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A hidden source of innovation? Revisiting the impact of initial vocational training on technological innovation

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Abstract

While an increasing number of studies postulate that vocational education and training (VET) activities have a positive impact on the innovative capacity of training companies, empirical evidence on the subject remains contradictory. This study exploits establishment data from a representative survey of German companies to estimate the correlations between firms' participation in initial VET and their innovation outcomes. The results based on linear probability models show that the impact of VET activity on innovation is indeed ambiguous. Overall, as expected, participation in initial VET has virtually no effect on radical product innovation. However, a positive impact of training apprentices is observed in case of incremental product innovation and process innovation activities. According to our estimates, this finding primarily applies to the case of microenterprises with fewer than ten employees. We conclude from this that active participation in the VET system primarily promotes the innovation activities of very small firms by stimulating knowledge diffusion in regional innovation systems and developing absorptive capacities at the company level. As a result, small-sized training firms should be more likely to succeed in overcoming – at least in part – some of their disadvantages in innovation.

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1. Introduction

In recent years, the question of the role that vocational education and training (VET) potentially plays for firm-level innovation has gained increasing attention in scholarly research (e.g. Barabasch and Keller 2020; Hodge and Smith 2019; Lund and Karlsen 2020; Porto Gómez, Zabala-Iturriagagoitia, and Aguirre Larrakoetxea 2018; Rodríguez-Soler and Icart 2018; Rupietta and Backes-Gellner 2019; Rupietta, Meuer, and Backes-Gellner 2021). Regarding the role of VET institutions in this context, it has been empirically shown that they provide an important contribution to the functioning of regional innovation systems (Lund and Karlsen 2020; Porto Gómez, Zabala-Iturriagagoitia, and Aguirre Larrakoetxea 2018; Rodríguez-Soler and Icart 2018).

It would be expected that the empirical evidence at the company level is analogous to this, although surprisingly this is not the case. The studies conducted by Hodge and Smith (2019) and Rupietta and Backes-Gellner (2019) provide different results regarding the direct influence of initial VET activities on innovation activities in training firms (i.e. in terms of the contribution of VET students to a firm's propensity to introduce new or significantly improved products, services or processes). While the first study – based on qualitative interviews from Australia – does not provide clear evidence that VET students contribute directly to a firm's innovativeness during their time of work placement, the second study – based on Swiss firm data – provides quantitative evidence that apprenticeship training has a positive impact on firm-level innovation under the conditions of dual VET systems.

According to Rupietta and Backes-Gellner (2019), the effect of initial VET on technological innovation outcomes follows an inverted u-shape with increasing firm size, i.e. the impact on innovation seems to be stronger for smaller enterprises, and tends to apply to product rather than process innovations. However, since small and medium-sized enterprises (SMEs) are a quite heterogeneous entity in terms of innovation (Thomä and Bizer 2013; de Jong and Marsili 2006), it remains unclear exactly to which group of SMEs this effect applies. Moreover, the non-significant result on process innovation outcomes appears surprising given that – compared to product innovation – the knowledge associated with improvements in business processes often contains a relatively high degree of tacitness (Gopalakrishnan, Bierly, and Kessler 1999), which should be associated with a stronger importance of VET-based learning and skills in this context (on this issue see Thomä 2017). Moreover, the Swiss study of Rupietta and Backes-Gellner (2019) does not distinguish between different degrees of innovative novelty. However, especially regarding incremental innovation, a potential contribution by VET students could be expected (Toner 2010).

By contrast, the qualitative results of Hodge and Smith (2019) imply that a VET student's contribution to firm-level innovation should not be overestimated, at least under conditions of full-time, school-based vocational training systems with company practice periods being constrained to temporarily limited work placements. The following pointed question by the authors illustrates this finding: "If VET students, like any students, are novices in an occupational area, why would we expect to find they contribute to innovation?" (p. 16). Hodge and Smith (2019) nevertheless argue that VET students may still contribute to firm-level innovation in a less visible manner through actively taking part in minor modifications and improvements of existing products, services and businesses processes (i.e. incremental innovation). Moreover, they expect VET students to be potential mediators of knowledge diffusion stemming from regional vocational education institutions. This may explain the finding of Rupietta and Backes-Gellner (2019) that the effects on innovation are stronger in smaller firms, given that – at the level of regional innovation systems – SMEs are probably profiting most from the VET system's important function in terms of knowledge diffusion (Lund and Karlsen 2020; Porto Gómez, Zabala-Iturriagagoitia, and Aguirre Larrakoetxea 2018; Rodríguez-Soler and Icart 2018).

