

Workers' Training and Resilience to Technology Shocks

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Workers' Training and Resilience to Technology Shocks*

Scientific Progress Report

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Abstract

This report studies how vocational training content shapes workers' resilience to technology shocks. We link German dual-system training curricula to patent-based measures of digital technology exposure and administrative employer–employee records. Using curriculum-update events, we examine how incumbents trained under earlier curriculum vintages adjust when occupational skill requirements are renewed. We are particularly interested in which initial skills matter for incumbents resilience to the arrival of newly trained workers. Digitally exposed occupations update their curricula more frequently, shifting training away from routine tasks and toward social and digital skills. Updates are associated with wage losses among older incumbents, while younger workers adjust primarily through occupational mobility. Initial skill bundles matter: workers in routine-intensive occupations experience larger post-update wage losses, whereas low routine intensity and stronger digital content are associated with greater resilience, particularly among older workers. We find no equally robust protective role for social and communication skills. The results identify curriculum design as an ex ante policy lever for reducing skill obsolescence.

Keywords: Vocational education, technological change, skill mismatch, curriculum updates

JEL codes: J25, J24, O33

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1 Introduction

Technological change alters the tasks performed within occupations and, consequently, the skills workers need to remain productive over their careers. This challenge is particularly salient for vocationally trained workers. Vocational education equips workers with a detailed, occupation-specific bundle of skills at the beginning of their working lives, but the economic value of that bundle can change when new technologies alter production processes, task content, and employers’ demand for expertise. Whether workers can withstand such changes depends not only on their exposure to technological change, but also on the type of skills embedded in their initial training. Identifying which vocational skills support workers’ resilience to technology shocks is therefore central to understanding how education systems can prepare workers for changing labour markets.

This report documents the scientific progress achieved under Task 5.6 of the Horizon Europe SkiLMeeT project, which studies the role of training for workers’ resilience to technology shocks. The task’s central aim is to identify the core skills embedded in vocational training curricula and to assess whether these skills shape workers’ ability to cope when technological change alters the skill requirements of their occupation. We focus in particular on routine task content, social and communication skills, and digital skills. These skill dimensions capture conceptually distinct channels through which training may affect resilience: routine-intensive skills may be more susceptible to technological substitution, whereas social and communication skills may complement changing technologies and facilitate adaptation to new work tasks; digital skills may allow workers to use, monitor, and work alongside new technologies.

The analysis draws on the novel data infrastructure developed in Deliverable 2.6 and used in the accompanying scientific paper (Salomons et al., 2025). We link the near-universe of legally binding German vocational training curricula over five decades to patent-based measures of digital technology exposure and administrative employer–employee data on workers’ earnings and career transitions. The curriculum texts allow us to measure the skill bundle taught in each training occupation and curriculum vintage rather than relying on broad occupational titles. We then use curriculum-update events as observable moments at which the occupation’s required expertise is revised, and examine how established workers trained under earlier curriculum vintages fare as newly trained workers with updated skills enter the labour market.

Our empirical strategy first establishes that curriculum updating is closely connected to

technological change: occupations with greater exposure to digital breakthrough technologies update their curricula more frequently and more rapidly. These revisions shift training content away from routine tasks and toward social and digital skills. We then study the labour-market consequences of these updates for incumbent workers. In a stacked event-study difference-in-differences design, we compare the wage and mobility trajectories of vocationally trained incumbents in occupations receiving a curriculum update with those of comparable incumbents in occupations not updating in the same period. Crucially for Task 5.6, we estimate these effects separately for occupations whose pre-update curricula differ in their intensity of routine, social and digital skills. This permits us to test whether the skill composition workers acquired in initial training predicts their resilience when occupational expertise is renewed.

The results show that curriculum updates are an important institutional response to technology-driven changes in skill requirements, but that their consequences for incumbent workers are uneven. More technology-exposed occupations update more frequently, and updates systematically introduce less routine-intensive and more non-routine skill content. At the same time, the arrival of newly trained workers with updated expertise is associated with declining relative wages for older occupational incumbents: five years after an update, daily wages are around 1.9 percent lower for workers aged 40 to 49 and 3.3 percent lower for workers aged 50 to 59. Younger incumbents exhibit little comparable wage loss, but adjust through greater occupational, industry, and employer mobility. These patterns indicate that curriculum updates can reveal or accelerate the obsolescence of older skill vintages, while also creating new opportunities for workers who can adapt.

The central contribution of Task 5.6 is to move beyond the average effect of curriculum updating and ask which initial skills are associated with resilience to these shocks. By comparing update events across curricula with different skill profiles, the analysis distinguishes whether workers' adjustment varies according to their exposure to routine tasks and their training in social and digital skills. The results show that the initial skill bundle matters substantially. Incumbents in occupations with relatively routine-intensive pre-update curricula experience pronounced wage losses after curriculum renewal, including among younger workers, whereas those in less routine-intensive occupations are considerably more protected. Digital skills are likewise associated with resilience, particularly for workers later in their careers: older incumbents in occupations with limited digital content experience clear wage losses when updated cohorts enter the labour market, while comparable workers from digitally stronger occupations show little evidence of such losses. By contrast, the estimates

for social and communication skills are too imprecise to establish a robust protective effect in this setting. In doing so, the report treats resilience not as a fixed worker characteristic, but as a property that can be shaped *ex ante* by the content of vocational education. The findings therefore speak directly to education and labour-market policy: curricula that embed non-routine and digital capabilities may reduce the distributional costs of technological progress by helping workers retain the value of their expertise as occupational requirements change.

Our report contributes to four strands of literature. A first strand asks which skills technology replaces and which it complements, and so supplies the candidates for our resilience classification (Autor et al., 2003; Weinberger, 2014; Deming, 2017; Deming and Kahn, 2018; Acemoglu et al., 2022; Edin et al., 2022; Autor et al., 2024; Autor and Thompson, 2025; Hampole et al., 2025). The routine-biased view holds that technology substitutes for labour in codifiable tasks and complements it in non-routine analytic and interactive ones (Autor et al., 2003). Later work sharpens this in two directions. Social and non-cognitive skills have become the scarce complement: jobs requiring high social interaction grew by nearly twelve percentage points of the US labour force between 1980 and 2012 while math-intensive but less social jobs shrank (Deming, 2017), the return to cognitive skill rose only for workers who also held strong social skills (Weinberger, 2014), and the return to non-cognitive skill roughly doubled between 1992 and 2013 while the return to cognitive skill was flat (Edin et al., 2022). Recent AI evidence finds that more exposed tasks subsequently face lower labour demand. (Acemoglu et al., 2022; Hampole et al., 2025). Autor and Thompson (2025) offer the most useful reframing for our purposes, arguing that what matters is not whether a task is routine but whether automation raises or lowers the expertise required for the tasks that remain. We contribute to this literature by bringing its task- and skill-based distinction to the content of formal vocational training. Using the text of legally binding German training curricula, we construct curriculum-vintage measures of routine-task intensity, digital-skill intensity, and social-skill intensity. We then examine whether incumbent workers' wage responses to subsequent curriculum updates differ according to the skill bundle embedded in the curriculum under which they were originally trained.

Second, we build on work on digital and information technology skills, which offers the most direct evidence that a particular kind of training protects workers (Janssen and Mohrenweiser, 2018; Genz et al., 2019; Falck et al., 2021; Kiener et al., 2022; Langer and Wiederhold, 2023). Falck et al. (2021) find sizable causal returns to ICT skills in Germany, with occupational sorting an important channel. Within vocational training specifically, IT content

is taught in bundles alongside complementary technical and non-technical skills, and each bundle carries a wage premium (Kiener et al., 2022), while returns to the digital and social skills acquired in German apprenticeship have risen since the 1990s (Langer and Wiederhold, 2023). Most closely related, Janssen and Mohrenweiser (2018) study a German reform that added in-depth IT skills to one large manufacturing apprenticeship and show that it increased the labor supply of graduates with advanced IT/CNC skills, producing incumbent earnings losses and occupational crowd-out. We contribute by covering the near-universe of German dual-system training occupations and relates workers’ responses to curriculum updates to the digital-skill intensity of the pre-update curriculum. Rather than isolating the effect of a particular IT reform or of a single digital skill, we test whether broader digitally oriented training bundles are associated with smaller incumbent wage losses when occupational training requirements are revised.

Third, our work engages with the literature on skill specificity and portability, which supplies the central tension of this task (Poletaev and Robinson, 2008; Lazear, 2009; Gathmann and Schoenberg, 2010; Hanushek et al., 2017; Eggenberger et al., 2018; Neffke et al., 2024; Cnossen et al., 2025). In the skill-weights framework, apparently specific human capital is really an unusual combination of general skills, so a curriculum can be represented as a vector of weights and an update as a reweighting (Lazear, 2009). Portability is then governed by the distance between skill bundles rather than by occupational labels: task-specific human capital accounts for up to 52 percent of wage growth (Gathmann and Schoenberg, 2010), and losses after a job change track the change in the skill portfolio rather than the change in classification code (Poletaev and Robinson, 2008; Neffke et al., 2024). The tension is that specificity is valuable and costly at once. More specific vocational programmes deliver higher wages but lower occupational mobility (Eggenberger et al., 2018), and vocational training raises employment early in the career and lowers it later, most sharply in apprenticeship countries (Hanushek et al., 2017). A resilience skill must therefore be one that raises the wage without narrowing the option set, and the available evidence points to cross-functional content, since among middle-educated Dutch workers resource-management and social skills carry the highest returns (Cnossen et al., 2025). We contribute by studying how the composition of occupation-specific training is related to workers’ capacity to retain the value of their skills when the occupation itself is renewed. The curriculum data allow us to observe the skill content of the training regulation in force before an update, while the worker data allow us to trace incumbent wages and mobility around the update event.

Fourth, we relate to research on skill obsolescence and on training as the margin along

which workers adjust to technological change (Neuman and Weiss, 1995; MacDonald and Weisbach, 2004; Card et al., 2018; Deming and Noray, 2020; Fillmore and Hall, 2021; Dauth et al., 2021; Battisti et al., 2023; Kogan et al., 2023; Schultheiss and Backes-Gellner, 2024; Buehler et al., 2025; Dillon et al., 2025; Hanushek et al., 2025; Hyman et al., 2025; Salomons et al., 2025). Education has a vintage, and knowledge acquired at school depreciates externally as the environment changes rather than only through ageing (Neuman and Weiss, 1995; MacDonald and Weisbach, 2004), a mechanism identified cleanly by Fillmore and Hall (2021) in a setting where a technology shock re-ranked the value of two skills. The adjustment evidence is more encouraging but conditional. German firms adopting new technology retrain routine workers into abstract roles, so exposed workers face no average earnings penalty, with older workers the exception (Battisti et al., 2023); incumbents absorb robot exposure through new tasks in their existing plants, so the cost falls on entrants (Dauth et al., 2021); and only labour-saving exposure lowers earnings whereas labour-augmenting exposure has heterogeneous effects (Kogan et al., 2023). Two recent findings sharpen our hypothesis in opposite directions. Hyman et al. (2025) find substantial retraining returns for workers from high-AI-exposure occupations, driven mainly by transitions into less AI-exposed occupations and, to a lesser extent, expansion of AI-complementary training. And Deming and Noray (2020) show that technical occupations turn over their skill content fastest, so returns to experience there are lowest. We contribute by studying curriculum renewal as an observable institutional moment at which the skill requirements of an occupation are revised and newly trained workers begin to enter with updated expertise. We show that such updates are more common in occupations with greater digital technology exposure and are associated with declining relative wages among older incumbents, while younger incumbents adjust more strongly through occupational, industry, and employer mobility. We then show that these adjustment costs differ with the skill content of the previous curriculum, analyzing which skills deliver resilience to a technology shock.

