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Modernization of Vocational Training Curricula and Technology Adoption in Firms: A Descriptive Analysis with German Data

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Modernization of Vocational Training Curricula and Technology Adoption in Firms: A Descriptive Analysis with German Data

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Abstract: This paper summarizes results of a project that tries to examine how the revision of vocational training (apprenticeship) curricula affects the training behavior and investment decision of training companies. The project paid particular attention to IT-related changes in curricula and firms' investments in IT and new production technology. Unfortunately, based on the available dataset, the German Linked-Employer-Employee-Data (LIAB), the project was not able to produce conclusive evidence on the expected relationship. We find first support for a positive correlation between curricula changes and the probability to invest in IT for training firms but with the small number of cases (occupational curricula changes) and the limited number of adequate dependent variables we did not find significant effects for most single occupations. In the following, however, we provide some descriptive patterns that shed light on what we do know and what we do not know.

Keywords: vocational education and training, curricula change, technology diffusion

JEL Classification: I21, O33

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1. Motivation

In times of fast-paced technological change, the timely adoption of new technologies is at least as important for the competitiveness and total factor productivity of single companies and the whole economy as the development of new technologies themselves (Papaconstantinou, 1997). One potential instrument to stimulate the adoption and diffusion of new technologies is a modernization of vocational education and training (VET) curricula. Updating training curricula ensures that workers have acquired adequate skills to effectively use newly innovated technologies and thereby support the diffusion across all firms that may be gained from such technologies (for more information on how curriculum-updating may help to foster innovation diffusion cf. Rupietta & Backes-Gellner, 2018).

The goal of this project was to investigate if and how past modernizations of VET curricula in Germany may have helped to a faster and/or broader adoption of new technologies across firms. In Germany, vocational training curricula are revised on a regular basis according to a well defined and institutionalized process. This process ensures that for a particular occupation, all the different types of companies within the relevant industries, and particularly the highly innovative companies, are participating in the curriculum-updating process. Thus, the skill-requirements that new technologies bring about are built into the curricula from a very early stage on. Technologies and skills that are only used in innovative firms and not yet in the rest of the industry are taught in intercompany training centers, where future workers learn how to handle technologies and machinery that their own training company does not yet employ.

Firms participating in apprenticeship training are thus equipped with workers that can help them to introduce and make efficient use of these new technologies (BMBF, 2007; Rupietta & Backes-Gellner, 2018). This hypothesis is supported by recent studies showing that VET can help to foster technology adoption and innovation by Rupietta and Backes-Gellner (2018), for product and process innovations in Switzerland, and Janssen and Mohrenweiser (2018), for the German manufacturing industry after the invention of CNC machinery. However, the empirical literature is still scarce and to date there is no study that was able to prove a causal effect of the introduction of new training curricula on investments at the firm level.

This project therefore aimed at answering the following research question: Can we prove a causal effect of changes in VET curricula to a faster adoption of new technologies (in particular IT technology) at the firm level? We find some evidence for a positive relationship between training a new apprentice in the year of the curriculum change and an establishment's probability to invest in IT for several occupations (or curricula changes, respectively). This correlation does not seem to be driven by selection effects, i.e. we observe no large changes in the characteristics of training establishments before and after the curriculum change. However, limited robustness due to high measurement error and small datasets prevent us from drawing definitive conclusions.

2. Data and Variables

To address the research question, we used the Linked-Employer-Employee-Data (LIAB) of the German Institute for Employment Research (IAB). The LIAB links the IAB establishment panel, a representative survey among approximately 16'000 establishments per year, with individual worker-level data from social security registers. We use the LIAB cross-sectional model, which contains the social security records (spells) of all individuals which were employed at an establishment on June 30th.