Hence, the question remains whether conducting initial VET actually fosters technological innovativeness at the company level. Against this background, our paper aims to contribute to the literature in two related ways. Compared to the Australian study of Hodge and Smith (2019), our empirical analysis uses a broad data set from Germany, a country where the dual system of VET forms an integral part of the national innovation system (Thomä 2017). Due to the duality of vocational training (i.e. the combination of long periods of practical learning in companies and theoretical learning at vocational schools), German VET students may contribute to firm-level innovation to a stronger degree compared to students of full-time vocational schools with limited practical periods during their time of training. In this way, we aim to provide quantitative evidence for the correlation between initial VET and technological innovation by placing a special emphasis on the difference between radical and incremental innovation, and hence supplement the findings of Hodge and Smith (2019).

Regarding the quantitative Swiss study of Rupietta and Backes-Gellner (2019), we add to the literature by distinguishing between different company size classes to shed further light on the role of SMEs in the present context. Moreover, by using a wider set of control variables and developing a comprehensive theoretical foundation for explaining the potential impact of initial VET on smaller firms' innovation activities – particularly in terms of process innovation and incremental product innovation – we complement Rupietta and Backes-Gellner (2019).

Overall, our results indicate that there is a positive impact of initial VET activity on firm-level innovation in Germany. However, this is only the case in microenterprises with fewer than ten employees. In this company size class, initial vocational training promotes the introduction of incremental product innovation and drives process innovation activity.

We conclude from this finding that the knowledge diffusion function that the VET system has in regional innovation systems primarily holds relevance for the smallest of the training companies.

The remainder of the paper is structured as follows. In the following section, we review and synthesize a number of theoretical arguments from the literature on how initial VET activities may contribute to knowledge diffusion, learning and innovation at the firm and regional levels. In the next sections, we introduce the dataset, discuss our estimation approach and present our main empirical results on the relationship between initial VET and firm-level innovation. Finally, the paper concludes with implications for policy and further research.

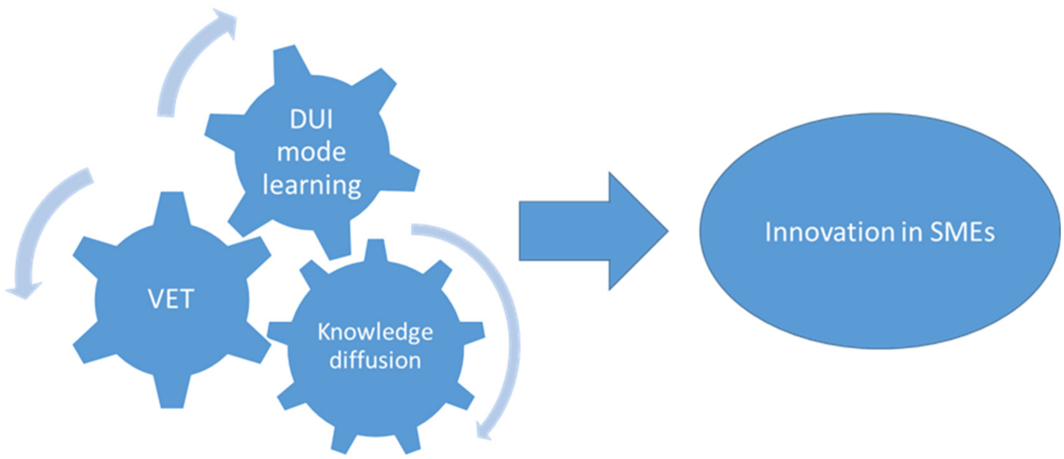
2. Innovation in the majority of German SMEs: Learning beyond formal R&D

2.1. Conceptual framework

Firm-level innovation activities can be based on different learning sources (Santamaría, Nieto, and Barge-Gil 2009). According to Jensen et al. (2007), innovating firms can be roughly distinguished according to the degree to which they have integrated formal processes of learning related to research and development (R&D) and the extent to which they use informal ways of learning based on doing, using and interacting (DUI). In this context, the innovation activity of smaller firms is often described as minimally or not at all R&D-intensive and being strongly rooted in the DUI mode (Baldwin and Gellatly 2003; de Jong and Marsili 2006; Tödtling and Kaufmann 2002; Hirsch-Kreinsen 2015). In the case of the "German Mittelstand", the importance of non-R&D-based DUI mode learning and innovation was found to be particularly strong (Pahnke and Welter 2019; Kirner, Kinkel, and Jaeger 2009; Kirner, Som, and Jäger 2015; Alhusen et al. 2021; Thomä 2017; Thomä and Zimmermann 2020).

