

Swiss Leading House

Economics of Education • Firm Behaviour • Training Policies

Working Paper No. 194

Apprenticeships

Uschi Backes-Gellner and Patrick Lehnert



Universität Zürich
IBW – Institut für Betriebswirtschaftslehre

u^b

^b
UNIVERSITÄT
BERN

Working Paper No. 194

Apprenticeships

Uschi Backes-Gellner and Patrick Lehnert

June 2022

Published as: "Apprenticeships." Elgar Encyclopedia of Labour Studies (2023), Ed. Tor Eriksson. Cheltenham: Edward Elgar Publishing Ltd., 14-18. By Uschi Backes-Gellner and Patrick Lehnert.

DOI: <https://doi.org/10.4337/9781800377547.ch04>

Die Discussion Papers dienen einer möglichst schnellen Verbreitung von neueren Forschungsarbeiten des Leading Houses und seiner Konferenzen und Workshops. Die Beiträge liegen in alleiniger Verantwortung der Autoren und stellen nicht notwendigerweise die Meinung des Leading House dar.

Discussion Papers are intended to make results of the Leading House research or its conferences and workshops promptly available to other economists in order to encourage discussion and suggestions for revisions. The authors are solely responsible for the contents which do not necessarily represent the opinion of the Leading House.

The Swiss Leading House on Economics of Education, Firm Behavior and Training Policies is a Research Program of the Swiss State Secretariat for Education, Research, and Innovation (SERI).

www.economics-of-education.ch

Apprenticeships

Uschi Backes-Gellner & Patrick Lehnert

University of Zurich, Department of Business Administration & Swiss Leading House VPET-ECON: A Research Center on the Economics of Education, Firm Behavior and Training Policies, Plattenstrasse 14, CH-8032 Zurich, Switzerland

Keywords: dual apprenticeship, vocational education and training (VET), human capital, training costs and benefits

JEL Codes: E24, J21, J24, J62, M51, M53

1. Introduction

Apprenticeship training, also known as ‘dual vocational education and training’ (VET), constitutes one of the two main pillars of the education systems in German-speaking countries (Eichhorst et al., 2015; Ryan, 2001; Wolter & Ryan, 2011). Students in these countries can choose either the academic educational path, which usually leads to a university education, or the vocational path, which leads to a dual apprenticeship in a vocational occupation of their choice. This article covers dual apprenticeships in countries with strong VET systems, such as Germany or Switzerland.

To enter a dual apprenticeship programme after completing compulsory school at age 15 to 16, students must apply to a training firm for an apprenticeship position, through an application procedure very similar to that for a regular job (e.g. Mueller & Wolter, 2014). During dual apprenticeships, students spend roughly three-quarters of their training time at a training firm, where they acquire practical skills according to well-specified, nationally defined occupational curricula. They

spend the remaining time at a vocational school, where they acquire both occupation-related and more general (cross-occupational) theoretical knowledge, again according to their occupational curriculum. Both the training firms and the vocational schools must follow the national curricula, and student learning is assessed through nationally defined examination procedures and timelines, thereby ensuring that all students completing a dual apprenticeship in a particular occupation possess similar skill sets. The duration of a dual apprenticeship programme is typically three to four years, depending on the occupation.

Given the structure of dual apprenticeships, firms are crucial contributors to VET and thus to the entire education system. Therefore, from an economic perspective, the question arises under what conditions firms are willing to contribute to a well-functioning apprenticeship system and how firms and individuals share the costs and benefits of dual apprenticeships. This article summarises key theoretical arguments on how costs and benefits of dual apprenticeships are shared and outlines important empirical evidence.

2. Theoretical foundations of dual apprenticeship training as a human capital investment

2.1 Standard human capital theory (Becker, 1962, 1964)

According to Becker (1962, 1964), any type of education constitutes an investment in human capital. Becker's (1962, 1964) human capital theory thus provides the foundation for an economic analysis of investments in apprenticeship training. According to his theory, individuals decide to participate in education or training (and thus invest in their human capital) if their expected benefits

exceed their participation costs. Likewise, firms decide to provide training to individuals if their expected benefits exceed their costs of providing training. Consequently, education and training programmes have to offer net benefits to individuals, firms or both to ensure their participation.

