layoffs taking place between 1988 and 2007. Estimates are based on equation (3), with the respective source as dependent variable. Reported coefficients are for the effects three years after displacement. Low- and high-wage workers are defined as workers with worker fixed effects in the bottom and top terciles of the estimated AKM worker fixed effects distribution, respectively. The establishment wage premium refers to the AKM establishment fixed effect as estimated in equation (2) in Section 4.2. The returns to establishment and occupation tenure are predicted using the respective estimates from equation (2) and a worker's observed years of tenure. Tenure variables are capped at ten years of tenure. Losses in the returns to experience are estimated as described in Section 4.3.3. Losses in match quality are defined as the residual wage loss. Panels A.2 and B.2 report the change in the wage loss as well as the five sources of wage losses between the first two and the last two two-year periods (i.e., between 1988 to 1991 and 2004 to 2007).

Figure 9: Sectoral Switching and Establishment Premium Losses over Time

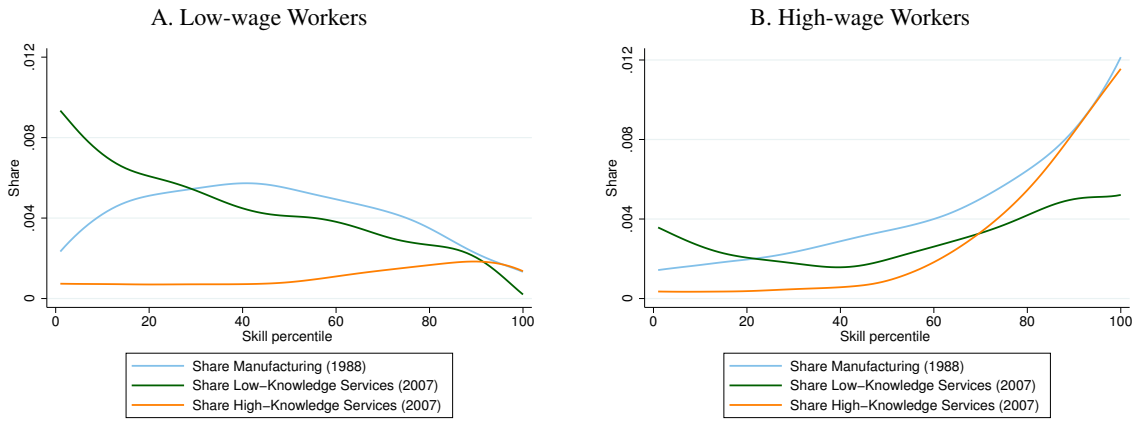
Panel A reports event study estimates of the likelihood of being employed in the manufacturing (Panel A.1), the low-knowledge service (Panel A.2) and the high-knowledge service sector (Panel A.3) three years after displacement, conditional on being employed. Panel B reports event study estimates of the effects of job displacement on establishment premiums by destination sector three years after displacement. Estimates are based on equation (3) estimated separately for each two-year period of layoffs taking place between 1988 and 2007. Lowand high-wage workers are defined as workers with worker fixed effects in the bottom and top terciles of the estimated AKM worker fixed effects distribution, respectively.

Figure 10: Effects over Time by Job Type - Low-wage Workers



Notes: The figures show, for low-wage workers, event study estimates of the effects of job displacement on wages in Panel A and on the establishment premium in Panel B. Estimates are based on equation (3) and are estimated separately for each two-year period of layoffs taking place between 1988 and 2007. Reported coefficients are for the effects three years after displacement. The establishment premium refers to the AKM establishment fixed effect as estimated in equation (2) in Section 4.2. Low-wage workers are defined as workers with worker fixed effects in the bottom of the estimated AKM worker fixed effects distribution. The solid lines show the effects for production workers, the long-dashed lines the effects for service workers and the dash-dotted line for workers in other occupations.

Figure 11: Job Polarization and Sectoral Distribution



Notes: The figure plots the share of manufacturing, low-knowledge service sector and high-knowledge service sector employment by 1988 occupational wage percentile rank for low-wage workers in Panel A and for high-wage workers in Panel B. Occupational wage percentiles are measured as the employment-weighted percentile rank of an occupation's median log wage in 1988. Each line is smoothed using a locally weighted smoothing regression (bandwidth 0.8 with 100 observations).

APPENDIX

Appendix A: Robustness and Extensions

Our main conclusions are robust to different ways of estimating establishment premiums and match quality, as well as to alternative definitions of displacement. For easier exposition, we present the robustness checks in the pooled sample using our full sample including all worker types (with the exception of Appendix A.4, where we allow for different establishment premiums by worker type).