Important elements of DUI-based innovation activities in SMEs are an emphasis on experience-based, interactive learning, the overall importance of locally embedded tacit knowledge, a strong customer orientation, incremental improvement of existing products and a close link to process innovation activities (Thomä and Zimmermann 2020). An essential prerequisite for DUI innovation in SMEs to succeed – and thus a key starting point for policy support – is effective knowledge diffusion. On this basis DUI-oriented SMEs often receive the necessary impetus to engage in innovation. Hence, measures to increase the capacity of smaller firms to absorb external knowledge, focus on a broad set of institutions that affect learning and innovation (particularity at the regional level), integrate SMEs in regional innovation systems and upgrade workforce skills in SMEs to enable their participation in DUI mode innovation are vital in this context (Rammer, Czarnitzki, and Spielkamp 2009; OECD 2010; Hervás-Oliver et al. 2021; Hewitt-Dundas 2006; Thomä 2017).

Figure 1. VET as a driving factor for innovation in SMEs



In summary, it can be assumed that DUI mode learning and knowledge diffusion within innovation systems are key drivers of innovation for the majority of SMEs. Our main argument at this point is that VET is closely involved in the relevant processes and dynamics (see Figure 1), leading to a mutual reinforcing relationship between these three elements and the innovativeness of SMEs, which tends to be overlooked by innovation scholars and policy-makers alike (Porto Gómez, Zabala-Iturriagagoitia, and Aguirre Larrakoetxea 2018).

2.2. The role of VET in knowledge diffusion

Toner (2010) argues that the VET system plays a critical role in knowledge diffusion, particularly regarding innovation in SMEs, which are not at the frontier of technological development. He stresses the importance of vocational education institutions as being highly responsive to the particular needs of local industries, offering customized training programs, serving as technology intermediaries between equipment or software producers and local businesses, and informing their students about new technologies, which increases the absorption capacity of a training company's workforce in terms of both practical skills and knowledge regarding production processes.

The role of vocational education institutions for the functioning of regional innovation systems is empirically examined in the studies of Porto Gómez, Zabala-Iturriagagoitia, and Aguirre Larrakoetxea (2018), Rodríguez-Soler and Icart (2018) and Lund and Karlsen (2020). The former conclude that for many industrial SMEs in Spain (Basque Country and Catalonia) VET institutions represent the main source of technological knowledge and hence play a pivotal role for the innovation processes in these companies. Moreover, it is shown that this is especially the case for DUI-based innovation activities, which are triggered by the demand-based and problem-solving-oriented training opportunities provided by VET institutions and "the type of skills and expertise held by their staff and the long-lasting [trust-based] relationships between these and local firms" (Porto Gómez, Zabala-Iturriagagoitia, and Aguirre Larrakoetxea 2018, p. 217).

For the Spanish regions of Catalonia and Aragon, Rodríguez-Soler and Icart (2018) establish that geographical proximity is crucial for knowledge exchange networks between VET institutions and SMEs. In this way, VET institutions can be a driving force of regional innovation systems in terms of knowledge diffusion. Again, VET institutions are described as "a key node" (p. 13) in the knowledge network of DUI-oriented SMEs.

Lund and Karlsen (2020) confirm the results of the Spanish studies with a focus on two Norwegian manufacturing regions, concluding that VET institutions are important sources of knowledge for local SMEs. In their study regions, vocational colleges promote manufacturers' competitiveness by developing programs for education tailored to regional industry that consider current technological trends and state-of-the-art technologies and new materials, which shows how VET institutions and regional innovations systems are co-evolving in terms of the diffusion of new technologies. According to the authors, these findings "extend our understanding of the DUI mode of innovation" (p. 28).

For the case of Switzerland, Rupietta and Backes-Gellner (2019) establish that the involvement of highly innovative companies in institutionalized curricula-updating processes fosters the distribution of new knowledge and technologies across the broad range of training companies and therefore enhances their innovation capacities. According to the authors, companies participating in initial VET are consequently confronted with new technologies of the industry leaders. By learning about these technologies, training firms develop competitive advantages over firms that do not participate in apprenticeship training. While large companies are primarily those that provide the innovative input into the curricula-updating process, SMEs are expected to profit most from this knowledge diffusion and the subsequent adaptation of new knowledge inputs to their individual needs.