Explanatory Variables

Using information from the Federal Institute for Vocational Education and Training (BIBB), we compiled a list of all substantial curricula changes and newly developed training curricula from 1997 to 2010. In the following analysis, we put a special focus on major reforms in six (larger) occupations. All these reforms strengthened the focus on IT-related training and we thus expect the reforms in these occupations to have a particularly strong effect on the IT investments of training firms.[1]

The combination of establishment and individual worker-level data in the LIAB allows us to construct an establishment-panel containing the number of new apprentices in an establishment for all relevant training occupations. We identify new first-year apprentices as those trainees who started their training in the establishment between August 1st, i.e. the date when curricula changes usually take effect (and most training contracts begin), and June 30th.

[1] These six occupations are Chemikant/Pharmakant (Laborberufe) (reform in 2000), Industriemechaniker (Industrielle Metallberufe) (reform in 2004), Elektroniker (Automation/Geräte und Systeme) (reform in 2003) and Fachinformatiker/Informatikkaufmann (established in 1997 as replacement for Datenverarbeitungskaufmann). We match each training occupation to the corresponding 3-digit Kldb 1988 occupational code used in the LIAB. Some KldB codes contain more than one training occupation. In case of conflicts, we usually only consider changes in the larger occupation (as measured by the number of new training contracts retrieved from the BIBB Dazubi Database).

To this establishment panel, we merge the information on curricula changes for each year and training occupation. We then construct indicator variables for having a new apprentice in the year of a curriculum change in different training occupations.

Dependent Variables

For our dependent variables, we are interested in the IAB establishment panel questions regarding investments in IT technology and new production equipment. The survey asks if a particular establishment invested in IT technology in the past fiscal year (yes/no) and for which percentage of total investments IT investments account for. The same questions apply for investments in (other) production equipment.[2] We use these four questions to construct our dependent variables on the incidence and magnitude of IT and production equipment investments.

3. Empirical Analysis

Descriptive Analysis

Based on this data, we investigate what happens in the training establishments when training curricula change. The following graphs (Figures 1-6) show the proportion of establishments that invest in IT technology for each year from 1993 to 2010, separately for establishments that do have a first-year apprentice in the respective year (red line) and establishments that do not have a first-year apprentice (blue line) and for our six main focus occupations. The samples contain only establishments that do train apprentices in the respective occupation in general (but possibly not in each year), i.e. we define training establishments as those establishments that started training an apprentice at least once during our observation period (1993-2010). The vertical red line indicates the year when the training curricula of the respective occupation changed. If training under the new curriculum leads to more investments in IT technology, we would, in the years following the change, expect to see a gap opening between establishments who do start training a new apprentice and establishments who do not start training a new apprentice.