A.1. Baseline Results – Full Sample. Our main analysis in Section 5 focuses on the consequences of job displacement for low- and high-wage workers, respectively. We present the baseline results and the decomposition of wage losses in the full sample in Table A.1. Displaced workers on average face a reduced likelihood of employment of 40 percent one year and 13 percent six years after displacement. They also face strong and persistent wage losses of around 10 percent (columns (1) and (2)). Decomposing the displacement wage loss into its sources, we show that lost establishment premiums are the most important source of wage losses, accounting for around 50 percent of the overall wage loss (column (3)). In line with the results by worker type, losses in establishment- and occupation-specific human capital are similarly important in the short run, together explaining nearly 40 percent of the immediate wage loss, but their contribution declines over time (columns (4) and (5)). In contrast, the importance of missed opportunities for general human capital accumulation due to time away from work increases with time since displacement, representing about 20 percent of the wage loss six years after the layoff (column 6). Overall, losses in establishment premiums and human capital account for 95 percent of the overall wage loss from displacement immediately after the layoff and 83 percent after six years. The remainder is attributed to losses in match quality (column 7).

A.2. Establishment Premiums from a Standard AKM Regression. Table A.4, column (1.3), shows establishment premium losses when using standard AKM establishment fixed effects estimated without controls for establishment and occupation tenure. The estimated loss is somewhat larger than in our baseline estimates (Table A.4, column (1.2)). For example, six years after the layoff, losses in establishment premiums result in wage losses of 6.2 percent (67 percent of the overall wage loss) when using establishment fixed effects from the standard AKM regression, but these shrink to 5.0 percent (54 percent of the overall wage loss) when occupational and establishment tenure are included in the AKM regression. Thus, omitting controls for establishment and occupation tenure in AKM regressions appears to somewhat overstate the importance of establishment premiums in overall displacement wage losses.

A.3. Establishment Premiums Using Six-Year Rolling Windows. Our baseline specification estimates AKM establishment fixed effects in a single regression using observations over a 27-year period from 1984 to 2010. In Table A.4, column (1.4), we show establishment premium losses when AKM establishment fixed effects are estimated over six-year rolling periods, thus allowing establishment fixed effects to slowly change over time. Estimated displacement losses in establishment premiums are of roughly similar magnitude as our baseline estimates, in line with the finding by Lachowska et al. (2023) and Engbom, Moser and Sauermann (2023) that establishment fixed effects tend to be stable over time.

A.4. Different Establishment Premiums by Worker Type. A key assumption behind the AKM model is that low- and high-wage workers are paid the same establishment premium. This assumption has been questioned by, for example, Bonhomme et al. (2019) since it does not allow for the possibility that high-wage workers are able to extract higher rents from the establishment than low-wage workers. Differential establishment premiums for low- and high-wage workers could, in principle, contribute to the larger estimated losses in establishment premiums for low-wage workers when these are constrained to be the same for the two types of workers. To rule out this possibility, we re-estimate the extended AKM model and allow establishment fixed effects to vary by worker type. In Figure A.4, we show the decomposition of wage losses into their components using the estimates from this model. The losses in establishment premiums are very similar to those estimated in our baseline specification for both worker types. The smaller decline in establishment premiums following job displacement among high-wage workers is therefore not an artifact of restricting establishment premiums to be the same across worker types.

A.5. Match Quality. In our decompositions, we interpret the residual displacement wage loss not explained by losses in establishment premiums or losses in general and specific human capital as being due to valuable match quality. We also estimate match quality for each worker-establishment pair more directly, closely following Lachowska et al. (2020) and Woodcock (2015). In a nutshell, log-wages net of year effects, returns to potential experience, and establishment and occupation tenure are averaged within worker-establishment matches and then regressed on establishment and worker fixed effects.[23] The residuals of this regression are then defined as match quality, capturing

[23] Log wages net of year effects, potential experience, occupation and establishment tenure are estimated in two steps. We first regress log wages on year fixed effects to obtain log wage residuals net of year effects (step 1). We then regress the residual log wages from step 1 on the square and cube of potential experience, the square of (capped) occupation and establishment tenure, indicator variables whether occupation and establishment tenure are capped at ten years, as well as a match-specific fixed effect. We then subtract predicted returns to potential experience and occupation and establishment tenure from individual residual log wages to obtain log wages net of year effects, potential experience,

variation in (net) average worker-establishment wages after accounting for worker and establishment effects. This procedure continues to assume that match quality is orthogonal to worker and establishment fixed effects. It does, however, allow match quality to be correlated with potential experience, occupation and establishment tenure.