2.3. VET and the DUI mode of innovation

According to Toner (2010), at the firm level processes of learning by doing and using are at the core of VET. Hence, it is only logical to expect a close link between a company's training activities in the VET system and its integration of the DUI mode of learning and innovation (Thomä 2017).

Within the DUI mode, practical problem-solving skills developed in production processes hold key importance for innovation activities at the firm level (Jensen et al. 2007). The VET system provides employees with corresponding skills and underpinning knowledge and hence raises the workforce's absorptive capacities (Toner 2010). In this way, knowledge flows within and between firms are facilitated (Proeger 2020; Rupietta and Backes-Gellner 2019) and apprentices are enabled to act as technology gatekeepers (Rupietta, Meuer, and Backes-Gellner 2021).

As a result, some studies in the DUI literature stress the importance of VET as an important element of innovation processes in SMEs. For example, Thomä (2017) argues that VET plays a key role in incremental product and process innovation activities in non-R&D-intensive firms and industries. Similarly, the empirical results of Thomä and Zimmermann (2020) imply that VET is a key driver of innovation in SMEs that are engaged in customer-oriented DUI innovation. To offer another example, the study of Alhusen and Bennat (2021) shows that "learning-by-training" through VET activities is mainly employed by SMEs that rely on the DUI mode in some way or another.

Moreover, it is argued in the literature that apprentices contribute to management innovation (Barabasch and Keller 2020; Hodge and Smith 2019; Rupietta, Meuer, and Backes-Gellner 2021), which holds particular relevance for DUI mode innovation (Parrilli, Balavac, and Radicic 2020; Parrilli and Radicic 2021). At the same time, organizational learning and creating a corresponding business culture are the micro-foundation of DUI mode learning (Asheim and Parrilli 2012). In this context, it should be kept in mind that dual VET in Germany is often associated with building up a distinct learning culture in training companies (Deissinger 2012; Deissinger 2015; Harris and Deissinger 2003; Pilz 2008; Wiemann and Pilz 2020). To sum up, it can be expected that initial VET activities exert a positive impact on DUI mode innovation in SMEs.

3. Data

To investigate the link between initial VET and innovation, we use cross-sectional data from the IAB EP dataset, an employer survey from the German Federal Employment Agency. The sampling frame in the IAB EP survey is the Establishment File of the Federal Employment Agency, which contains all German business units with at least one employee covered by social security, thus comprising all companies that provide initial VET. Ellguth et al. (2014) provide further details on the sampling of the IAB EP dataset and the overall design of the survey.

We analyse data for 2017, which we access via a remote data execution system (JoSuA) of the Research Data Centre (FDZ) of the German Federal Employment Agency. The dataset includes information on 15,421 establishments, 43.2% of which report innovation outcomes and 45.6% report initial VET activities. 39.6% of the companies have fewer than ten employees, 31.1% 10-49 and 29.3% more than 49. A full description of all variables and the respective descriptive statistics by VET status is provided in Table A1.

Our main variables of interest are indicators for innovation outcomes and initial VET. The IAB survey asks respondents a number of questions on innovation activities that we can use to construct our dependent variables. Following Rupietta and Backes-Gellner (2019), we distinguish between general, product and process innovation. Additionally, we differentiate between radical and incremental product innovation. The underlying survey questions fully comply with the Oslo Manual guidelines on measuring firm-level innovation (OECD and Eurostat 2018).[1]

The survey further gathers extensive information concerning VET activities of individual companies. We construct our primary variable of interest – the binary training indicator 'training company' – based on information in the IAB survey on whether a company employs VET students (i.e. apprentices) or not. In addition, we also use the comprehensive information on the qualification structure of the company's workforce provided in the dataset. Here, we construct metric variables on the share of workers with different qualification levels. We divide the sample by VET status and report descriptive statistics for training companies and non-training firms in Table A1. Correlations between the variables are listed in Table A2.

4. Estimation Strategy

We conduct our analysis using standard ordinary least square estimators. Given that our dependent variables are binary indicators, we refer to the estimations as linear probability models (LPMs) (Angrist and Pischke 2008). In analogy to the Swiss study of Rupietta and Backes-Gellner (2019), we rely on LPMs rather than probit or logit models for consistency. Generally, the choice of the estimation model will hardly affect the results given that LPMs and non-linear models based on link functions are known to deliver similar results (Angrist and Pischke 2008).