To determine who is willing to cover the costs and who will earn the benefits of an education and training programme, human capital theory distinguishes between general and firm-specific human capital. General human capital increases productivity to the same extent in both the training firm and any other firm, is fully marketable, and thus forces firms to pay the trained individuals wages that equal those individuals' marginal productivity. Therefore, individuals reap all the benefits of investments in general training. Hence, human capital theory predicts that individuals themselves have to bear all the costs of general training, because firms are not willing to bear any.

In contrast, firm-specific human capital increases productivity only in the training firm and is not marketable, thereby enabling firms to pay trained individuals wages below those individuals' marginal productivity. Firms can thus reap benefits from investments in firm-specific training, but only if the trained workers stay in the training firm. Therefore, firms are willing to bear training costs as long as they can expect the trained workers to stay. To incentivise workers to stay, firms share both the benefits and costs of firm-specific training with the trained workers.

Dual apprenticeship programmes provide general human capital because the training has to follow legally binding, nationally standardised curricula. Therefore, according to standard human capital theory, firms are not expected to be willing to invest in apprenticeship training or bear any training costs. However, empirical studies clearly show that firms both offer dual apprenticeship training and cover substantial parts of the costs of this training. For example, recent cost-benefit studies show that about 70% of German training firms and about 40% of Swiss training firms incur net costs (Gehret et al., 2019; Schönfeld et al., 2020), and earlier studies already showed similar results, for example for the 1970s and 1980s (Sachverständigenkommission Kosten und

Finanzierung der beruflichen Weiterbildung, 1974; von Bardeleben et al., 1995). The early empirical results thus started an extensive research discussion on the ‘net-cost puzzle’ of dual apprenticeship training, often also referred to as the ‘new training literature’.

2.2 New training literature

Early theoretical studies in the new training literature include Sadowski (1980), who discusses labour market reputation and improved recruiting as an explanation for the net-cost puzzle of dual apprenticeship training, or Harhoff and Kane (1993, 1997), who argue that a compressed wage structure in Germany gives firms an opportunity to reap the benefits of apprenticeship training. Later studies – for example Stevens (1994) and Acemoglu and Pischke (1998) – point more generally towards market imperfections that equip firms with enough market power to prevent dual apprenticeship-graduates from switching to external employers without losing income. More recent studies consider additional sources of labour market frictions, such as residential inertia or works councils (e.g. Booth & Bryan, 2007; Dustmann & Schönberg, 2009, 2012).

All these theories help explain why firms are willing to invest in apprenticeship training even though it teaches general skills. Importantly, however, these theories do not systematically distinguish between different types of apprenticeship occupations. Yet this distinction is critical, given that firms and individuals may face very different occupation-specific challenges. Lazear’s (2009) skill-weights approach provides a new foundation for both studying the net-cost puzzle of dual apprenticeships and answering research questions resulting from the gap in previous theoretical explanations.

2.3 Lazear's (2009) skill-weights approach: a micro-foundation of human capital theory

According to Lazear's (2009) skill-weights approach, all single skills are general, but particular combinations of single skills (skill bundles) can be more or less specific depending on their usefulness in the overall labour market. Drawing on this theory, one can interpret occupations as representing skill bundles, with different occupations being more or less specific. This interpretation helps explain differences in a variety of labour market outcomes across occupations.

The first study to apply this approach is Mure (2007), followed by Geel et al. (2011), Eggenberger et al. (2018) and Rinawi & Backes-Gellner (2021). These studies show, for example that a higher degree of occupational specificity leads to lower occupational mobility and to a larger share of training costs borne by firms. Later studies apply Lazear's (2009) theory, for example in explaining differences in individuals' labour market outcomes across occupations after international trade shocks (Eggenberger et al., 2022) or after opening borders for free movement of labour (Pregaldini & Backes-Gellner, 2021). In addition, the theory has great potential for explaining other labour market phenomena arising from, for example increased digitisation or ageing societies.