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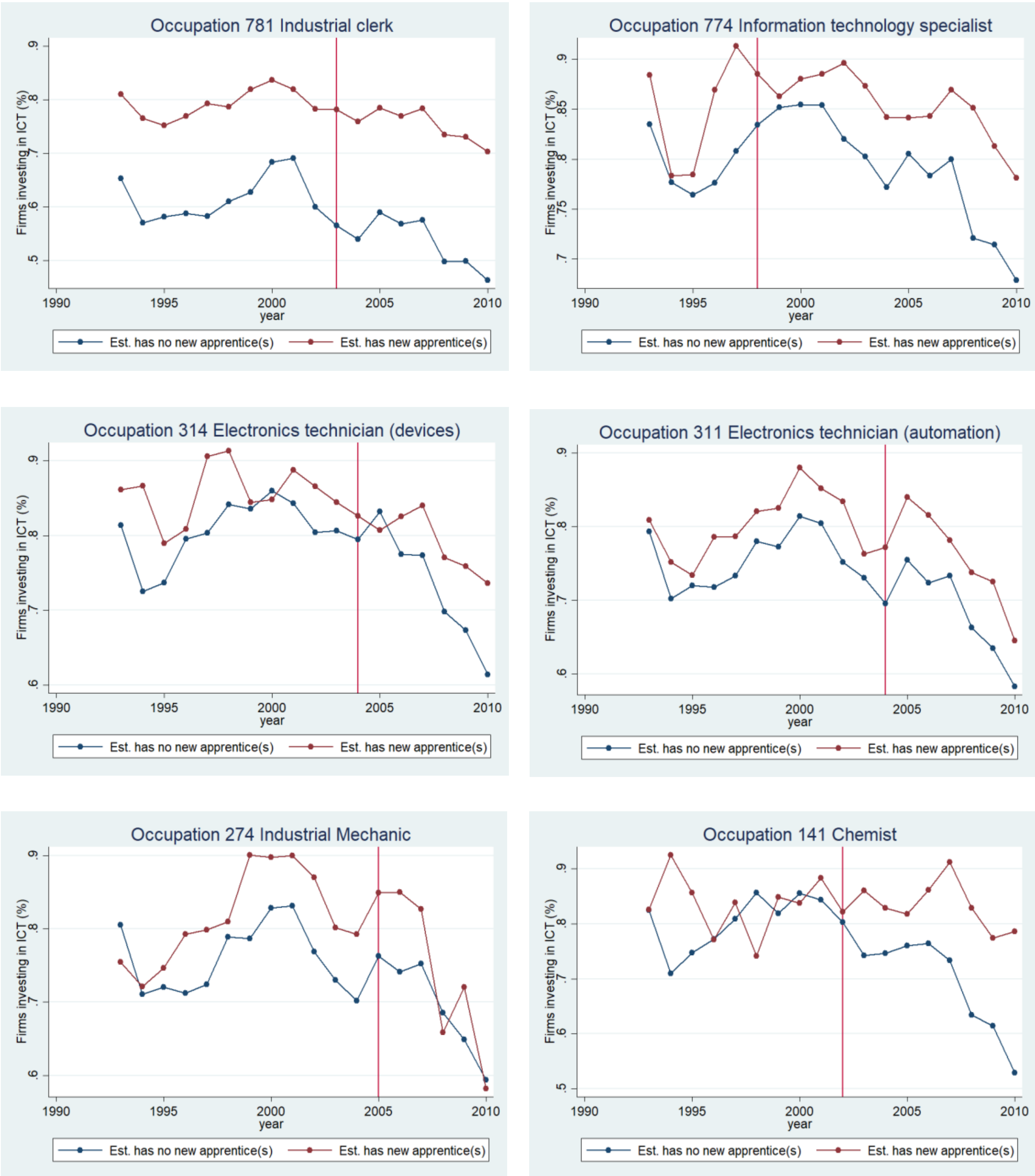
[2] The questions regarding the percent values for IT investments are only available for the years 2000-2006.