Our estimation model is thus given by:

$$INNO_j = \gamma_0 + \gamma_1 VET_j + \sum_{k=1}^{K} \gamma_k x_{kj} + e_j \qquad (1)$$

where INNO denotes the innovation indicator (equal 1 for innovating companies, and 0 otherwise), VET takes the value of 1 if the firm is currently engaged in initial VET activities, k denotes the number of control variables, j denotes the number of companies and e is the error term.

In our set of controls, first we include information on workforce qualification based on the share of qualified employees and the share of employees with an academic qualification. Second, our competition measures refer to a question asking survey respondents to assess the pressure of competition in their market (1 for medium or substantial pressure). Third, as a control variable for demand changes, we use information on the business volume expectation (1 if a company expects increasing business volume in the next year). We also control for economic sector, firm size, shortage of skilled workers, foreign ownership and regional dummies (Rupietta and Backes-Gellner 2019).

Moreover, we control for in-house R&D and continuing training as both increase the knowledge stock of companies, affect their knowledge flows and thus should have a positive impact on firm-level innovativeness (Bauernschuster, Falck, and Heblich 2009; Fagerberg, Srholec, and Verspagen 2010).

Further, we consider indicators on investment and the technical state of equipment as important inputs into the knowledge production process. The technical state of equipment reflects a firm's technological endowment and its ability to convert resources into innovative outputs. Investments in new production facilities, plants or equipment increase this

[1] The questions asked in the IAB survey 2017 were: 'In the last business year of 2016, did your establishment improve or further develop a product or service which had previously been part of your portfolio?' (*incremental product innovation*); 'In the last business year of 2016, did your establishment start to offer a product/service that had been available on the market before?' (*new-to-the-firm product innovation*); 'Have you started to offer a completely new product or service in the last business year of 2016 for which a new market had to be created?' (*radical product innovation*); 'Did you develop or implement procedures in the last business year of 2016 which have noticeably improved production processes or services?' (*process innovation*).

stock and capabilities (Barney 1991; Heidenreich 2009). We can include both indicators as control variables by drawing on the questions in the IAB EP survey concerning the technical state of a company's equipment (1 'state of the art' – 4 'out of date') and its investment activities (1 for investments in 2016, 0 otherwise).

Finally, we also include a dummy for export activities, as this indicator has been shown to affect firm-level innovativeness (Peters and Rammer 2013). We conduct the analysis for the whole sample as well as differentiated by company size into three classes to investigate the correlation between VET and innovation for different learning environments, namely fewer than ten, 10-49 and more than 49 employees.

5. Results

In the regression analysis, we observe a highly significant effect of training activity (yes/no) on innovation in general (3.8***) as well as for companies with fewer than ten employees (5.1***). For the other size classes, we detect no effect. The same holds for product innovation, with an effect size of 3.7*** and 5.2***, respectively. We thus find a direct correlation between initial VET and technological innovation, with a significant effect in case of small firms, which drives the effects obtained for the whole sample. As expected, in case of radical product innovation our estimates do not yield significant effects. For incremental product innovation as well as process innovation, again we obtain significant effects for the whole sample (3.0*** and 2.9***) and companies with fewer than ten employees (4.0** and 3.1**). Hence, there is evidence that initial VET drives the incremental product and process innovation activities of microenterprises with fewer than ten employees.

The effects on both process as well as incremental product innovation can be substantiated theoretically as VET students and VET trained workers play a critical role in incremental innovation activities (Toner 2010), and given that the transfer of tacit knowledge – as a central element of VET-based learning (Harris and Deissinger 2003) – constitutes a key element of knowledge associated with process innovations (Gopalakrishnan, Bierly, and Kessler 1999).

On the other hand, incremental process innovations typically arise as a result of cumulative learning among employees (Matthews, MacCarthy, and Braziotis 2017; Dutton and Thomas 1984), while initial VET in Germany or Switzerland is often associated with a distinct learning and training culture (Deissinger 2012; Harris and Deissinger 2003; Pilz 2008; Deissinger 2015; Wiemann and Pilz 2020). Hence, small DUI mode firms should profit most from knowledge diffusion stemming from vocational education institutions (see Section 2).