The rest of this report is structured as follows: We present our datasets in Section 2. That covers the vocational training data used to identify curriculum updates and vocational skills; exposure to digital technologies embedded in breakthrough patents; and social security records on workers’ careers. Section 3 analyzes the effect of digital technology exposure on vocational training curricula updates as well as skill changes. We study the consequences of curriculum updates on workers’ careers, with a special focus on the role of key skills, in Section 4. Section 5 concludes.

2 Data

This section summarises the principal data sources underlying the empirical analysis. The research design relies on three interconnected datasets: vocational training curricula and their updates, patent-based measures of technology exposure, and administrative employer-employee records tracking workers’ labour-market outcomes. These three datasets are the output of Deliverable 2.6 of the SkiLMeeT project (Salomons et al., 2025). Full methodological details on data construction, variable definitions, and sample restrictions for the three datasets are provided in the main paper (Salomons et al., 2025, Sections 2 and 4.1); the description below therefore remains at a summary level sufficient for understanding the empirical strategy and results.

2.1 Vocational Training Curricula

The analysis in this report draws on the vocational training curriculum data developed in Deliverable 2.6 of the SkiLMeeT project. In the present report, only a concise summary is provided, while the full description of data sources, processing steps, and validation is available in Deliverable 2.6 (see Salomons et al., 2025).

The curriculum data cover the German dual vocational training system, in which nationally standardised training regulations define the content of apprenticeship training for recognised occupations. These curricula are highly informative for the present purpose because they specify, in considerable textual detail, the knowledge, tasks, and skills that apprentices are expected to acquire, and they are revised when occupational skill requirements change. The dataset follows curriculum vintages over time for German training occupations from 1971 to 2021. This longitudinal structure makes it possible to identify when an occupation’s curriculum was updated and to compare the content of successive curriculum versions within the same occupation.

To construct the dataset, the full curriculum texts were digitised and machine-translated, and the substantive textual content was retained for analysis. The resulting corpus is very rich: according to Salomons et al. (2025), the average curriculum contains about 34,374 tokens, which allows for detailed text-based measurement of occupational skill requirements and their evolution over time.

The data are particularly well suited for studying curriculum reform because they permit the identification not only of update timing, but also of what changed in the curriculum text.

Salomons et al. (2025) show that curriculum revisions are substantial events: on average, nearly 200 distinct words are removed and around 170 distinct new words are added in an update, corresponding to roughly 35 to 45 percent of the curriculum’s distinct vocabulary.

This vocational training dataset is central to the empirical strategy of the report. It is used to characterise the skill content of training occupations and to analyse whether occupations that are more exposed to technological change update their curricula more frequently. All of these uses build directly on the data infrastructure established in Salomons et al. (2025).

To identify the vocational skills that may shape workers’ resilience to technology shocks, we construct three curriculum-based indicators: routine task intensity, digital-skill intensity, and social-skill intensity. All three measures are assigned at the curriculum-vintage level. They therefore capture the skill bundle specified in the legally binding training regulation that was in force when a worker completed vocational training.

Routine task intensity. Our measure of routine task intensity follows the task-based approach in the literature on routine-biased technological change. We first represent each vocational curriculum as a text vector based on the substantive nouns and verbs contained in its full text. We then compare this vector to textual descriptions of job tasks from the U.S. Occupational Information Network (O*NET). The task measures include routine cognitive activities, such as performing administrative activities, and routine manual activities, such as controlling machines and processes. They also include non-routine analytic tasks, such as analysing data and information, thinking creatively, and interpreting information for others; non-routine interpersonal tasks, such as establishing and maintaining personal relationships, guiding and motivating others, and coaching or developing others; and non-routine manual tasks, such as operating vehicles, mechanised devices, or equipment.

For each curriculum, we calculate its semantic similarity to the task descriptions and aggregate these similarities into routine and non-routine task components. The routine task intensity measure is the difference between the curriculum’s routine-task content and its non-routine-task content, standardised across curriculum observations within year. Higher values therefore indicate that a curriculum places relatively greater emphasis on codifiable, repetitive, or rule-based tasks, whereas lower values indicate a more non-routine skill bundle involving analytic, interpersonal, creative, or adaptive tasks. In the empirical analysis, this measure allows us to test whether workers trained in curricula with more routine-intensive content are more vulnerable when their occupation undergoes technology-related skill re-

newal.

Digital-skill intensity. We measure digital-skill intensity using the European Skills, Competences, Qualifications and Occupations taxonomy (ESCO, version 1.2.1). ESCO provides a hierarchical classification of skills and competences, together with detailed textual descriptions. We define digital skills as the combination of the ESCO categories “information and communication technologies” and “working with computers.” This category encompasses, among other capabilities, accessing and analysing digital data; setting up, maintaining, and protecting computer systems; programming computer systems; using digital tools to control machinery; and using digital tools for collaboration, content creation, and problem-solving.

We assign curriculum words to ESCO skill clusters using semantic similarity between word-embedding representations of the curriculum text and the embedding centroid of each ESCO skill cluster. Digital-skill intensity is then measured as the share of a curriculum’s skill-related textual content assigned to the digital-skills cluster. A higher value indicates that the vocational programme embeds more content related to the use, configuration, programming, or application of digital technologies. This measure captures not only explicitly named information-technology skills, but also digitally enabled work processes and the use of computer-based tools in otherwise non-IT occupations.

Social-skill intensity. Social-skill intensity is constructed using the same ESCO-based procedure. We define social skills as the combination of ESCO’s “communication, collaboration and creativity” and “social and communication skills and competences” categories. This measure captures skills such as collaborating in teams and networks, communicating with colleagues or clients, leading others, advising and consulting, negotiating, presenting information, writing and composing, promoting and selling, and working effectively with others.

The resulting indicator is the share of curriculum content semantically assigned to this social-skills cluster. Higher values identify curricula that place greater emphasis on interpersonal interaction, communication, coordination, teamwork, and client-facing activities. Such skills are particularly relevant for the resilience analysis because they may complement rather than substitute for new technologies, facilitate the reallocation of workers across tasks and employers, and help workers adapt when technological change changes the organisation of work.

For the analyses below, we classify curriculum-update events according to whether their

pre-update curriculum lies above or below the median of each skill measure. We show in Appendix Figure A1 that there are only weak associations between the three skill clusters: Curricula which are routine intense, have slightly fewer digital skills (Panel A) and slightly fewer social skills (Panel B), but the relationship is weak. There is essentially no relationship between digital and social skills (Panel C).

Splitting the sample by skills, we will assess in the rest of the paper whether the wage and mobility consequences of a curriculum update differ systematically between workers whose occupation embedded relatively high versus low levels of routine, digital, or social skills. The estimates should therefore be interpreted as showing how the initial composition of vocational training is associated with workers’ adjustment to a subsequent change in their occupation’s required expertise, rather than as the effect of a single isolated skill.

2.2 Technology Exposure

The measure of technology exposure used in this report was developed in Salomons et al. (2025), the project’s main scientific paper. It captures the extent to which the skill and task content of a vocational training curriculum is related to recent breakthrough technological innovations, rather than simply assigning technologies to occupations on the basis of occupational titles or industry affiliation.

The measure combines the full texts of vocational training curricula with the text of breakthrough patents. Patent data are drawn from the project’s patent database and include patents classified as technological breakthroughs following Kelly et al. (2021); the baseline measure focuses specifically on digital breakthrough technologies, reflecting the central role of digitalisation in recent technological change. The basic idea is that a training occupation is more exposed to a technology when the skills and tasks described in its curriculum are closely related to the capabilities, processes, or applications described in patents. This approach is appropriate because curricula typically describe what workers do and need to know, rather than naming particular technologies directly. Consequently, the measure captures technologically relevant changes in occupational content even when curriculum texts do not explicitly mention terms such as artificial intelligence, software, automation, or digitalisation.

To construct the measure, Salomons et al. (2025) apply a semantic text-matching approach based on word embeddings. After retaining the substantive nouns and verbs in both curricula and patent texts, each document is represented by a term-frequency-inverse-document-frequency weighted vector of pre-trained word embeddings. Technology exposure

is then based on the cosine similarity between each curriculum and each breakthrough patent, with similarities normalised at the patent level to account for systematic differences in the technical language used across patents. For each curriculum, the measure aggregates the 15 most closely related patents. The resulting count of textually linked breakthrough patents provides a continuous occupation- and curriculum-specific indicator of technology exposure. The measure is constructed separately for all breakthrough patents and for digital breakthrough patents; the latter is the preferred measure in the empirical analyses reported here.

An important feature of the approach is its dynamic nature. Technology exposure is measured using patents emerging in a five-year window 20-25 years before the curriculum year. This timing reflects the fact that major technological advances often affect occupational skill requirements and vocational curricula only with a considerable lag, as technologies diffuse, are adopted by firms, and become embedded in workplace tasks. The measure exhibits substantial variation across training occupations. Exposure is highest in IT and scientific-service occupations, followed by production occupations, and lower in commercial, business-service, and personal-service occupations. Highly exposed curricula include various electronics-technician, industrial-mechanic, plant-mechanic, tool-mechanic, and automation-related occupations, whereas substantially lower exposure is observed in a range of service and traditional production occupations. The validity of the measure is supported by administrative information on reasons for curriculum updates. Among update applications observed since 2011, curricula explicitly revised in response to digitalisation had substantially greater digital patent exposure than other updated curricula, with an average of 382 compared with 178 linked digital patents.

In this report, the technology-exposure measure is used to examine whether technologically affected occupations update their training curricula more frequently and whether workers' labour-market responses to curriculum updates differ by the degree of technological exposure. As with the curriculum data, the full methodological description and validation exercises are reported in Deliverable 2.6; the present report uses the measure as a core input for the analysis of worker resilience to technology shocks.

2.3 Workers' Careers

The worker-level analysis uses the Sample of Integrated Employer–Employee Data (SIEED), provided by the Institute for Employment Research (IAB). SIEED is a 1.5 percent random sample of German establishments linked to the administrative employment records of all workers ever employed in the sampled establishments; it also includes pre-estimated firm

wage-premium measures based on the Abowd–Kramarz–Margolis framework. The data provide longitudinal employment biographies from 1975 to 2018. For each employment spell, they contain information on earnings, occupation, industry, establishment location, and employer, allowing workers to be followed over time as they remain in, or move between, occupations, industries, and firms. The administrative records also identify apprenticeship-training spells, including the training occupation and timing of training completion.

As in the preceding subsections, the linked worker–curriculum dataset and its preparation are described in full in [Salomons et al. \(2025\)](#), the project’s main scientific paper. For the purposes of this report, the data are used to examine whether workers experience changing wages and career mobility after their occupation receives an updated vocational training curriculum.

For the analysis, the data are organized as a worker-level panel around curriculum-update events. Incumbents are defined as vocationally trained workers who were employed full time in the same occupation for at least five consecutive years before that occupation received a curriculum update. This restriction identifies workers with established occupation-specific skills that were acquired before the revised curriculum became available to new trainees. The sample excludes apprentices and workers who are not subject to social-security contributions. Restricting the analysis to full-time, established incumbents also reduces the likelihood that observed changes in wages or mobility simply reflect marginal labour-force attachment or short-term employment fluctuations

Each treated incumbent is observed for five years before and up to five years after the update to the curriculum in the worker’s occupation. The analysis compares these workers with incumbent workers in occupations that did not receive a curriculum update in the same period, enabling the study to distinguish changes associated with the arrival of newly trained workers from general labour-market developments. Because curriculum updates occur at different times across occupations, the data are structured as stacked event-specific panels. Workers and occupations may therefore appear in more than one event window, either as treated workers following an update in their occupation or as controls for another event. Control incumbents are sampled from the same broad occupational group—manufacturing or services—as the treated occupation, and observations are weighted so that events contribute in proportion to their number of treated workers.