We then assess the role of losses in match quality in accounting for the overall displacement wage loss by estimating regression equation (3) with estimated match effects as the dependent variable. Using this method, the loss in match quality results in a wage loss of around 2 percent, or 20 percent of the overall wage loss, six years after the layoff (Table A.1, column (7)). Both the magnitude and the pattern in the loss in match quality are similar to the residual displacement wage loss presented in Section 5.2 (compare to Table A.1, column (6)). We report separate results for low- and high-wage workers in Tables A.2, column (7) and A.3, column (7). Whereas losses in match quality are negligible or even positive for low-wage workers, they amount to nearly 4 percent (or 25 percent of the overall wage loss) for high-wage workers. These findings corroborate the notion that the job ladder operates along the match quality margin for high-wage workers and along the establishment premium margin for low-wage workers.

A.6. Displacement Effects due to Plant Closures. Since workers who separated from the establishment in a mass layoff event may differ from workers who continue to work in the establishment, we repeat our baseline analysis for the subset of workers who were displaced because of an establishment closure as a robustness check. Following Hethey and Schmieder (2010), we define establishment closures as events where at least 80 percent of the workforce separates from the establishment. Plant closures comprise around 58 percent of our pooled mass layoff sample. Wage losses (Table A.4, column (2.1)) and declines in establishment premiums (Table A.4, column (2.2)) are similar for plant closures and mass layoffs, indicating that there is little such selection.

A.7. Compositional Changes of Displaced Workers and Layoff Establishments over Time. The increasing wage losses and losses in establishment premiums among low-wage workers after displacement could, in principle, reflect changes in the composition of displaced workers or displacing establishments. That is, even among low-wage workers, displaced workers may become increasingly negatively selected with regards to their worker characteristics. Similarly, the composition of establishments may change over time. For example, high-wage establishments may account for an increasingly large share of mass layoff establishments. Such shifts would result in larger losses in establishment premiums over time.

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occupation and establishment tenure (step 2). Note that the linear terms of potential experience, occupation and establishment tenure are absorbed by the match-specific fixed effects.

We apply two approaches to assess the importance of such compositional changes. First, we categorize workers and establishments by the decile of their respective fixed effects distribution, resulting in a 10 x 10 matrix of cells. We then re-estimate our baseline regression for each two-year period, but we use the ratio between the number of displaced workers in a given worker-establishment cell in the initial 1988-1989 period and the number of workers in that cell in later periods as weights for later periods. This way, the reweighted sample of displaced and control workers in later periods resembles the sample in the first period in terms of the distribution of worker and establishment fixed effects. This approach has advantages as it non-parametrically and thus very flexibly controls for changes in the composition of worker and firm fixed effects in the full sample of displaced workers.

Secondly, we adopt an alternative method proposed by Schmieder et al. (2023) to account for multiple dimensions of composition changes. We first obtain an individual "treatment effect" of job loss for each individual by comparing wage (or establishment premium) change between four years before and three years after the layoff for each displaced worker with that of the matched control worker. In the second step, we regress these individual "treatment effects" on layoff year indicator variables in a single regression over all layoff years and account for compositional changes over time by controlling for worker fixed effects, levels of general experience (age and age squared), firm- and occupation specific tenure (linear and squared terms), education, establishment fixed effects and the industry of the layoff establishment. Each of these controls is measured prior to the layoff. An advantage of this approach is that we can account for compositional changes along additional dimensions.[24]

The results in Figure A.5 demonstrate that the increasing wage losses over time are not driven by compositional changes. The solid lines in Panel A and B of Figure A.5 depict our baseline estimates for the losses in wages and establishment premiums for low-wage workers (reported in Figure 10); the long-dashed and dashed-dotted lines display reweighted losses that hold the composition of displaced workers and mass layoff establishments constant over time and the short-dashed lines present results based on the Schmieder et al. (2023) method. If anything, both wage and establishment premium losses would have been somewhat larger if the composition of displaced workers and displacement establishments had remained constant over time. The increasingly large establishment premium losses therefore reflect lower establishment premiums of post-displacement establishments over time, and not higher establishment premiums of displacement establishments.

[24] Note that the sample using this approach differs from our baseline sample, as it reduces our sample to pairs where both treated and control workers are employed three years after the layoff, while in the first approach only one displaced and one control worker in each matching cell has to be employed.