In line with previous research (Hall and Jaffe 2018; Heidenreich 2009), we observe a very strong association between R&D and all output measures of innovation. Companies that report formal R&D activities have a higher probability of reporting innovation outputs by between 14.5% and 36.0% (depending on the type of innovation and firm size). Similarly, companies that invest in new technology and report a more advanced technological equipment display a significantly higher probability of innovating, which is also a result known from the literature (Smith 2005; Barney 1991). Like Bauernschuster et al. (2009) and Peters and Rammer (2013), we also observe a positive impact of continuing training on innovation.

Overall, while supplementing and partially confirming the findings of Rupietta and Backes-Gellner (2019), our estimates are partly in contrast to the observations of Hodge and Smith (2019), who only find a VET student's influence on management innovation. However, the latter study relies on case studies in four medium-sized companies from the service sector, focusing on work placements of students enrolled in school-based courses with a duration of one to two years. Taken together, the relevance of firm size (Rupietta and Backes-Gellner 2019; Alhusen and Bennat 2021), sectoral differences in innovative behaviour (Pavitt 1984) and the type of VET system (i.e. dual VET systems vs. school-based VET systems) might determine the innovative contribution of initial VET activities to firm-level innovation.

Table 1. Regression results

	Linear probability models																			
	General innovation				Product innovation				Radical product innovation				Incremental product innovation				Process innovation			
	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
Training company	0.038***	0.051***	0.008	0.035	0.037***	0.052***	0.008	0.036	0.005	0.006	-0.003	0.005	0.030***	0.040**	-0.002	0.019	0.029***	0.031**	0.012	0.040*
Controls																				
Company size	0.000	-0.004	0.002**	0.000	0.000	-0.004	0.002***	0.000	0.000	0.001	0.001*	0.000	0.000*	-0.001	0.002**	0.000*	0.000***	0.002	0.000	0.000***
Share qualified workers	0.043***	0.047*	0.068**	0.033	0.035***	0.041	0.065**	0.025	0.011	-0.006	0.007	0.047*	0.053***	0.062**	0.041	0.076**	0.013	0.027*	0.014	-0.017
Share of university graduates	0.195***	0.099	0.163***	0.326***	0.192***	0.106*	0.149***	0.343***	0.108***	0.021	0.153***	0.132***	0.216***	0.113*	0.162***	0.380***	0.081***	0.057	0.087*	0.063
Shortage of skilled workers	0.041***	0.046**	0.044**	0.021	0.035***	0.044**	0.039**	0.015	0.011*	0.039***	-0.004	0.001	0.038***	0.045**	0.032**	0.022	0.032***	0.011	0.036***	0.036**
Continuing training	0.101***	0.099***	0.091***	0.085***	0.096***	0.094***	0.095***	0.068**	0.014***	0.017**	0.007	0.008	0.088***	0.080***	0.091***	0.076**	0.046***	0.040***	0.038***	0.086***
R&D activities	0.260***	0.318***	0.289***	0.204***	0.281***	0.327***	0.306***	0.234***	0.145***	0.178***	0.173***	0.115***	0.320***	0.360***	0.342***	0.263***	0.220***	0.293***	0.205***	0.193***
Investment activities	0.127***	0.121***	0.119***	0.145***	0.122***	0.116***	0.111***	0.150***	0.026***	0.028***	0.021**	0.011	0.104***	0.094***	0.093***	0.139***	0.055***	0.052***	0.047***	0.080***
Technical equipment	0.042***	0.056***	0.039***	0.017	0.043***	0.056***	0.039***	0.021*	0.011***	0.017***	0.006	0.004	0.045***	0.047***	0.055***	0.031**	0.028***	0.022***	0.024***	0.048***
Export activities	0.110***	0.177***	0.071***	0.071***	0.103***	0.165***	0.074***	0.059**	0.025***	0.031**	0.025**	0.025	0.091***	0.117***	0.077***	0.059**	0.052***	0.064***	0.050***	0.030
Competitive pressure	0.064***	0.057***	0.067***	0.072**	0.064***	0.057***	0.066***	0.083***	0.006	-0.004	0.015	0.028*	0.054***	0.045***	0.049***	0.086***	0.021***	0.018**	0.005	0.037
Demand expectation	0.074***	0.074***	0.080***	0.066***	0.073***	0.068***	0.080***	0.069***	0.026***	0.032***	0.031***	0.015	0.065***	0.058***	0.064***	0.076***	0.038***	0.028***	0.054***	0.031*
Foreign company	-0.003	-0.042	-0.028	0.032	-0.006	-0.035	-0.038	0.026	0.009	0.001	-0.046**	0.050**	-0.006	-0.022	-0.054*	0.023	0.016	-0.000	-0.025	0.051*
Observations	10,955	4,855	3,529	2,571	10,956	4,856	3,529	2,571	10,960	4,860	3,528	2,572	10,955	4,857	3,526	2,572	10,958	4,859	3,527	2,572
R^2	0.213	0.141	0.191	0.218	0.211	0.141	0.190	0.224	0.082	0.076	0.097	0.074	0.224	0.137	0.191	0.234	0.146	0.117	0.110	0.131
Adj. R^2	0.210	0.133	0.181	0.204	0.207	0.132	0.180	0.210	0.078	0.067	0.086	0.058	0.221	0.128	0.181	0.221	0.142	0.109	0.099	0.115