Table 1 shows descriptives of occupational incumbents. The final incumbent sample comprises 419 curriculum-update events, with 710,926 unique treated workers and 596,398 unique control workers, although control workers may contribute to multiple event-specific

Table 1: Descriptives of Vocationally Trained Occupational Incumbents

	Mean	SD	Median
Age	41.09	10.01	40
Year of birth	1959	12	1960
Female	0.43	0.49	0.00
Average daily wage (euros)	91.24	50.00	87.84
Annual daily wage growth	0.01	0.31	0.01
Annual days employed	297	129	365
Annual labor earnings (euros)	27,661	20,559	28,082
Firm size	711	3,040	68
Job mobility (year-to-year):			
Occupation	0.12	0.32	0.00
Industry	0.11	0.31	0.00
Firm	0.16	0.36	0.00

SIEED, full sample prior to stacking. $N = 50,554,417$ worker by year observations.

samples. Incumbents are, on average, 41 years old, 43 percent are female, and their average daily wage is approximately EUR 91.

The prepared panel supports the analysis of several dimensions of worker resilience and adjustment. The principal outcomes are daily wages and annual earnings, as well as changes in occupational, industry, and employer affiliation; annual non-employment days can additionally be observed from the administrative employment histories. This design focuses on whether the introduction of a revised curriculum—and the subsequent entry of workers trained under that new curriculum—changes the labour-market position of established workers with older skills. It therefore provides the empirical basis for assessing whether and for whom vocational skills become obsolete as technology-induced skill requirements evolve.

3 Technology Exposure and Curriculum Updates

This section examines how technological change is reflected in the evolution of vocational training curricula. Drawing on the evidence reported in [Salomons et al. \(2025\)](#), the project’s main scientific paper, the results show that occupations more exposed to technological change update their curricula more frequently and that these updates systematically shift training content toward skills that are more complementary to new technologies.

The first key result (Table 2) is that technology exposure significantly increases the like-

Table 2: Curriculum Updates and Digital Technology Exposure

	(1)	(2)	(3)	(4)
<i>A. Unweighted</i>				
Digital Tech Exposure	0.44*** (0.09)	0.47*** (0.10)	0.51*** (0.10)	0.49*** (0.10)
N	10,729			
<i>B. Weighted by initial employment share</i>				
Digital Tech Exposure	0.84*** (0.17)	0.79*** (0.17)	0.79*** (0.16)	0.82*** (0.15)
N	10,729			
Initial Curriculum Year	X	X	X	X
Year	X	X	X	X
Broad Occ		X	X	X
Broad Occ $\times$ Year			X	X
Initial Empl. Share				X

Dependent variable: Dummy for curriculum update. Linear probability models, coefficients multiplied by 100. Initial curriculum year fixed effects in five year bins. Standard errors clustered by 5 digit occupation. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

likelihood of curriculum reform. The annual probability that a curriculum is updated rises with the occupation’s digital technology exposure, measured through links between curriculum texts and breakthrough patents. A doubling of exposure increases the annual curriculum-update probability by about 0.44 to 0.51 percentage points in the unweighted models and by about 0.79 to 0.84 percentage points in the employment-weighted models.

These are economically meaningful effects. A one-standard-deviation increase in digital technology exposure raises the annual update probability by around 1.26 percentage points in the unweighted data, which corresponds to a 33 percent increase relative to the baseline update rate of 3.8 percent; in the weighted models, the increase is 2.14 percentage points, or 42 percent relative to the weighted baseline of 5.1 percent.

The timing results reinforce this interpretation. Table 2 shows that technology exposure not only raises the probability of curriculum updating, but also accelerates the arrival of updates among occupations that are eventually revised. A one-standard-deviation increase in exposure reduces the time to update by about 1.6 years, corresponding to roughly 11 percent of the average update interval of 15.3 years.

This pattern is important because it shows that curriculum reform is not random or merely administrative. Instead, the training system appears to respond systematically to occupations’ technological environment, which supports the view that vocational curricula serve as an institutional mechanism through which skill supply adapts to changing labour-market demands.

The content of those updates is equally important. The results in Figure 1 show that curriculum updates shift training content toward less routine-intensive tasks. Measured using text-based links between curricula and task descriptions, non-routine task intensity rises over time across updated curricula, and the increase is especially strong in occupations with high technology exposure. Specifically, non-routine task intensity increases by 0.041 standard deviations per year on average among updated curricula, which cumulates to 1.8 standard deviations over 1976–2021. For highly technology-exposed occupations, the increase is larger—0.057 standard deviations annually, or about 2.6 standard deviations cumulatively—compared with 0.022 annually, or about 1.0 standard deviation cumulatively, for less exposed occupations.

These findings suggest that curriculum reform does not simply refresh existing content, but systematically reorients training toward tasks that are harder to automate and more complementary to digital technologies. This is exactly what one would expect if technological change shifts occupational demand away from routine tasks and toward forms of work

Figure 1: Changes in Non-Routine Task Intensity in Updated Curricula, 1976–2021

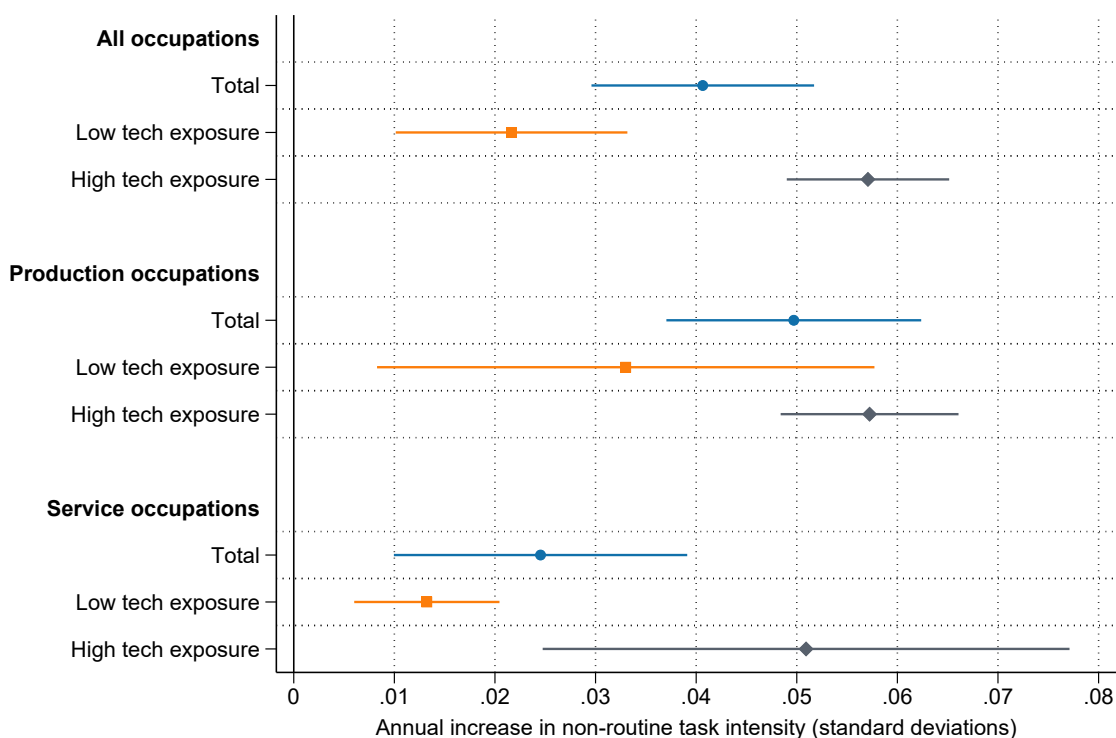


Figure reports coefficients on a linear timetrend, from a regression of non-routine task content in vocational training curricula, for the subsample of curricula with updates over 1976–2021. Horizontal lines reflect 95% confidence intervals. High tech (low tech) defined as curricula with an initial digital technology exposure above (at or below) the median across all occupations.

requiring greater problem-solving, interpersonal interaction, and adaptability. Results by [Salomons et al. \(2025, Appendix F\)](#) further indicate that these shifts occur mainly through the addition of new skills rather than the mere removal of old ones. On average, a curriculum update removes nearly 200 distinct words and adds around 170 new words, amounting to about 35 to 45 percent of the curriculum’s distinct vocabulary. The main paper shows that these newly added terms play a particularly important role in making curricula more non-routine-intensive.

This distinction matters: If updated curricula primarily added new expertise, then the training system is not only pruning obsolete content but actively building the capabilities needed to cope with technological change. That interpretation fits closely with the project’s focus on workers’ resilience, because it implies that resilience depends on whether training provides access to newly relevant skill combinations rather than only preserving legacy occupational knowledge.

The skill composition of these additions points in a clear direction. [Figure 2](#) shows that curriculum reforms shift emphasis toward social and communication skills, digital skills, thinking skills, and management-related skills, while emphasis declines in physical and manual skills, manufacturing and engineering skills, and some basic skills. Social communication skills show the strongest positive shift, with digital and thinking skills also becoming more prominent. The technologies studied here appear to raise demand not only for technical digital competence, but also for non-routine analytical and interpersonal capabilities. As a result, curriculum adaptation seems to strengthen precisely those dimensions of training that are likely to help workers remain productive when occupational tasks change in response to technological advances.

A further result from the main paper underscores the quantitative relevance of this margin of adjustment. Curriculum updates account for around two-thirds of the aggregate increase in the non-routine task content of vocational skills supply between 1976 and 2021. More precisely, overall non-routine task intensity in vocational skills supply rises by 0.95 standard deviations over this period, of which 0.63 standard deviations—66 percent—come from within-occupation curriculum change rather than from shifts in the occupational composition of trainees. This is a central finding because it shows that adaptation within occupations is more important than changes in the distribution of workers across occupations. Put differently, technological change is not accommodated only because workers move into different jobs, but also because the content of training within existing occupations evolves. That makes curriculum reform a central mechanism of resilience to technology shocks.