Appendix B: Within and Between Sector Decomposition

The increase in establishment premium losses following job displacement between the initial displacement period $t = 0$ and the final displacement period $= 1$, $E_1[\Delta\psi_{J(i)}] - E_0[\Delta\psi_{J(i)}]$, can be decomposed into a within and a between sector component as follows:

$$E_1[\Delta\psi_{J(i)}] - E_0[\Delta\psi_{J(i)}] = \underbrace{E_1[\Delta\psi_{J(i)}|d_i = M] - E_0[\Delta\psi_{J(i)}|d_i = M]}_{\text{within manufacturing}} + \underbrace{\begin{aligned}&\textstyle\sum_{k\,\in \mathrm{L,H}} \Pr_1(d_i = \mathrm{k})\big(E_1\big[[\Delta\psi_{J(i)}|d_i = k\big] - E_1\big[\Delta\psi_{J(i)}|d_i = \mathrm{M}\big]\big) - \\ &\Pr_0(d_i = \mathrm{k})\big(E_0\big[[\Delta\psi_{J(i)}|d_i = k\big] - E_0\big[\Delta\psi_{J(i)}|d_i = \mathrm{M}\big]\big).\end{aligned}}_{\text{between sectors}}$$

$\Pr_t(d_i = \mathrm{k})$ is the probability of being re-employed in sector k in displacement period t, and d_i is a variable indicating whether the individual is re-employed in the manufacturing sector ($k = M$), the low-knowledge service sector ($k = L$) or the high-knowledge service sector ($k = H$) after displacement. The between-sector component can be further decomposed into a component due to increased sectoral switching and a component due to increased gaps in establishment premiums across sectors:

$$\textit{between component} = \underbrace{\sum\nolimits_{k\in L,H} \big(\Pr_1(d_i = \mathrm{k}) - \Pr_0(d_i = \mathrm{k})\big)\,\overline{\mathrm{gap}}_k}_{\text{increased sectoral switching}} + \underbrace{\begin{aligned}&\sum\nolimits_{k\in L,H} \overline{\Pr(d_i = \mathrm{k})}\big(E_1\big[[\Delta\psi_{J(i)}|d_i = k\big] - E_1\big[\Delta\psi_{J(i)}|d_i = \mathrm{M}\big]\big) - \\ &\big(E_0\big[[\Delta\psi_{J(i)}|d_i = k\big] - E_0\big[\Delta\psi_{J(i)}|d_i = \mathrm{M}\big]\big)\end{aligned}}_{\text{increased gaps in sectoral wage premiums}}$$

where

$$\begin{aligned}\overline{\mathrm{gap}}_k = \; & 0.5 * \big(E_1[\Delta\psi_{J(i)}|d_i = k] - E_1[\Delta\psi_{J(i)}|d_i = \mathrm{M}]\big) + \\ & 0.5 * \big(E_0[\Delta\psi_{J(i)}|d_i = k] - E_0[\Delta\psi_{J(i)}|d_i = \mathrm{M}]\big)\end{aligned}$$

is the gap in establishment premiums between sector k and the manufacturing sector averaged over periods $t = 0$ and $t = 1$ and

$$\overline{\Pr(d_i = \mathrm{k})} = 0.5 * \Pr_0(d_i = \mathrm{k}) + 0.5 * \Pr_1(d_i = \mathrm{k}))$$

is the probability of being re-employed in sector k after displacement averaged over periods $t = 0$ and $t = 1$.

We decompose the change in establishment premiums between the first two two-year estimation periods of our "time-series" sample, 1988-1989 and 1990-1991 ($t = 0$) and the final two two-year periods 2004-2005 and 2006-2007 ($t = 1$). The estimated switching probabilities and establishment premium losses in each period that are used to compute the various decomposition components are presented in Table B.1. The estimates are based on equation (3) and reported coefficients are for the effects three years after displacement.

Table A.1: Baseline Results - Full Sample

	(PSORPHQW	:DJH	(VWDEOLVKPHQW 3UHPLPfl	5HWUQV WR SDWLRQfl 7HQUH	5HWUQV (VWDEOLVKPHQW 7HQUH	5HWUQV WR (SHULHQFH	5HWUQVfl WRfl 0DWFKfl4DOLW	5HVLGDO
2								
2								
2								
2								
2								
2								
2								
2								
2								
2								
2								
2								
2								

Notes: The table reports event study estimates of the effects of job displacement from the manufacturing sector on employment, wages, and its sources (establishment premium column (3); returns to occupation tenure in column (4); returns to establishment tenure in column (5); returns to experience in column (6); the residual (match quality) in column (7)). Estimates are based on equation (3). The establishment wage premium refers to the AKM establishment fixed effect as estimated in equation (2) in Section 4.2. For the procedure to estimate wage losses due to occupation and establishment tenure and experience, see Section 4.3.3. The sample consists of male workers displaced between 1990 and 2004 and their matched control workers. Both displaced and control workers are aged 25-50 with at least four years establishment tenure in the year of layoff. Levels of significance are * p<0.10, ** p<0.05, *** p<0.01.