Figures 1-6: Establishments investing in IT



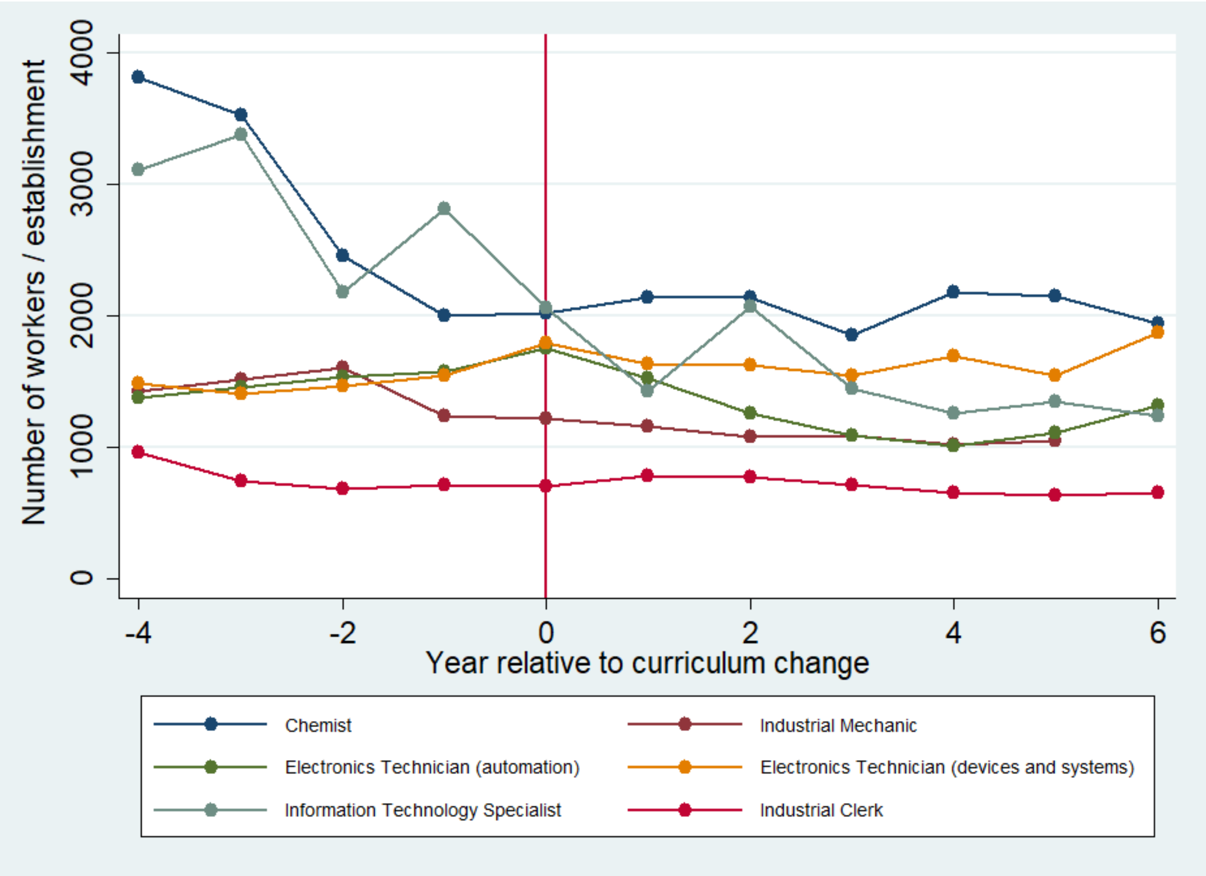
A first visual inspection shows that, for all occupations, the share of establishments that reported to invest in IT technology started at a rather high level in 1993 and then declined rapidly in the following year. The general trend then shows that more establishments started investing with a peak around 2001, before the number of establishments investing in IT started to decline again.

If we compare establishments that do and do not have new apprentices in a given year, we see that establishments who do start training apprentices are more likely to invest in IT than establishments that do not start training new apprentices in this year (but who do train apprentices in the respective occupation in other years). After the reform and for some training occupations (in particular for firms training information technology specialists, electronics technicians or chemists) it appears that there is indeed a growing gap in the propensity to invest in IT between establishments that do train new apprentices and establishments that do not (currently) train new apprentices.

Of course, establishments that train often and establishments that train infrequently (or not at all) might be fundamentally different. As we have seen in figures 1-6, establishments that take on new apprentices in a given year are generally also more likely to invest in IT. The establishments that are more likely to train apprentices are also larger and thus probably already more likely to invest in IT. If the composition of the training establishments changes after a change in the curriculum, it is thus difficult to separate the effect of a change in the curriculum from selection effects.

Therefore, we also examine whether the composition of the training establishments changes after the curricula change. Figure 7 shows descriptive evidence that this does not seem to be the case for the six occupations in our focus. The graph shows the average size of establishments with new first-year apprentices. We find no significant change in the average establishments size in the years following the change (indicated by the red vertical line). Small establishments are not driven out of the training business after a curriculum change. Likewise, we find no significant differences in average profitability or industry composition of training establishments before and after the change (results available on request).