Figure 2: Distribution of Newly Added Words Relative to Removed Words Across Skill Categories

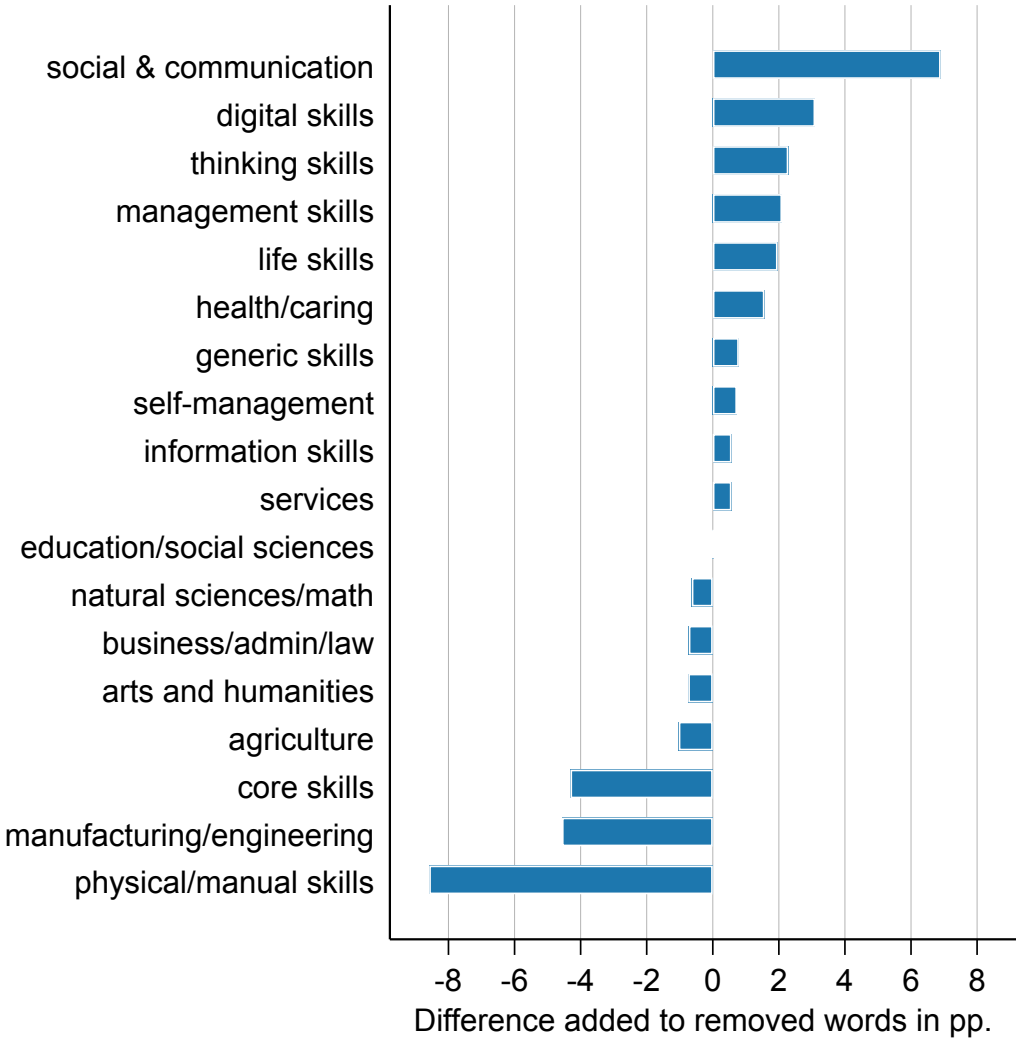


Figure presents the distribution of newly added words relative to the distribution of removed words in curriculum updates across ESCO skills categories.

Salomons et al. (2025) provide supporting evidence that these content changes are meaningful for workers. Using survey data, they show that workers trained under more recently updated curricula report that their training is more useful for their current jobs. While this report does not focus on those survey results in detail, they strengthen the interpretation that the observed shifts in curriculum content capture genuine changes in economically relevant expertise rather than merely changes in wording or regulatory format.

Taken together, the results in this section show a coherent pattern. Technology exposure increases the likelihood and speed of curriculum updates; these updates make training less routine-intensive; and they do so especially by introducing new social and digital skills. In the context of this report, these findings establish the first link in the broader causal chain: technological change alters the skill requirements of occupations, and the vocational training system responds by updating the content of training.

That conclusion provides the foundation for the subsequent analysis of worker outcomes. If technology-driven curriculum change systematically reshapes the skill bundle taught to new cohorts, the next question is whether workers trained under older curricula are more vulnerable when occupations are updated, and whether certain pre-existing skills make them more resilient than others.

4 Curriculum Updates and Workers' Careers

4.1 Empirical Strategy

The empirical strategy of this report draws directly on the empirical framework developed in Salomons et al. (2025), the accompanying scientific paper. We study the effects of curriculum-update events on incumbent workers. The core idea is that a curriculum update marks the arrival of a new cohort of workers trained with revised and potentially more technologically relevant skills, while incumbent workers in the same occupation continue to hold the older skill bundle. This creates a natural setting to examine whether technological change and curriculum adaptation alter the labour-market position of established workers.

To analyse these effects, Salomons et al. (2025) construct a worker-level panel of occupational incumbents and estimates an event-study difference-in-differences model around the year of the curriculum update. The sample is restricted to vocationally trained workers who were employed full time in the same occupation for at least five consecutive years before the update, so that the analysis focuses on established incumbents whose skills predate the

reform. Outcomes are then observed from five years before to five years after the update year:

$$Y_{ijte} = \sum_{\substack{\tau=-5 \\ \tau \neq -1}}^5 \beta_{\tau} \text{Update}_{je} \times I_{\tau e} + \delta_{ie} + \gamma_{te} + \varepsilon_{ijte} , \quad (1)$$

The empirical model compares incumbent workers i in occupations j that experience a curriculum update with incumbent workers in occupations that do not update in the same period. Individual fixed effects absorb time-invariant worker heterogeneity, while relative-time indicators trace the dynamic adjustment of wages, earnings, and mobility before and after the update. The specification is estimated in stacked event time t , with controls interacted by event e and standard errors clustered at the occupation-by-event level.

This approach directly links the technology-exposure analysis to worker outcomes. Technology exposure helps explain which occupations update their curricula, while the incumbent-worker event study examines whether those update events are followed by wage losses or increased mobility among workers trained under older curricula.¹ In this way, the empirical strategy connects technological change, curriculum adaptation, and workers' resilience to technology shocks in one integrated framework.

4.2 Empirical Results

We now examine how curriculum updates affect incumbent workers' labour-market outcomes. The main finding is that curriculum updates generate uneven effects across incumbent workers. Figures 3 and 4 indicate that the arrival of newly trained workers with updated skill bundles appears to reduce the relative value of older skill vintages, particularly for older incumbents, while younger incumbents adjust more through mobility than through wage declines. The wage results in Figure 3 show little evidence of adverse effects for younger incumbents aged 30 to 39. By contrast, wage losses become visible and economically meaningful for older workers: five years after a curriculum update, daily wages are about 1.9 percent lower for incumbents aged 40 to 49 and about 3.3 percent lower for those aged 50 to 59, relative to comparable incumbents in occupations without such updates. These pat-

¹Technology exposure might also directly affect wages. In [Salomons et al. \(2025\)](#), we show that results are robust to controlling for the exposure of the initial curriculum to new technologies.

terns are the clearest evidence that curriculum change can render existing occupational skills partly obsolete.

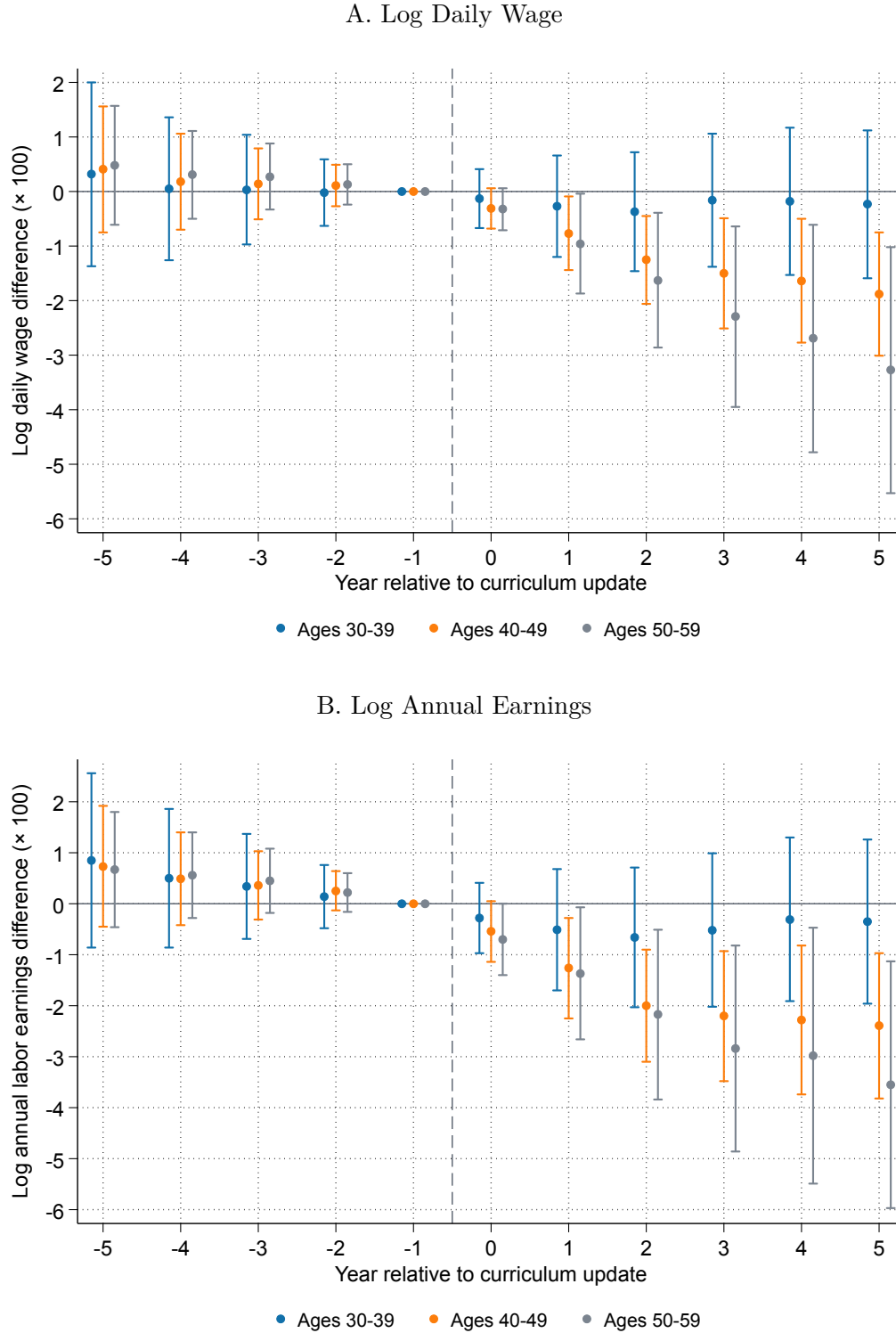
The same age gradient appears in annual earnings, which suggests that the wage losses are not driven mainly by falling employment days. Instead, the results indicate a decline in the market value of incumbent workers' existing expertise once their occupation begins to absorb a new cohort trained under the revised curriculum. This is consistent with the interpretation in the main paper that curriculum updates create new, more relevant expertise, which in turn lowers the relative price of older expertise within the same occupation.

The mobility results in Figure 4 help clarify how workers adjust to this pressure. Younger incumbents do not experience comparable wage losses, but they become more likely to switch occupation, industry, and employer after a curriculum update. The interpretation is that younger workers retain greater adaptability: rather than staying put and absorbing wage declines, they respond to changing skill demands by moving to different jobs and career paths. Older incumbents, by contrast, appear less able to rely on this margin of adjustment. Their weaker mobility response means that a larger share of the adjustment takes place through declining wages rather than through occupational reallocation. In the context of this report, this is a central result: resilience to technology-related skill change depends not only on what workers originally learned in training, but also on whether they can subsequently adapt through retraining, mobility, or both.

Figure 5 also shows that these wage losses partly reflect sorting into lower-paying firms. This is the mirror image of the result for newly trained workers under updated curricula, who are more likely to sort into higher-paying firms (see SkilMeeT Deliverable D 5.6). At the same time, wage losses remain visible even within firms, indicating that the incumbent penalty is not only about where workers are employed, but also about the changing value of their skills within the employment relationship itself. An important part of the interpretation is that firms do not seem to offset these effects through strong retraining responses for incumbent workers. [Salomons et al. \(2025\)](#), see Appendix F) finds only weak evidence of additional formal employer-provided training after curriculum updates, and this response is concentrated mainly in firms that themselves train apprentices in the updated occupation. For the broader set of incumbent workers, there is little sign that post-update retraining is sufficient to neutralise the wage effects.