3. Empirical evidence on the costs and benefits of dual apprenticeship training

3.1 Firms' costs and benefits during and after dual apprenticeships

A series of studies on the costs and benefits of dual apprenticeships in Switzerland find that, on

average, Swiss firms that train apprentices experience net benefits during the three- to four-year training period (e.g. Gehret et al., 2019; Wolter et al., 2006). While firms' costs for apprenticeship training (e.g. apprentice pay, trainers' wages, materials) may exceed their immediate benefits (i.e. apprentices' productive work output) in the first one to two years, firms' benefits become larger than their costs during the third or fourth year, thereby enabling firms to earn net benefits over the entire training period (Gehret et al., 2019; Strupler & Wolter, 2012).

In contrast, empirical evidence for Austria and Germany suggests that firms in these two countries face net costs during the training period (Beicht et al., 2004; Dionisius et al., 2009; Moretti et al., 2019). These country differences are attributable to apprentices in Germany spending less training time on productive activities and by apprentice pay being higher in Austria (Dionisius et al., 2009; Moretti et al., 2019). Accordingly, Mohrenweiser and Backes-Gellner (2010) find that the majority of German training firms follow an investment strategy, that is they accept net costs during the training period to earn benefits from dual apprenticeship-graduates staying at the training firm in the post-training period.

As a further benefit, firms engaging in dual apprenticeship training profit from improved innovativeness. Two mechanisms lead to this improvement. Firstly, a systematic process of updating occupational curricula with inputs from firms operating at the innovation frontier promotes the most future-oriented skills in dual apprenticeships and, thereby, the diffusion of new technologies (Backes-Gellner, 1996; Rupiotta & Backes-Gellner, 2019; Schultheiss & Backes-Gellner, 2021). Secondly, firms can profit from new skill combinations of dual apprenticeship-graduates who continue to a university of applied sciences (UAS), a tertiary-level institution targeting primarily dual apprenticeship-graduates and teaching vocational and applied research knowledge. The knowledge that dual apprenticeship-graduates obtain at UASs enables firms to increase their research and development activities and, ultimately, their profits (Lehnert et al., 2020; Pfister et al., 2021; Schlegel

et al., 2022). For an overview of the benefits of dual apprenticeship training for innovation, see Backes-Gellner and Pfister (2019) and Backes-Gellner and Lehnert (2021).

These empirical results demonstrate that the solution to the net-cost puzzle takes different forms in different countries. Indeed, additional empirical analyses provide evidence of large differences in labour market imperfections across countries and for firms using alternative internal mechanisms (e.g. incentive pay) to retain their dual apprenticeship-graduates (e.g. Mohrenweiser et al., 2019; Mühlemann et al., 2013; Pfeifer & Backes-Gellner, 2018; Rinawi & Backes-Gellner, 2020). Further research also shows that training apprentices can serve as a screening instrument for more effectively recruiting internally (particularly for firms following an investment strategy), thereby saving potentially high recruitment costs (Blatter et al., 2016; Mohrenweiser et al., 2019; Pfeifer & Backes-Gellner, 2018). Moreover, participation in dual apprenticeship training can positively influence firms' reputations, thereby attracting better workers from the external labour market (Backes-Gellner & Tuor, 2010; Sadowski, 1980).

3.2 Individuals' benefits from apprenticeship training

As to the long-term benefits for individuals who invested in apprenticeship training, empirical evidence for Switzerland suggests that the lifetime earnings and employability of dual apprenticeship-graduates are comparable to those of individuals with an academic degree. Dual apprenticeship-graduates thus profit from their investment in apprenticeship training and offset the costs they bear during the training period (Pfister et al., 2017; Schweri et al., 2020; Tuor & Backes-Gellner, 2010). Moreover, Chuard & Grassi (2021) find a high intergenerational income mobility in Switzerland compared to many other developed countries, attributing it to the dual apprenticeship system and the permeability in the overall education system.