Table A.2: Decomposition of Wage Losses - Low-wage Workers

	:DJH	(VWDEOLVKPHQW 3UHPLPfl	5HWUQV WR SDWLRQfl 7HQUH	5HWUQV WR (VWDEOLVKPHQW 7HQUH	5HWUQVfl WRfl (SHULHQFH	5HVLGDO 0DWFKfl4DOLW	0DWFKfl4DOI DFKRVNDfl HW DOfl
2							
2							
2							
2							
2							
2							
2							
2							
2							
2							
2							
2							
2							

Notes: The table reports event study estimates of the effects of job displacement for low-wage workers on wages and its sources (establishment premium column (2); returns to occupation tenure in column (3); returns to establishment tenure in column (4); returns to experience in column (5); the residual (match quality) in column (6); and match quality as estimated in Lachowska et al. (2020) in column (7)). Estimates are based on equation (3). The establishment wage premium refers to the AKM establishment fixed effect as estimated in equation (2) in Section 4.2. For the procedure to estimate wage losses due to occupation and establishment tenure and experience, see Section 4.3.3. The sample consists of male workers displaced between 1990 and 2004 and their matched control workers. Both displaced and control workers are aged 25-50 with at least four years establishment tenure in the year of layoff. Levels of significance are * p<0.10, ** p<0.05, *** p<0.01.

Table A.3: Decomposition of Wage Losses - High-wage Workers

	:DJH	(VWDEOLVKPHQW 3UHPLPfl	5HWUQV WRfl SDWLRQfl 7HQUH	5HWUQV (VWDEOLVKPHQW 7HQUH	5HWUQVfl WRfl (SHULHQFH	5HVLGO 0DWFKfl4DOLW	0DWFKfl4DO DFKRVNDfl HW DOfl
2							
2							
2							
2							
2							
2							
2							
2							
2							
2							
2							
2							
2							

Notes: The table reports event study estimates of the effects of job displacement for high-wage workers on wages and its sources (establishment premium column (2); returns to occupation tenure in column (3); returns to establishment tenure in column (4); returns to experience in column (5); the residual (match quality) in column (6); and match quality as estimated in Lachowska et al. (2020) in column (7)). Estimates are based on equation (3). The establishment wage premium refers to the AKM establishment fixed effect as estimated in equation (2) in Section 4.2. For the procedure to estimate wage losses due to occupation and establishment tenure and experience, see Section 4.3.3. The sample consists of male workers displaced between 1990 and 2004 and their matched control workers. Both displaced and control workers are aged 25-50 with at least four years establishment tenure in the year of layoff. Levels of significance are * p<0.10, ** p<0.05, *** p<0.01.

Table A.4: Robustness and Extensions

	Baseline Sample				Plant Closure Sample	
	Wage (1.1)	Est. Premium Extended AKM (1.2)	Est. Premium Standard AKM (1.3)	Est. Premium Six-year Rolling (1.4)	Wage (2.1)	Est. Premium (2.2)
τ=-6	0.004	0.001	0.001	0.003	0.005	0.002
	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
τ=-5	0.000	0.000	0.000	0.001	0.000	0.000
	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
τ=-4						
τ=-3	-0.008	0.000	0.000	0.000	-0.009	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
τ=-2	-0.018	0.000	0.000	-0.001	-0.019	0.000
	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
τ=-1	-0.027	0.000	0.000	-0.002	-0.027	0.000
	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
τ=0	-0.103	-0.049	-0.062	-0.039	-0.103	-0.047
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
τ=1	-0.104	-0.053	-0.066	-0.041	-0.105	-0.052
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
τ=2	-0.103	-0.054	-0.067	-0.042	-0.103	-0.054
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
τ=3	-0.101	-0.054	-0.067	-0.043	-0.101	-0.053
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
τ=4	-0.099	-0.053	-0.065	-0.043	-0.099	-0.052
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
τ=5	-0.096	-0.051	-0.063	-0.042	-0.098	-0.051
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
τ=6	-0.092	-0.050	-0.062	-0.042	-0.095	-0.050
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)