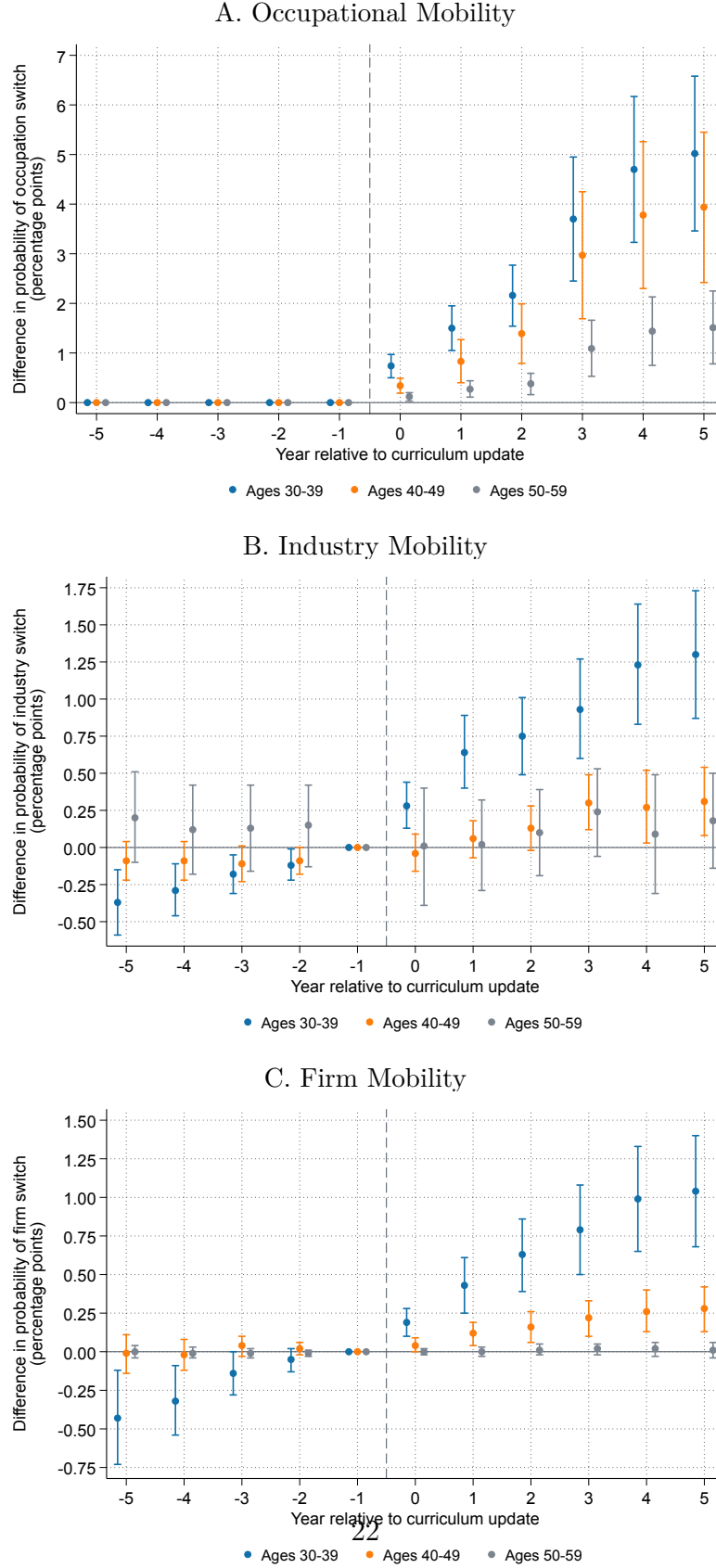
These findings fit closely with the overall storyline of the report. The previous section showed that technology exposure induces curriculum updates and pushes training content toward more non-routine, digital, social, and problem-solving skills. The present results

Figure 3: Wage and Earnings Impacts of Curriculum Updates for Occupational Incumbents



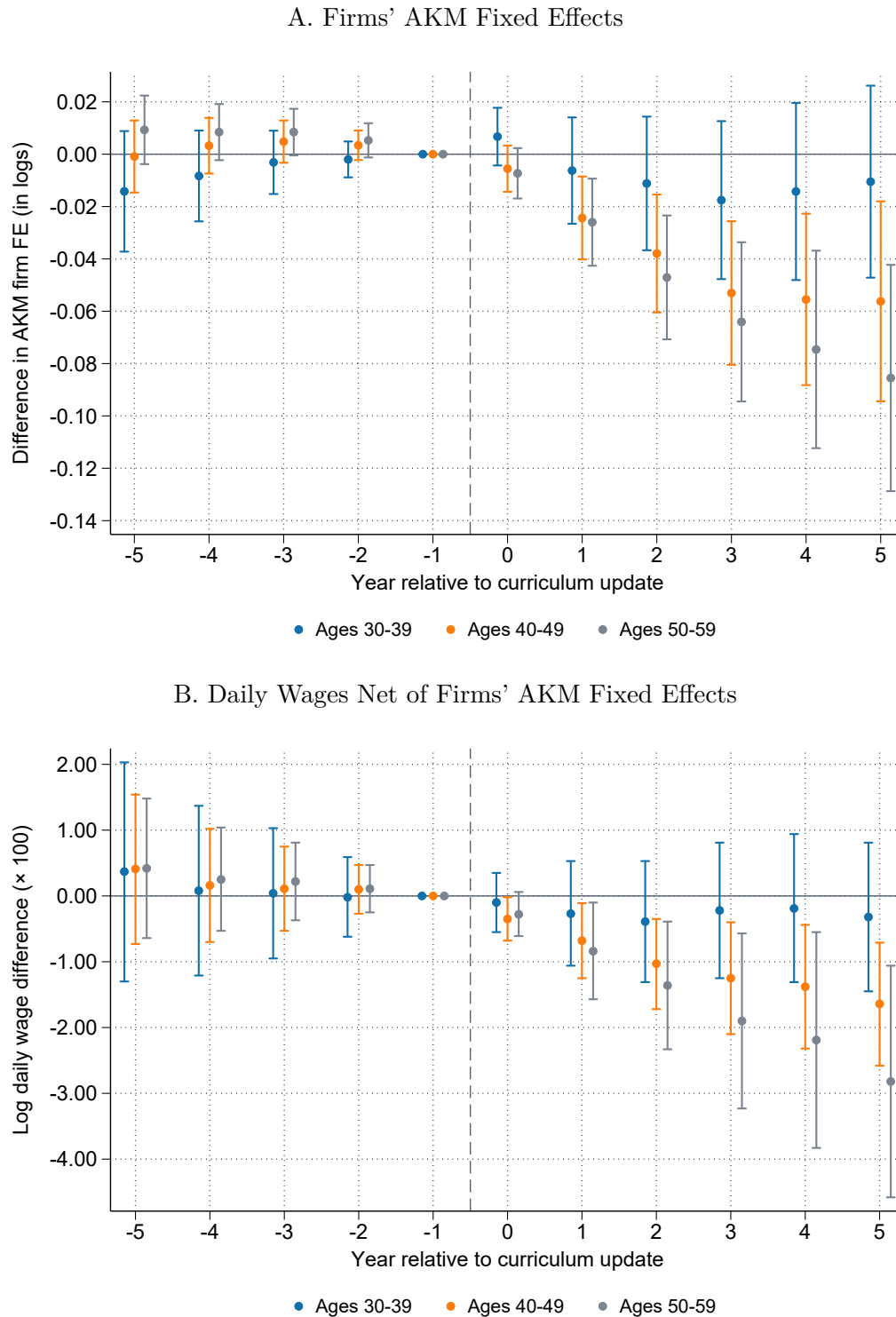
Stacked difference-in-differences estimates of equation (1), and 95% confidence intervals. Age measured in $t = 0$. Based on 419 curriculum update events for both panels. $N_{30-39} = 6,664,012$, $N_{40-49} = 7,504,989$, $N_{50-59} = 4,860,341$ for both panels. Panel A: A Wald test of the joint significance of the coefficients for cohorts < -1 yields $p = 0.73$, $p = 0.83$, and $p = 0.83$ for ages 30–39, 40–49, and 50–59, respectively. Panel B: A Wald test of the joint significance of the coefficients for cohorts < -1 yields $p = 0.45$, $p = 0.37$, and $p = 0.95$ for ages 30–39, 40–49, and 50–59, respectively.

Figure 4: Job Mobility Impacts of Curriculum Updates for Occupational Incumbents



Stacked difference-in-differences estimates of equation (1), and 95% confidence intervals. Age measured in $t = 0$. Based on 419 curriculum update events for all panels. Panel A: $N_{30-39} = 3,911,246$, $N_{40-49} = 4,428,832$, $N_{50-59} = 2,665,873$; Panels B and C: $N_{30-39} = 6,529,453$, $N_{40-49} = 7,377,891$, $N_{50-59} = 4,725,374$. Panel A observations are lower because mobility is only estimated over the post-period (it is constant by construction for $t < 0$).

Figure 5: Impacts of Curriculum Updates on Incumbent Wages: The Role of Firms



Stacked difference-in-differences estimates of equation (1), and 95% confidence intervals. Age measured in $t = 0$. Based on 419 curriculum update events for both panels. Panel A: $N_{30-39} = 6,494,318$, $N_{40-49} = 7,331,238$, $N_{50-59} = 4,686,166$. Panel B: $N_{30-39} = 6,491,187$, $N_{40-49} = 7,329,124$, $N_{50-59} = 4,682,662$

show the worker-side consequence of that process: when the training system adapts to technological change, not all workers benefit equally, and workers trained under older curricula may face a loss in relative labour-market position.

This is why curriculum reform should be seen as both an adaptation mechanism and a distributional mechanism. It helps occupations renew their skill base in response to technological change, but it also redistributes opportunities within occupations between workers holding newer and older skill bundles.

For the purposes of this report, these results motivate the next step of the analysis. If curriculum updates are associated with wage losses for some incumbent workers but not others, then the natural question is whether resilience depends on the specific skill composition. This is precisely the issue taken up in the next subsection on the role of key skills.

4.3 The Role of Key Skills

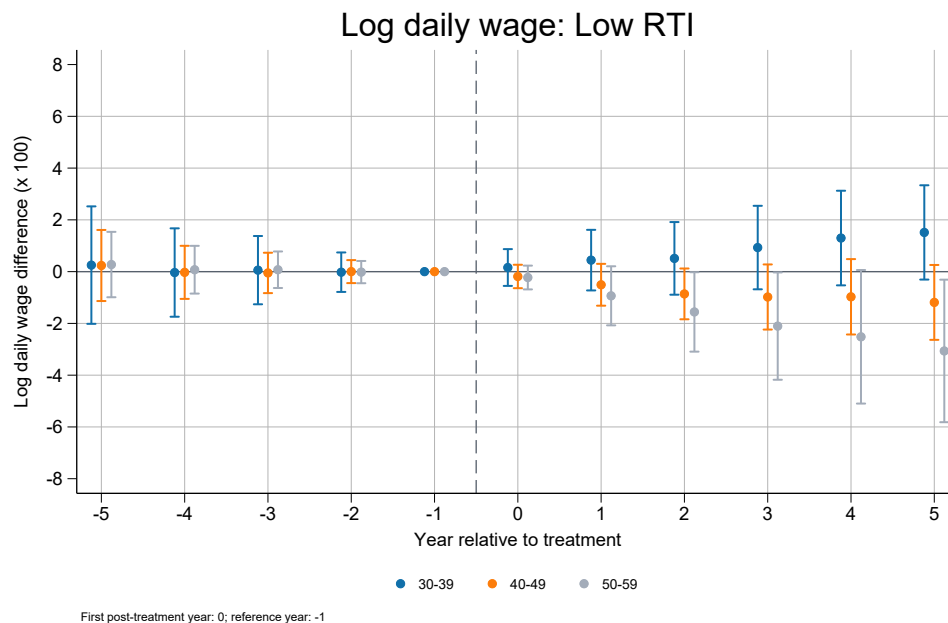
The average effects in the previous subsection show that curriculum updates can reduce the relative labour-market position of workers trained under earlier curriculum vintages, particularly among older incumbents. The central question for Task 5.6, however, is whether this vulnerability depends on the skill content of the pre-update curriculum. If some skill bundles are more robust to changing technological requirements than others, curriculum design may shape resilience before a technology shock or curriculum update occurs.