*Notes: The table displays marginal effects from linear probability models, estimated for different dependent variables (binary indicators for general, product, radical and incremental product, and process innovation) by company size classes (I: full sample; II: 1-9 employees; III: 10-49 employees, IV: 50 or more employees). Further controls include indicators for economic sector and sixteen federal states. Significance levels are based on robust standard errors and denoted as: * p-value < 0.1, ** p-value < 0.05, *** p-value < 0.01.*

Source: IAB Establishment Panel, Wave 2017. Data access was provided via remote data execution. DOI: 10.5164/IAB.IABBP9317.de.en.v1.

6. Conclusion

The importance of VET for company's innovation activities has gained increased research interest. In this context, it has been empirically shown that VET institutions have an important contribution to the functioning of regional innovation systems. It would be expected that the empirical evidence at the company level is analogous to this, although surprisingly this is not the case as only a small or no relation between initial VET and innovation has been found. Hence, there is a need for further empirical research to establish whether and for which types of enterprises participation in VET results in innovation outcomes. This study directly addresses this research gap and provides empirical evidence on the role of VET for innovation in SMEs.

In this paper, we provide a conceptual framework for the channels through which VET may exert a positive impact on innovation in the majority of SMEs. On this basis, we evaluate the impact of initial VET activities on innovation outcomes at the company level using data from the German Employment Agency (the IAB EP dataset). To date, the quantitative testing of the hypothesis on a positive link between initial VET and innovation is underdeveloped. To our knowledge, the pioneering study of Rupietta and Backes-Gellner (2019) was the first to provide some empirical evidence on this issue. However, their estimates are in contrast to the results obtained by Hodge and Smith (2019).

Against this background, we observe a positive correlation between VET activities and innovativeness for the whole sample of German companies. Overall, as expected, participation in initial VET has virtually no effect on radical product innovation. However, a positive impact of training apprentices is observed in case of incremental product innovation and process innovation activities. According to our estimates, this finding primarily applies to the case of microenterprises with fewer than ten employees. We conclude from this that active participation in the VET system primarily promotes the innovation activities of very small firms by stimulating knowledge diffusion in regional innovation systems and developing absorptive capacities at the company level.

Our results – which show the importance of initial VET for innovation in small-sized firms – hold relevance for innovation policy. They imply that a microenterprise's participation in the VET system helps it to improve its skill and competence portfolio, establish structures conducive to organizational learning and strengthen its capacity to absorb technological knowledge from VET education institutions. Hence, particularly the smallest among training companies seem to benefit from the knowledge transfer from VET institutions. As a result, they should be more likely to succeed in overcoming – at least in part – some of their size-related disadvantages in innovation.

Promoting a company's engagement in the VET system should therefore not only be regarded by policy-makers as a tool to foster the smooth integration of youth into the regular labor market and secure a supply of skilled workers, but also as a measure of innovation policy towards the SME sector. Similarly, the technological upgrade of vocational schools and training centers should not only be considered as a tool of modern education policy, but also as an integral part of (SME-oriented) innovation policy.