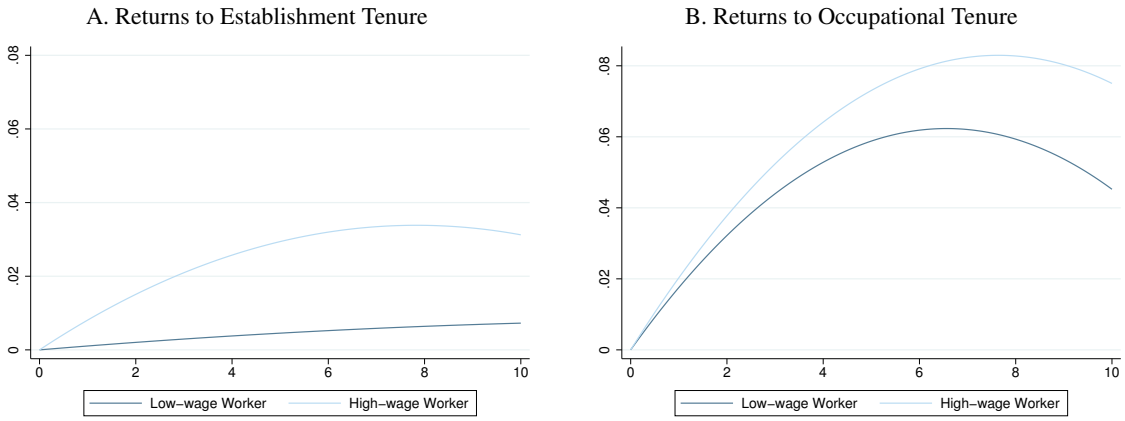
Notes: The table reports event study estimates of the effects of job displacement on wages and the establishment premium. Estimates are based on equation (3). Columns (1.1) and (1.2) present the baseline estimates presented in Figure 4, Panel A. Column (1.3) displays coefficients estimated based on the baseline sample but with establishment premiums estimated in a standard AKM model without controls for establishment and occupation tenure as dependent variable. The sample in columns (2.1) and (2.2) consists only of plant closures defined as mass layoff establishments in which at least 80 percent of employees left the establishment. The sample consists of male workers displaced between 1990 and 2004 and their matched control workers. Both displaced and control workers are aged 25-50 with at least four years establishment tenure in the year of layoff. Levels of significance are * p<0.10, ** p<0.05, *** p<0.01.

Table B.1: Parameter Estimates

Switching Probabilities		Establishment Premium Losses	
$\Pr_0(d_i = M)$	-0.280	$E_0\left[\Delta\psi_{J(i)} \mid d_i = M\right]$	-0.012
$\Pr_0(d_i = L)$	0.176	$E_0\left[\Delta\psi_{J(i)} \mid d_i = L\right]$	-0.073
$\Pr_0(d_i = H)$	0.048	$E_0\left[\Delta\psi_{J(i)} \mid d_i = H\right]$	-0.040
$\Pr_1(d_i = M)$	-0.391	$E_1\left[\Delta\psi_{J(i)} \mid d_i = M\right]$	-0.049
$\Pr_1(d_i = L)$	0.287	$E_1\left[\Delta\psi_{J(i)} \mid d_i = L\right]$	-0.214
$\Pr_1(d_i = H)$	0.062	$E_1\left[\Delta\psi_{J(i)} \mid d_i = H\right]$	-0.071

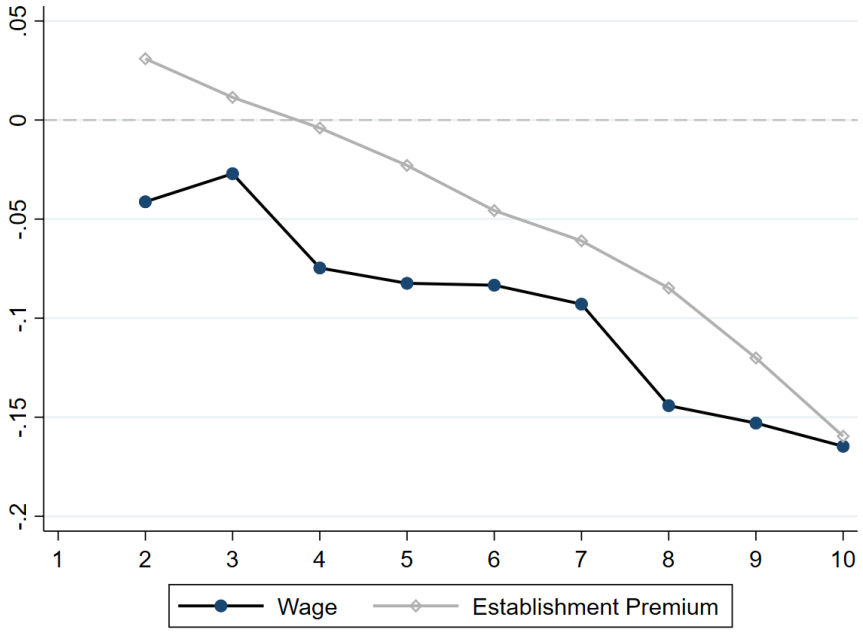
Notes: The switching probabilities and establishment premium loss estimates are based on equation (3). Reported coefficients are for the effects three years after displacement. *M* denotes the manufacturing sector, *L* the low-knowledge service sector and *H* the high-knowledge service sector. Period 0 represents the two two-year periods 1988-1989 and 1990-1991, and period 1 denotes the final two two-year periods 2004-2005 and 2006-2007.