We therefore extend the incumbent-worker event-study analysis by splitting curriculum-update events according to the skill intensity of the pre-update curriculum. Specifically, we distinguish occupations whose pre-update training curricula lie above or below the median in routine-task intensity, digital-skill intensity, and social-skill intensity. The estimates compare the post-update wage trajectories of established incumbents in these different types of training occupations with those of comparable workers in occupations not updating in the same period. This approach does not identify the causal effect of a single isolated skill. Rather, it tests whether the broader skill bundle embedded in initial vocational training is systematically associated with workers' ability to withstand the arrival of a newly trained cohort holding updated occupational expertise.

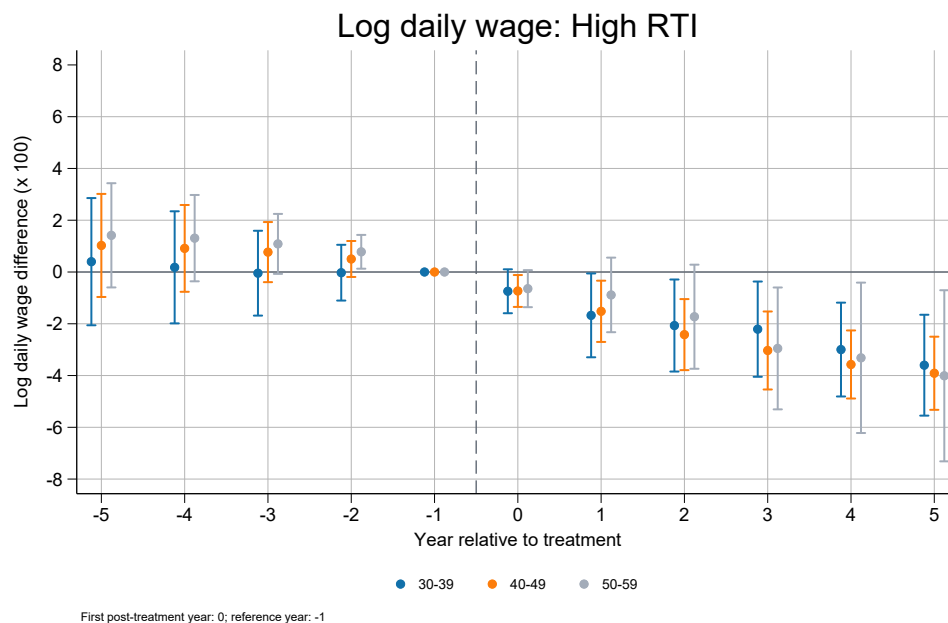
Figure 6 presents the results by routine-task intensity. Panel A shows the effects for occupations with low routine-task intensity in the pre-update curriculum, while Panel B reports the corresponding estimates for occupations with high routine-task intensity. The contrast between the two panels is pronounced. Where the original curriculum was relatively

Figure 6: Impacts of Curriculum Updates on Incumbent Wages: The role of RTI

A. Low RTI



B. High RTI



Stacked difference-in-differences estimates of equation (1), and 95% confidence intervals. Age measured in $t = 0$. Panel A: low RTI in the pre-update curriculum; Panel B: high RTI in the pre-update curriculum.

non-routine-intensive, younger incumbent workers aged 30 to 39 experience no visible wage penalty following a curriculum update and, at some post-update horizons, even exhibit positive point estimates. Workers aged 40 to 49 and 50 to 59 show some wage declines, but these losses are smaller and less systematic than in the high-routine group.

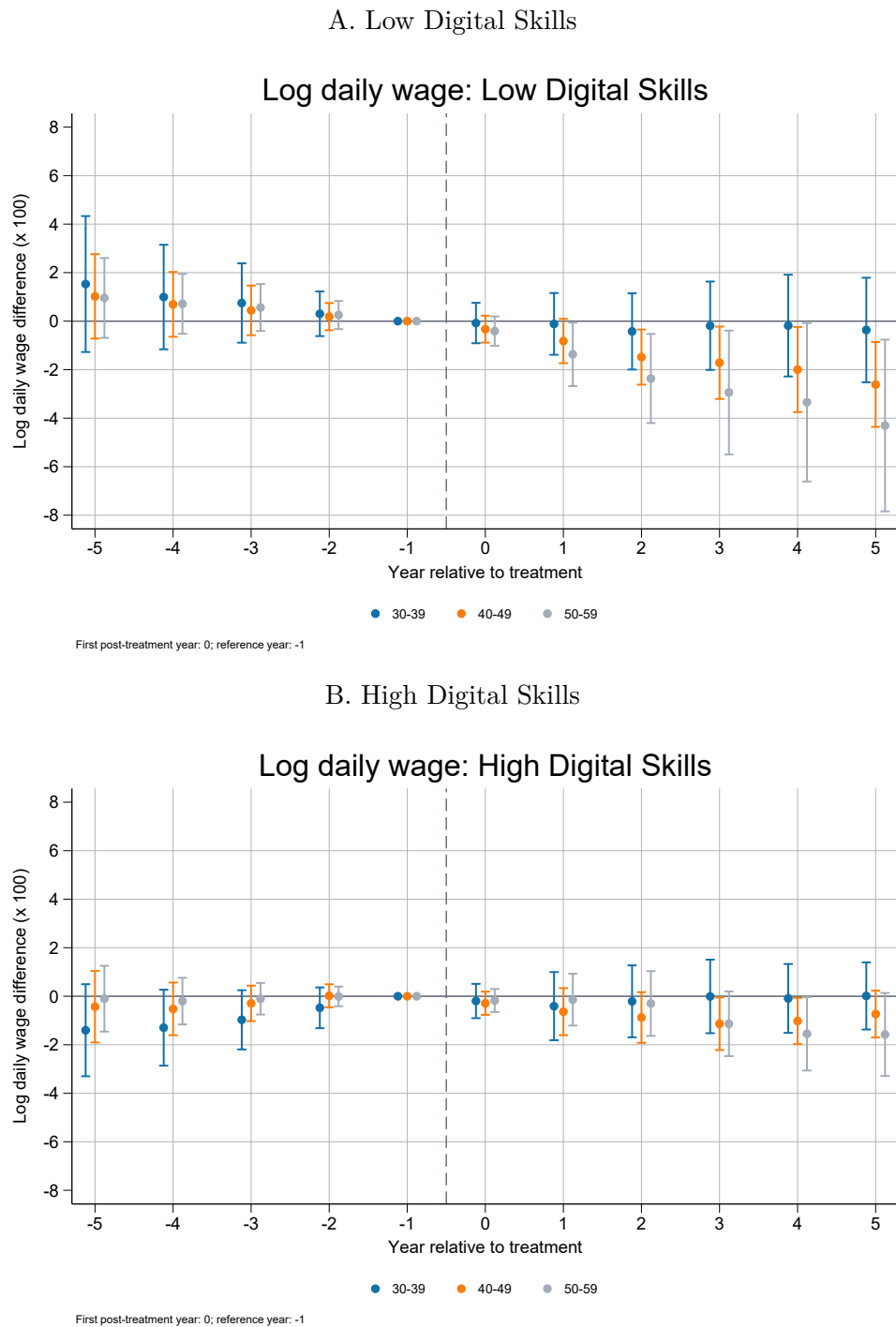
The pattern is markedly different for workers in occupations whose pre-update curricula contained a relatively high share of routine tasks. In these occupations, curriculum updates are followed by substantial relative wage losses across all age groups. The negative effects become visible soon after the update and persist through the post-update period, across all age groups. The estimates therefore suggest that workers holding skill bundles centred more heavily on codifiable, repetitive, or rule-based tasks are less protected when occupational training requirements are renewed.

This finding is consistent with the broader evidence in Sections 3 and 4.2. Curriculum updates induced by technological change tend to move training content away from routine tasks and toward more non-routine forms of expertise. When a new cohort enters the labour market with this revised skill bundle, workers trained under highly routine-intensive earlier curricula appear to face a sharper decline in the relative market value of their existing skills. Conversely, a more non-routine initial training profile seems to provide a degree of protection against this form of skill obsolescence. In this sense, non-routine task content appears to be an important component of resilience to technology-related changes in occupational expertise.

Figure 7 examines the role of digital skills. Here, too, the main contrast is between occupations in which the pre-update curriculum contained relatively little digital content and those in which it already contained an above-median level of digital skills. Among workers from low-digital-skill curricula, older incumbents experience clear relative wage losses after an update. The negative post-update coefficients are particularly apparent for workers aged 40 to 49 and 50 to 59, indicating that older workers whose occupation provided limited digital expertise are vulnerable when new cohorts enter with updated skills.

Younger workers from low-digital-skill curricula do not display the same wage decline. This result is in line with the mobility evidence in Section 4.2: younger incumbents may be better able to adjust by changing occupations, industries, or firms, and may also find it easier to acquire newly relevant skills after entering the labour market. The relative absence of a wage penalty for younger workers should therefore not be interpreted as showing that low digital-skill content is unimportant. Rather, it suggests that younger workers can use adjustment margins that are less accessible to workers further into their careers.

Figure 7: Impacts of Curriculum Updates on Incumbent Wages: The role of Digital Skills



Stacked difference-in-differences estimates of equation (1), and 95% confidence intervals. Age measured in $t = 0$. Panel A: low digital skills in the pre-update curriculum; Panel B: high digital skills in the pre-update curriculum.

The results differ substantially for occupations whose pre-update curricula already contained relatively high digital-skill intensity. For these occupations, even older incumbent workers show little evidence of systematic wage losses after a curriculum update. The point estimates are generally closer to zero and are substantially less negative than for workers trained in low-digital-skill curricula. This pattern suggests that digital content embedded in vocational training may help workers remain productive and valuable when occupational requirements are revised in response to technological change.

This result is especially relevant given the nature of the curriculum reforms documented in Section 3. Digitally exposed occupations update more frequently, and updates increase the digital content of vocational training. The findings in Figure 7 indicate that digital skills may not merely improve workers’ access to technology-intensive jobs at labour-market entry. They may also reduce the subsequent depreciation of occupational human capital when technologies diffuse and new cohorts arrive with more recently updated training. Digital skills thus appear to function as a resilience-relevant component of vocational education, particularly for workers who have fewer opportunities to respond through later-career mobility.