Figure 7: Average size of training establishments



Panel Regression Analysis

In a more elaborate econometric analysis, we use multivariate panel data models to examine whether establishments that have an apprentice in the first year of training at the time of the curriculum change are more likely to invest in IT in the following years, compared to establishments that do not train at that time. Thereby, we use the panel structure of the data to control for the long-term investment averages of the establishments, i.e. we examine whether we find differences in the deviations from the establishments' own investment averages between the two groups. This allows us to eliminate potential time-invariant confounders.

We run the model separately for each occupation and the different dependent variables (probability to invest in IT technology, percent of total investments spent on IT, probability to invest in new production technology and percent of total investments spent on new production technology). We consider different control groups and time lags. Our preferred control groups consist of establishments which had new apprentices in the respective occupation shortly before or after the change, but not at the time of the change itself.[3] If an establishment starts training an apprentice under a new curriculum ("early trainers"), we expect it to have a higher probability to invest in IT in the following years than the control group which did not train in the first year after the change.

Regression Results

Table 1 reports the results of the fixed effects regression for all six occupations. The variable "NewCurricula" is equal to one if the establishment trains a new apprentice in the year of the change. The variables with prefix L1, L2 and F1 represent lagged (and pre-shifted) versions of the same variable and allow to estimate the correlation between having a first-year apprentice at the time of the change and investments two and three year after the change, and in the year before the change, respectively.

[3] We also consider control groups consisting of firms who simply have employees in the respective occupations and firms who always train in the respective occupation (results not reported).

Table 1: Curriculum Changes and IT investments: Fixed Effects Regressions

	IT-Investment Dummy (LPM)			IT-Investment Share		
	B	**SE**	**Groups**	**B**	**SE**	**Groups**
Variables	Industrial Clerk 781					
NewCurricula	0.033*	0.019	2’261	0.619	1.312	1’994
L1.NewCurricula	0.017	0.021	2’192	0.213	1.492	1’922
L2.NewCurricula	-0.014	0.021	1’968	-1.049	1.420	1’710
F1.NewCurricula	0.015	0.020	1’915	-0.542	1.390	1’717
	IT Specialist 774					
NewCurricula	-0.004	0.054	290	--		
L1.NewCurricula			287	--		
L2.NewCurricula			275	--		
F1.NewCurricula			258	--		
	Electronics Technician (for devices and systems) 314					
NewCurricula	0.055	0.049	278	-1.162	2.969	259
L1.NewCurricula	0.077*	0.042	277	5.449**	2.485	258
L2.NewCurricula	0.089*	0.055	256	3.436	3.126	242
F1.NewCurricula	-0.044	0.049	256	-2.854	2.330	273
	Electronics Technician (Automation) 311					
NewCurricula	0.086*	0.040	559	0.285	2.186	504
L1.NewCurricula	0.030	0.041	553	-0.733	2.002	494
L2.NewCurricula	0.009	0.047	503	-3.838	2.789	445
F1.NewCurricula	-0.023	0.039	473	2.173	2.065	430
	Industrial Mechanic 274					
NewCurricula	0.015	0.055	280	-0.256	1.638	264
L1.NewCurricula	0.009	0.059	275	-3.554	2.257	261
L2.NewCurricula	-0.030	0.076	259	1.153	1.967	242
F1.NewCurricula	0.121	0.061	243	0.621	1.922	231
	Chemist 141					
NewCurricula	0.015	0.055	280	1.788	4.520	64
L1.NewCurricula	0.009	0.059	275	6.216	4.745	63
L2.NewCurricula	-0.030	0.076	259	0.246	3.503	60
F1.NewCurricula	0.121	0.061	243	-1.885	5.669	58

Notes: Table reports coefficients for establishment-fixed effects estimations; Dependent variables: investment in ICT (yes/no), investment in ICT in percent of total investment; Control variables: Establishment size, Year; For IT specialists, no information on the IT-investment share is available at the time of the curriculum change; Standard errors (SE) clustered on the establishment level; Significance levels: *p < .05, **p<.01, ***p<.001.