Figure A.1: Returns to Establishment and Occupation Tenure



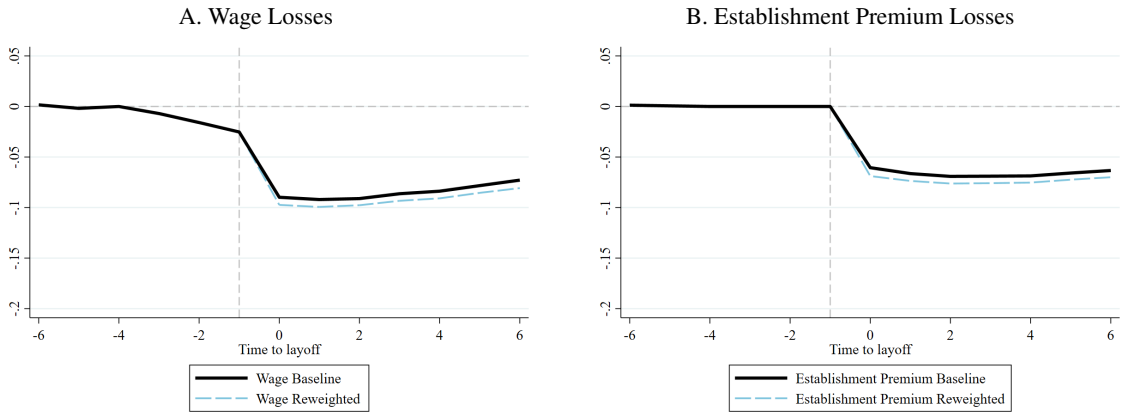
Notes: The figure shows returns to years of establishment tenure in Panel A and to occupational tenure in Panel B as estimated in the extended AKM model specified in equation (2) in Section 4.2. Low-wage workers are defined as workers whose worker fixed effect falls into the bottom tercile of the distribution of worker fixed effects and high-wage workers as workers whose worker fixed effects fall into the top tercile.

Figure A.2: Displacement Losses by Establishment Premium Decile



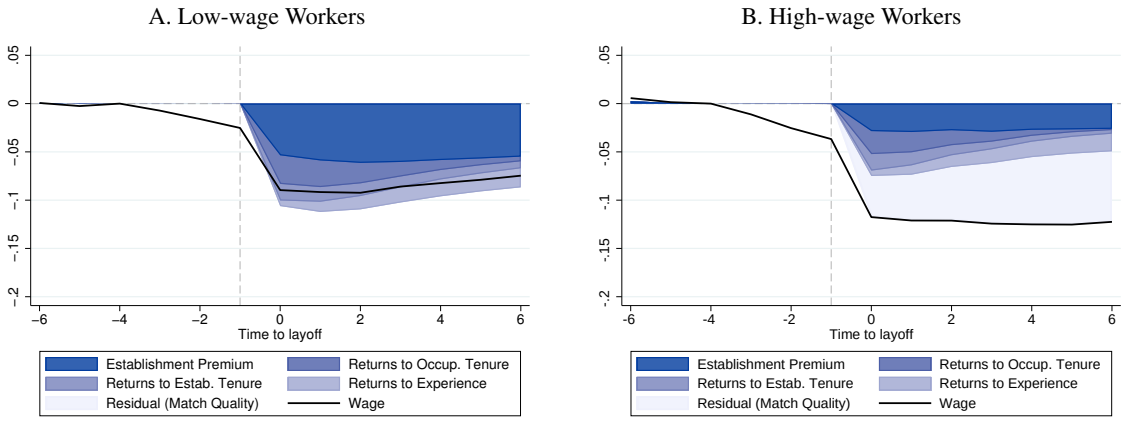
Notes: The figure reports event study estimates of the effects of job displacement on wages and establishment premiums by displacement establishment premium decile. Estimates are based on equation (3) and reported coefficients are for the effects three years after displacement. The establishment wage premium refers to the AKM establishment fixed effect as estimated in equation (2) in Section 4.2. Deciles are defined over the universe of establishments and workers, including establishments in the service sector. There are no establishments in the lowest decile (1) in the manufacturing sector. The sample consists of male workers displaced between 1990 and 2004 and their matched control workers. Both displaced and control workers are aged 25-50 with at least four years establishment tenure in the year of layoff.