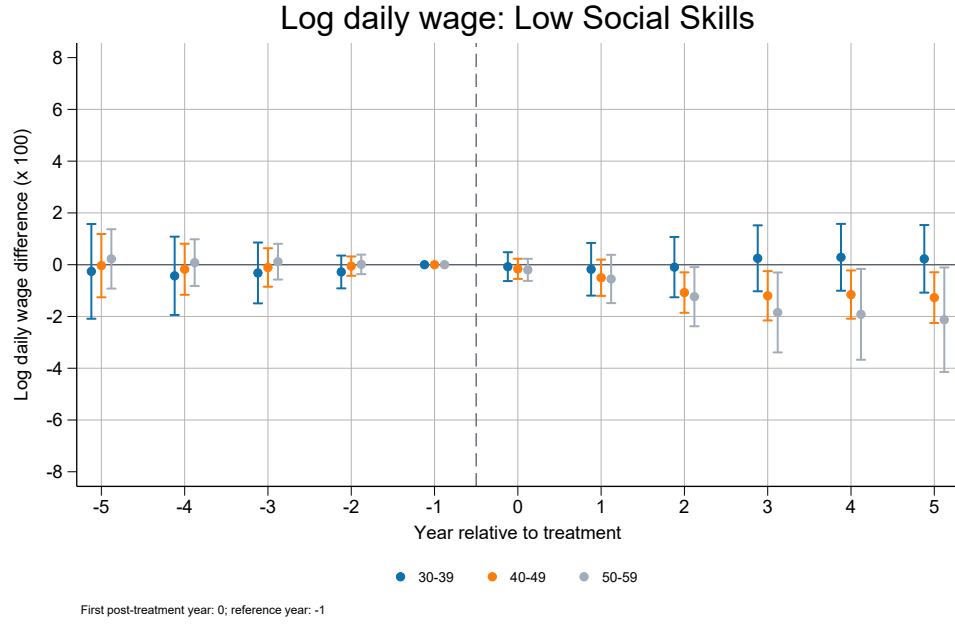
Figure 8 reports the corresponding analysis for social and communication skills. The results provide weaker and less precise evidence than those for routine-task intensity and digital skills. Among workers trained in curricula with relatively low social-skill intensity, younger workers show little indication of wage losses after a curriculum update, whereas older workers display some negative post-update point estimates. However, the confidence intervals are comparatively wide, limiting the precision with which these effects can be distinguished from zero.

For workers from curricula with relatively high social-skill intensity, the estimates are also imprecise. Although some point estimates may be consistent with a protective role for social and communication skills, the standard errors are too large to support firm conclusions about whether such skills systematically reduce wage losses following curriculum updates. This lack of precision may reflect the fact that social skills are broadly distributed across vocational occupations, are more difficult to measure from curriculum text than explicitly technical content, or operate through adjustment channels that are not fully captured by wage effects within the five-year event window.

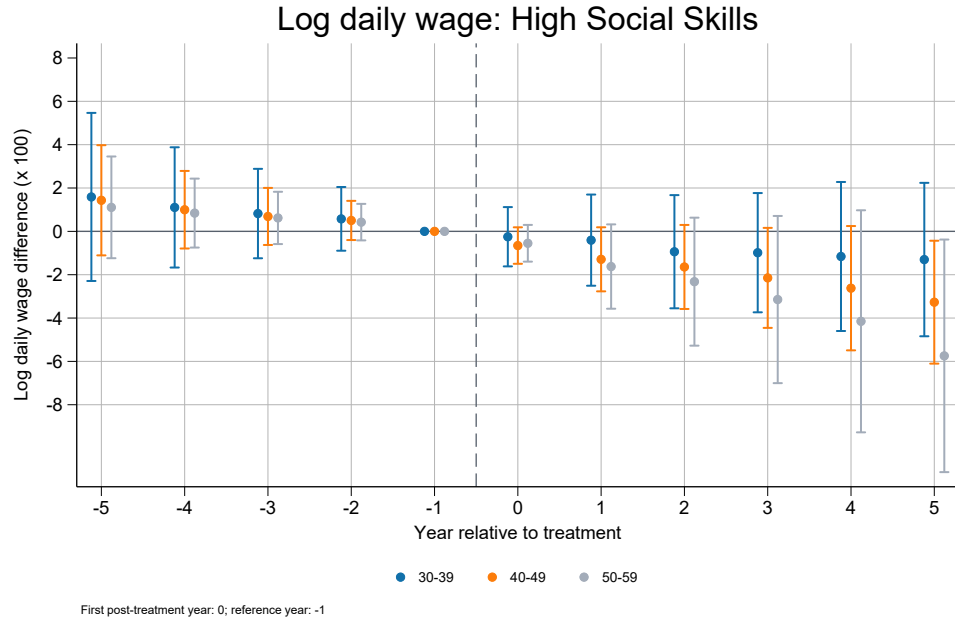
The absence of robust evidence for social skills in this analysis should not be interpreted as evidence that these skills are unimportant in technologically changing labour markets. Section 3 showed that social and communication skills are among the categories most strongly added during curriculum updates, and the wider literature emphasises their complementar-

Figure 8: Impacts of Curriculum Updates on Incumbent Wages: The role of Social Skills

A. Low Social Skills



B. High Social Skills



Stacked difference-in-differences estimates of equation (1), and 95% confidence intervals. Age measured in $t = 0$. Panel A: low digital skills in the pre-update curriculum; Panel B: high digital skills in the pre-update curriculum.

ity with technological change. Instead, the present results indicate that, within the available incumbent-worker design, the clearest empirical evidence for resilience is found for lower routine-task intensity and stronger digital-skill content in workers’ original training curricula. The role of social skills remains more uncertain and requires further investigation with more precise measures and, potentially, a longer horizon over which to observe occupational adjustment.

A potential caveat for these analysis could be correlation between skills and technology exposure, as well as the role of skills for the time it takes for a curriculum to receive the next update. We therefore study the relationship between technology exposure and skills in Appendix Figure A2 for technology exposure and Appendix Figure A3 for curriculum lifespan. Neither routine task intensity, nor digital skills show strong associations with technology exposure or curriculum lifespan (i.e. time between introduction and end of a curriculum). Neither are curricula with many routine tasks and few digital skills more exposed to new technologies, nor are they updated more often (have shorter lifespans). Only social skills show clearer relationships: Curricula with many social skills have lower exposure to new technologies, and have longer lifespans. This might explain why heterogeneity of the effects of curricula updates by social skill intensity is inconclusive, as these interrelate with technology exposure and lifespan (thus, age of curriculum at the time it receives the update).

Taken together, the heterogeneity results refine the average findings from Section 4.2. Curriculum updates do not affect all incumbents equally because workers enter the labour market with different initial skill bundles. Workers trained in relatively routine-intensive curricula are more exposed to wage losses when occupational expertise is renewed, whereas workers trained in curricula with greater non-routine content appear better protected. Similarly, low digital-skill intensity is associated with wage losses among older incumbents, while workers from digitally stronger curricula experience little comparable decline. These patterns support the interpretation that vocational education can shape resilience *ex ante*: curriculum content affects not only workers’ initial placement in the labour market, but also their capacity to retain the value of their skills when technologies and occupational requirements change.

The results also highlight an important distributional implication. Younger workers may often avoid wage losses by acquiring new skills or moving across employers, industries, and occupations. Older workers have fewer such adjustment opportunities and appear more dependent on the resilience of the skills embedded in their original training. Designing vocational curricula around non-routine and digitally relevant skill bundles may therefore

help reduce the risk that workers' expertise becomes obsolete over the course of their careers. At the same time, the results should be interpreted as evidence on the resilience associated with broader curriculum-level skill bundles, rather than as evidence that any single skill category alone determines workers' adjustment outcomes.

5 Conclusions

Technological change alters the skills required within occupations, creating a central challenge for vocational education systems: training must prepare new entrants for changing work while also limiting the risk that the skills held by existing workers lose value. This report has examined that challenge using linked data on German dual-system vocational training curricula, patent-based measures of digital technology exposure, and administrative employer–employee records. The analysis provides evidence that curriculum reform is an important institutional mechanism through which vocational training responds to technology-driven changes in labour demand, but also that this response has uneven consequences for workers trained before the update.

The first main finding is that technological change is systematically related to curriculum renewal. Occupations with greater exposure to digital breakthrough technologies update their vocational curricula more frequently and more rapidly. These reforms are not merely administrative revisions. They shift training content away from routine tasks and toward non-routine, digital and social skills. Curriculum updates account for a substantial share of the long-run increase in the non-routine content of German vocational training. This indicates that adaptation to technological change occurs not only through workers moving between occupations, but also through changes in the skill bundles supplied within continuing occupations.

The second main finding is that curriculum updates are associated with a deterioration in the relative labour-market position of some established workers. When newly trained workers enter the labour market with revised occupational expertise, incumbents trained before the update can face declining returns to their existing skills. The wage effects are concentrated among workers later in their careers. Five years after a curriculum update, daily wages are around 1.9 percent lower for incumbents aged 40 to 49 and around 3.3 percent lower for those aged 50 to 59, relative to comparable workers in occupations without an update. Younger incumbents experience little comparable wage decline, but respond through higher occupational, industry, and employer mobility. The evidence therefore suggests that the costs

of occupational skill renewal are partly borne by workers whose initial training predates the revised curriculum, and particularly by those with fewer opportunities to adapt through later-career mobility.

The third and central finding for Task 5.6 is that workers' resilience depends on the skill content of their original vocational training. Workers in occupations with relatively routine-intensive pre-update curricula experience the largest wage losses after a curriculum update. This pattern is visible across age groups, although the effects remain most pronounced among older incumbents. By contrast, workers in curricula with lower routine-task intensity are substantially more protected, with younger workers showing little evidence of post-update wage losses and older workers facing smaller and less systematic declines. These results are consistent with the interpretation that non-routine task content makes workers' skills less vulnerable when technological change alters the expertise required within their occupation.

Digital skills also emerge as an important dimension of resilience. Older workers in occupations with limited digital-skill content experience clear wage losses when their occupation's curriculum is renewed. In occupations where the pre-update curriculum already included relatively strong digital content, however, even older incumbents show little evidence of comparable wage declines. This result suggests that digital vocational skills are valuable not only for obtaining technology-related work at labour-market entry, but also for preserving the value of workers' occupational human capital as technologies diffuse and training requirements evolve. Younger workers from low-digital-skill curricula appear better able to avoid wage losses, potentially because they can more readily acquire new skills or move to alternative employers, industries, and occupations. Nevertheless, the stronger vulnerability of older workers indicates that insufficient digital preparation can become particularly consequential over longer careers.

The results for social and communication skills are less conclusive. Curriculum updates tend to add social and communication content, and these skills remain conceptually important because they may complement technology and facilitate adjustment to changing workplace organisation. However, the present estimates are too imprecise to establish a robust protective effect of social-skill intensity in the pre-update curriculum. This should not be read as evidence that social skills do not matter. Rather, it indicates that their role cannot be identified with the same confidence as the roles of routine-task intensity and digital-skill content in the available incumbent-worker analysis. Social skills may operate through channels that are not fully reflected in short- to medium-run wage effects, such as job quality, task reorganisation, access to training, or longer-run career mobility.

Taken together, the findings imply that curriculum reform is both an adaptation mechanism and a distributional mechanism. Updating curricula helps occupations adjust their skill supply to technological change, but it can also sharpen the contrast between workers holding newer and older skill vintages. The relevant policy question is therefore not whether curricula should be updated—timely updating is necessary—but how their content can be designed to provide workers with skills that retain value as work evolves. The evidence in this report points especially to the value of reducing excessive reliance on routine task content and embedding digital capabilities more broadly in vocational education. Such content may make workers less susceptible to skill obsolescence and reduce the wage costs associated with occupational renewal.