We find small positive and statistically significant (on the 10% level) correlations between having a first-year apprentice in the year of the curriculum change and the probability to invest in IT in the following year for the occupations “Industrial Clerk” and “Electronics Technician, automation”. Moreover, we find positive coefficients for “Electronics Technician, devices and systems” in the second and third year after the change. To give the coefficients an interpretation, establishments that train electronics technician (devices and systems) apprentices early under the new curriculum are 7.7 percentage points more likely to invest two (Lag2), and 8 percentage points more likely to invest three years (Lag3) after the curriculum change. For the IT investment share, we only observe a significant 5 percentage point increase in the second year after the change for «Electronics Technician, devices and systems". For all other occupations, the correlations between training under the new curricula and the IT investment share are insignificant.[4] Of the twenty occupations with largest sample size, we find small significant positive correlations between having a new apprentice in the first year after the curriculum change and the probability to invest in IT for three occupations, i.e. the already mentioned occupations "Electronics technician automation" (Elektroniker Automatisierungstechnik) and "Industrial clerk" (Industriekaufmann) as well as for "Sales assistant for retail services" (Verkäufer). However, the positive correlations do not persist for more than one year and we find no corresponding correlations for the IT investment share. The remaining large occupations show no significant correlation, neither positive nor negative.[5]

All in all, we only find the expected positive and significant correlations for a few occupations. Nevertheless, the sign of the correlation seems to be positive in most cases, although the coefficients can only be estimated relatively imprecisely. The high standard errors could be caused by, for example, measurement errors in the dependent variable or measurement errors in the assignment of the training curricula to the 3-digit occupational codes used in the LIAB. In addition, we cannot completely rule out that the decision to train after a curriculum change is not random. However, in general, we find no evidence that the characteristics of training establishments differ before and after the curricula change.

Conclusion

The results suggest that, as theoretically expected, there may be a positive effect of training curricula changes on technology adoption at the establishment level. We find some descriptive evidence that training new apprentices after a change in the curriculum has a positive correlation to the establishment's probability to invest in IT in the following years, at

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[4] Unfortunately, there are also reasons for a cautious interpretation of the results, or the reliability of our measures, respectively. For example, when running placebo tests, we repeatedly find significant positive and negative results in years where we would not expect to find significant results. For example, for "Electronics Technician, devices and systems", we find that having a new apprentice (as opposed to not having a new apprentice) in the year 2002 (two years before the actual curriculum modernization) has positive effects and having a new apprentice in 2000 (four years before the modernization) has negative effects. For "Electronics Technician, automation" we find significant negative effects in 2003, but no significant effects after the reform, although the occupation essentially received the same new qualifications as "Electronics Technician, devices and systems" (see Borch & Weissmann, 2003). For "Industrial Clerk", we find significant negative effects in 2000 and 2001. In general, the results are also rather sensitive to different specifications, i.e. the different time lags and different longitudinal panels (i.e. different samples of establishments).

[5] Results for other occupations are available on request.

least for some occupations. Moreover, this correlation does not seem to be driven by selection effects, i.e. changes in the composition of training establishments before and after the curriculum change. In particular, we find that small establishments are not driven out of the training business after a curriculum change.

However, for most occupations, we find no supporting evidence for the expected effects of training curricula changes on IT investments; this, however, does not mean the effects do not exist, it just means that we cannot prove them. Reliably isolating consistent effects proved to be difficult, in particular because of the small sample sizes and high measurement error in the dependent and independent variables. More research will be necessary in the future, with data sets that are better tailored to the problem.

One additional important finding is that we find no significant change in the average establishments size before and after the introduction of the new curriculum. Thus, the introduction of new curricula did not prevent smaller firms to participate in apprenticeship training in the years following the change. Small Firms obviously find ways to adapt to the new curricula requirements, which - as argued by Rupietta/Backes-Gellner 2018 – might help to diffuse innovations to small firms in particular.

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