Figure A.3: Composition Adjusted Losses - Low-wage Workers



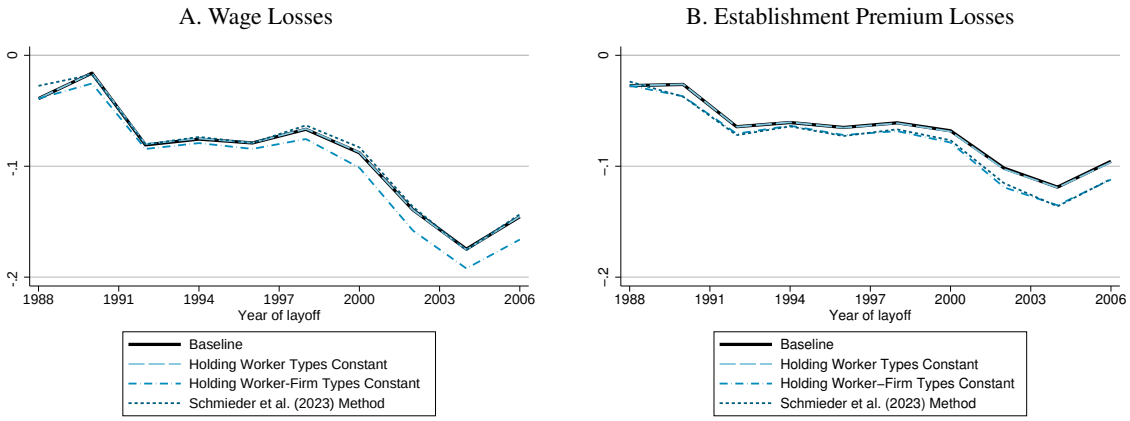
Notes: The figure reports, for low-wage workers, event study estimates of the effects of job displacement on wages in Panel A and on the establishment premium in Panel B. Estimates are based on equation (3). The establishment wage premium refers to the AKM establishment fixed effect as estimated in equation (2) in Section 4.2. Low-wage workers are defined as workers with worker fixed effects in the bottom of the estimated AKM worker fixed effects distribution. The solid lines show the baseline wage and establishment premium losses equivalent to those presented in columns (1) and (2) of Table A.1. The long-dashed lines reweight the low-wage worker observations to reflect the establishment premium distribution of high-wage workers' displacement establishments. The sample consists of male workers displaced between 1990 and 2004 and their matched control workers. Both displaced and control workers are aged 25-50 with at least four years establishment tenure in the year of layoff.

Figure A.4: Decomposition Allowing the Establishment Premium to Vary by Worker Type



Notes: The figure reports event study estimates of the effects of job displacement on wages and on five potential sources of wage losses (establishment premium, returns to establishment and occupation tenure, returns to experience and match quality) by worker type. Panel A reports the estimates for low-wage workers and Panel B for high-wage workers. Low- and high-wage workers are defined as workers with worker fixed effects in the bottom and top terciles of the estimated AKM worker fixed effects distribution, respectively. All estimates are based on equation (3), with the respective source as dependent variable. The establishment premium refers to the AKM establishment fixed effect as estimated using a variant of equation (2) in Section 4.2 that allows the establishment fixed effects to vary by worker type. The returns to establishment and occupation tenure are predicted using the respective estimates from the same AKM model and a worker's observed years of tenure. Tenure variables are capped at ten years of tenure. Losses in the returns to experience are estimated as described in Section 4.3.3. Losses in match quality are defined as the residual wage losses. The sample consists of male low- and high-wage workers displaced between 1990 and 2004 and their matched control workers. Both displaced and control workers are aged 25-50 with at least four years establishment tenure in the year of layoff.

Figure A.5: Composition Adjusted Losses over Time - Low-wage Workers



Notes: The figures show, for low-wage workers, event study estimates of the effects of job displacement on wages in Panel A and on the establishment premium in Panel B. Estimates are based on equation (3) and are estimated separately for each two-year period of layoffs taking place between 1988 and 2007. Reported coefficients are for the effects three years after displacement. The establishment premium refers to the AKM establishment fixed effect as estimated in equation (2) in Section 4.2. Low-wage workers are defined as workers with worker fixed effects in the bottom of the estimated AKM worker fixed effects distribution. The solid lines show the baseline wage and establishment premium losses equivalent to those presented in Figure 9, Panel B and C. The long-dashed lines reweight the composition of workers in each of the two-year periods to reflect the worker-type distribution in the first two-year estimation period (i.e. 1988 and 1989); the dashed-dotted line instead reweights the composition of workers to reflect the worker and establishment distribution in the first two-year estimation period. The short-dashed line applies the Schmieder et al. (2023) method to account for compositional changes. Both methods are described in more detail in Appendix A.7.