Regarding future research, there is an ongoing need for further empirical studies to establish the empirical relationships between VET and innovation and hence deliver further evidence for education and innovation policy. Identifying whether and for which types of enterprises participation in initial VET helps to facilitate organizational learning and results in superior innovation outcomes also remains unresolved, particularly in the interplay with induced management innovations (Rupietta, Meuer, and Backes-Gellner 2021; Barabasch and Keller 2020; Hodge and Smith 2019). Quantitatively, the central challenge refers to improving the identification strategy. In this respect, it would be promising to examine the long-term innovation effects of initial VET activities based on panel data, especially focusing on the impact for SMEs as these often rely on innovation sources beyond R&D (Hervás-Oliver et al. 2021). Focusing on the individual level, apprentices' contributions to management and technological innovation should be investigated thoroughly (Hodge and Smith 2019; Rupietta, Meuer, and Backes-Gellner 2021) considering the characteristics of an innovation-friendly learning environment for apprenticeships (Barabasch and Keller 2020). Hence, there remains a need and room for further research on the subject matter.

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Appendix A.

Table A1. Descriptive Statistics

		All companies		Training companies		Non-training companies	
	Description	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Dependent variables							
General innovation	1 if firm conducted product and/or process innovation	0.43	0.50	0.53	0.50	0.35	0.48
Product innovation	1 if firm conducted product innovation	0.41	0.49	0.50	0.50	0.34	0.47
Radical product innovation	1 if firm conducted new-to-market product innovations	0.07	0.26	0.09	0.29	0.06	0.23
Incremental product innovation	1 if firm conducted product innovation which is not new to the market	0.41	0.49	0.50	0.50	0.33	0.47
Process innovation	1 if firm conducted process innovation	0.16	0.37	0.22	0.41	0.11	0.31
Explanatory variable							
Training company	1 if firm employs apprentices (VET students)	0.46	0.50	1.00	0.00	0.00	0.00
Control variables							
Company size	Total number of employees	114.30	858.34	215.06	1,257.90	29.81	110.04
Share of workers with vocational qualification	Employees with completed vocational training in total employment (%)	0.55	0.29	0.63	0.24	0.49	0.30
Share of workers with university degree	Employees with higher education in total employment (%)	0.09	0.18	0.09	0.16	0.08	0.19
Competitive pressure	1 for medium / substantial competitive pressure	0.69	0.46	0.73	0.44	0.66	0.47
Demand expectation	1 if company expects increasing business volume next year	0.26	0.44	0.30	0.46	0.24	0.43
Foreign company	1 if company is foreign owned	0.06	0.24	0.07	0.26	0.06	0.23
Shortage of skilled workers	1 if a company reports lack of skilled workers	0.25	0.43	0.34	0.47	0.17	0.37
Continuing training	1 if a company provides continuing training to their employees	0.67	0.47	0.86	0.35	0.51	0.50
R&D activities	1 if a company conducts in-house R&D	0.11	0.31	0.16	0.37	0.06	0.23
Investment activities	1 if a company made investments in 2016	0.61	0.49	0.74	0.44	0.50	0.50
Technical equipment	State of a company's technical equipment (1 "state-of-the-art" – 4 "out of date")	2.75	0.76	2.80	0.73	2.71	0.78
Export activities	1 for exporting companies	0.22	0.41	0.30	0.46	0.15	0.36

Source: IAB Establishment Panel, Wave 2017. Data access was provided via remote data execution. DOI: 10.5164/IAB.IABBP9317.de.en.v1

Table A2. Correlation Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13
Training company	1												
Company size	0.108	1											
Share qualified workers	0.253	0.012	1										
Share university graduates	0.023	0.081	-0.280	1									
Shortage of skilled workers	0.194	0.032	0.123	0.068	1								
Continuing training	0.364	0.079	0.232	0.216	0.173	1							
R&D activities	0.169	0.110	0.010	0.257	0.096	0.157	1						
Investment activities	0.238	0.069	0.118	0.097	0.147	0.262	0.148	1					
Technical equipment	0.055	0.018	0.060	0.057	0.043	0.147	0.028	0.129	1				
Export activities	0.177	0.074	0.090	0.199	0.073	0.130	0.430	0.152	-0.013	1			
Competitive pressure	0.082	0.012	0.063	-0.070	0.071	-0.000	0.105	0.070	-0.011	0.118	1		
Demand expectation	0.067	0.016	-0.004	0.026	0.128	0.066	0.106	0.137	0.066	0.094	0.042	1	
Foreign company	0.030	0.040	-0.029	0.088	0.012	0.018	0.138	0.009	-0.036	0.160	0.059	0.037	1

Source: IAB Establishment Panel, Wave 2017. Data access was provided via remote data execution. DOI: 10.5164/IAB.IABBP9317.de.en.v1