These findings have implications for both initial vocational education and lifelong learning. First, curriculum design should not treat digital competence as relevant only for specialised information-technology occupations. As digital technologies increasingly affect production, administration, services, and maintenance work, digitally relevant skills may need to be incorporated across a broad range of training occupations. Second, maintaining a non-routine orientation in training—through analytical, problem-solving, adaptive, and judgement-intensive tasks—may improve the durability of vocational skills even when the specific technologies used at work change. Third, the pronounced vulnerability of older incumbents points to the need for more effective mechanisms to update skills after labour-market entry. The evidence presented here and in the accompanying scientific paper suggests that formal employer-provided retraining rises only weakly after curriculum updates and is concentrated among firms that train apprentices in the updated occupation. Policies that facilitate continuing training for workers in non-training firms may therefore be especially important.

The report also points to several directions for further research. A first priority is to examine more directly whether particular forms of post-update retraining can offset wage losses for incumbents trained under older curricula. A second is to study whether the role of social and communication skills becomes clearer when resilience is measured over a longer horizon or through outcomes other than wages, including employment stability, occupational transitions, training participation, and job quality. A third is to investigate how the timing and content of curriculum updates interact with firm-level technology adoption, collective bargaining institutions, and regional labour-market conditions. More broadly, future work could distinguish more finely between types of digital skills, including basic digital literacy, the use of digital tools, programming and systems-related capabilities, and the ability to

work effectively alongside automated or AI-enabled systems.

Overall, the evidence supports a forward-looking view of vocational education. Vocational training is not only a mechanism for allocating workers to their first jobs; it also determines the durability and adaptability of the skills workers carry through their careers. When curricula are updated in response to technological change, workers trained under older skill standards may bear substantial adjustment costs. Training systems can reduce those costs ex ante by embedding skill bundles that are less routine-bound and more digitally capable, while labour-market and training policies can reduce them ex post by ensuring that incumbent workers—especially those later in their careers—have meaningful opportunities to renew their expertise.

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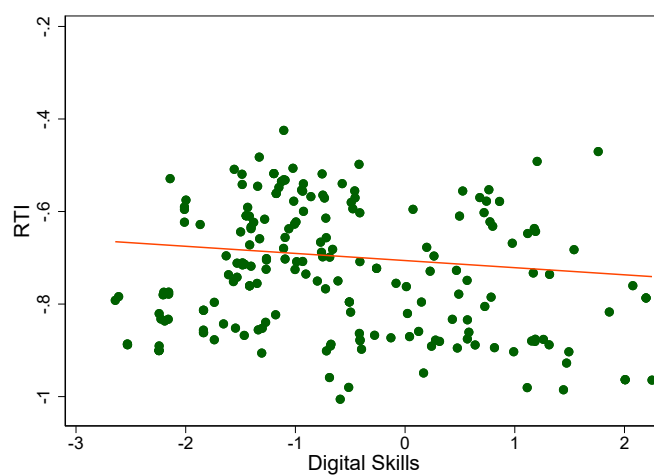
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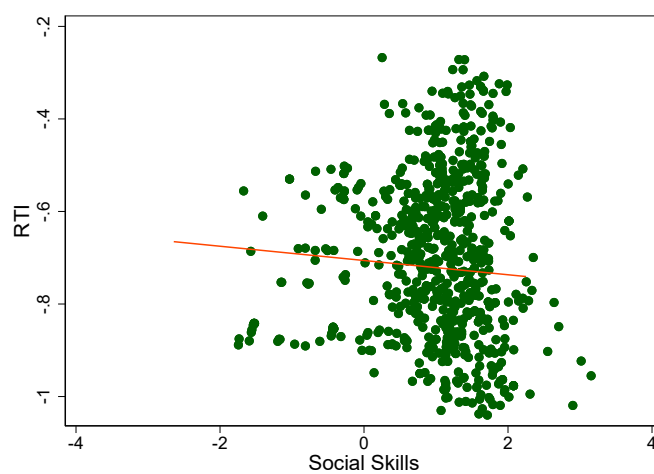
A Additional Figures and Tables

Figure A1: Relationships between Key Skills

A. RTI versus Digital Skills



B. RTI versus Social Skills



C. Digital versus Social Skills

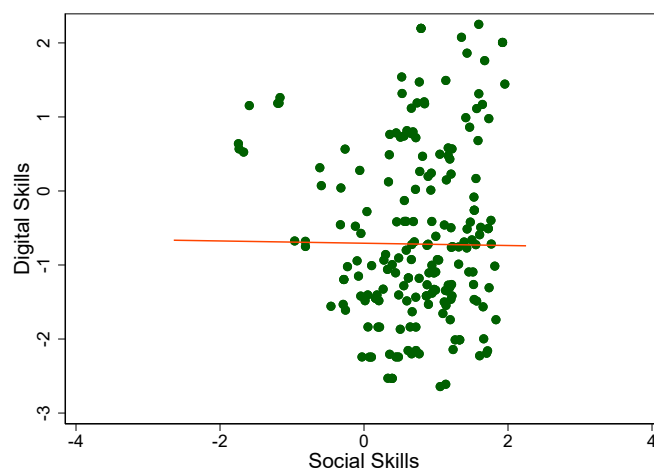
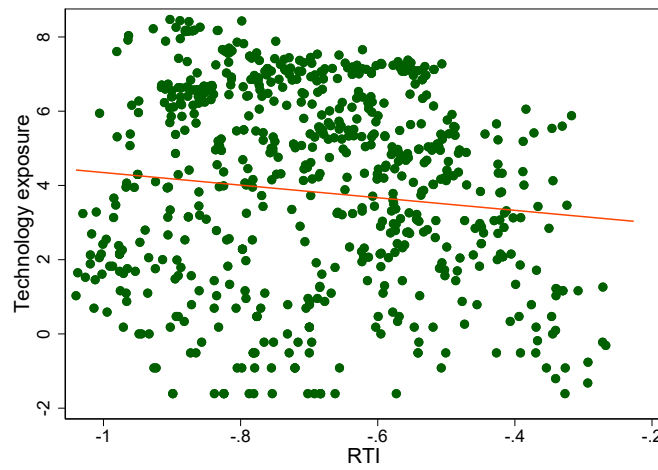
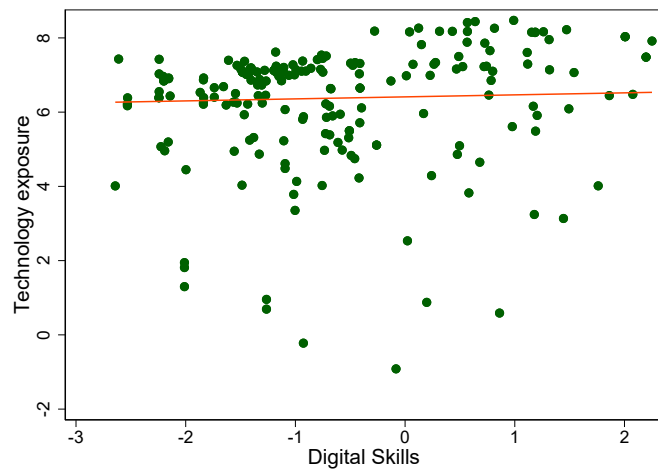


Figure A2: Key Skills versus Technology Exposure

A. RTI versus Technology Exposure



B. Digital Skills versus Technology Exposure



C. Social Skills versus Technology Exposure

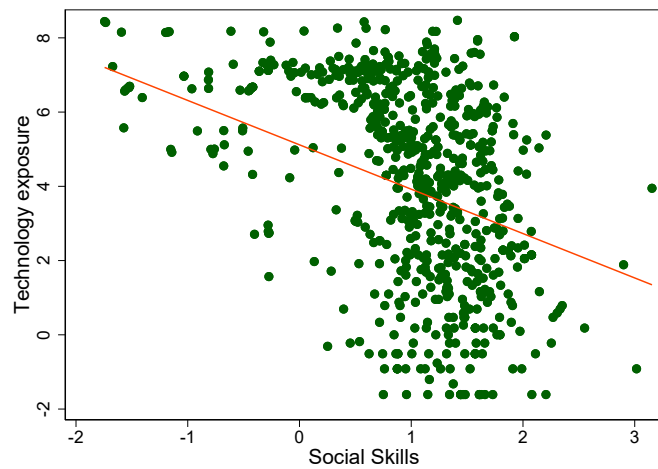
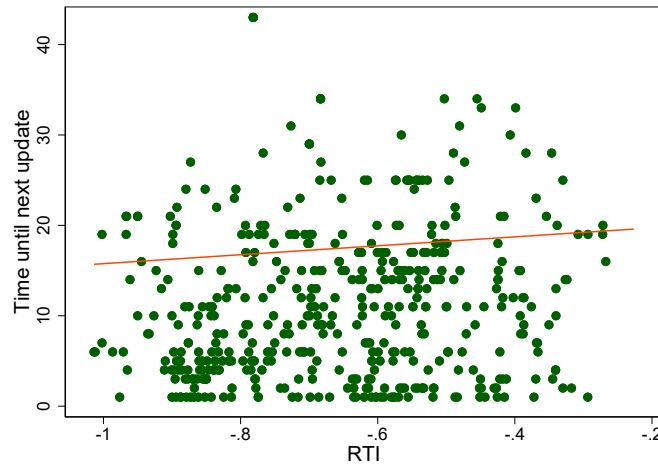


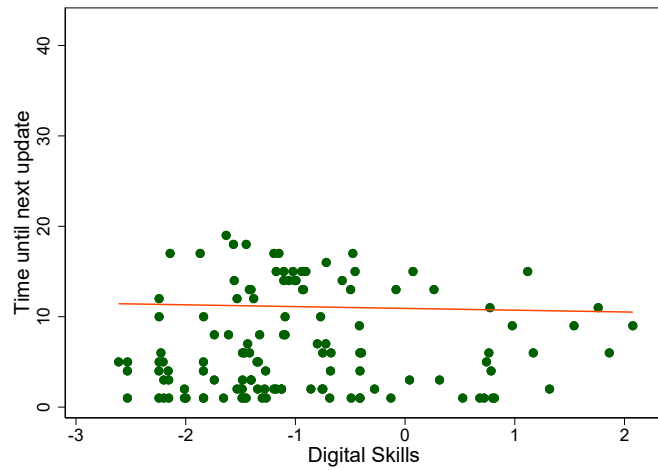
Figure reports scatter plots and a linear fit for three curriculum initial skills and technology exposure (log patent counts). Each dot represents a curriculum. For digital and social skills, we report the log share of these skills per curriculum.

Figure A3: Key Skills versus Curriculum Lifespan

A. RTI versus Curriculum Lifespan



B. Digital Skills versus Curriculum Lifespan



C. Social Skills versus Curriculum Lifespan

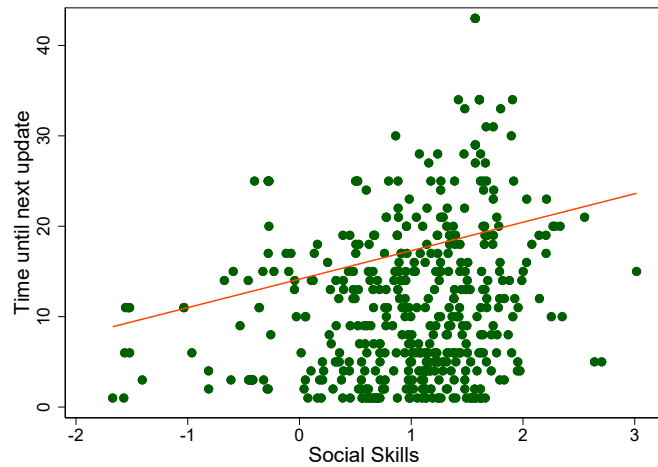


Figure reports scatter plots and a linear fit for three curriculum initial skills and time until the next update (curriculum lifespan). Each dot represents a curriculum. For digital and social skills, we report the log share of these skills per curriculum.



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