Recent studies drawing on Lazear's (2009) skill-weights approach refine this empirical evidence. They show that individuals who completed a dual apprenticeship programme in a more specific occupation have lower occupational mobility but higher average earnings, provided that they stay in their original occupation (Eggenberger et al., 2018; Geel & Backes-Gellner, 2011; Rinawi & Backes-Gellner, 2021). Hence, given this trade-off, individuals can choose their training occupation according to their individual risk preferences. Further empirical evidence suggests that social skills and certain types of digital skills (both of which individuals acquire in dual apprenticeship programmes in many occupations) increase occupational mobility and employability and that individuals always have to consider risk-return trade-offs, particularly when economic conditions are likely to change (e.g. in case of external trade shocks or accelerated technological progress) (Eggenberger & Backes-Gellner, 2021; Eggenberger et al., 2022; Kiener et al., 2019).

In addition to benefits such as higher earnings and better employability, dual apprenticeship-graduates also experience a variety of further advantages. For example Switzerland's highly permeable education system gives dual apprenticeship-graduates not only excellent prospects for labour market entry but also a diversity of educational career options (e.g. obtaining a tertiary-level vocational degree at a UAS or – after fulfilling additional requirements – studying at a top Swiss academic university) (Cattaneo, 2011; Pfister et al., 2017; Tuor & Backes-Gellner, 2010). Such educational upgrades also build valuable knowledge bridges between dual apprenticeship-graduates and tertiary-level academic graduates in firms, thereby creating positive spillovers for dual apprenticeship-graduates in these firms – just as a rising tide lifts all boats (Schultheiss et al., 2021). Dual apprenticeships also foster the development of personal characteristics such as self-esteem or self-competence, which, in the long term, are associated with increased labour market success (Hoeschler et al., 2018).

4. Discussion and future research

This article has presented theoretical foundations and empirical evidence on the costs and benefits of dual apprenticeships, and shown that an investment in dual apprenticeships is beneficial for both individuals and firms in the short and long terms. Although research on the costs and benefits of dual apprenticeships is already steadily increasing, the field still offers a variety of valuable avenues for future research.

A first such avenue is the contribution of dual apprenticeship training to innovation. International literature on the effects of education on innovation often argues that an economy needs tertiary-level academic skills, rather than vocational skills, to achieve a high level of innovation (e.g. Aghion et al., 2014; Krueger & Kumar, 2004). However, this literature often neglects the important role of vocational education in innovation in countries with well-developed dual VET systems. While the empirical evidence summarised in this article has shown that dual apprenticeships can be an important driver of innovation, analysing the underlying mechanisms – and thus contributing to a better understanding of this relation – is promising for future research.

A second, and related, avenue is the ability of dual VET systems to adapt to technological change and guarantee sufficient adaptation with the necessary speed. While systematic updates of dual apprenticeship curricula (e.g. approx. every five years in Switzerland) ensure that both individuals and firms can keep pace with technological change and continue contributing to innovation (Backes-Gellner & Pfister, 2019), sometimes curricula will need more frequent updates, given the accelerating pace of technological change. In addition, meeting these challenges may require adjustments in other elements of a dual VET system (e.g. training modes, trainer qualifications, examination types). The question of which incentives are critical for achieving such systemic

adjustments, in particular, remains unexplored.

A third avenue for future research entails tackling the consequences of ageing societies for economies based on dual apprenticeship training. In ageing societies with fewer labour market entrants, imparting new skills (especially digital skills) to the workforce through dual apprenticeship-graduates will no longer suffice. Rather, lifelong learning that systematically adds to older workers' initial education and training will become crucial. The empirical evidence on the adaptability of dual apprenticeship-graduates with broad occupational skill bundles (summarised in this article) suggests that dual VET systems are thus far comparatively well-equipped for meeting changing skill demands. However, future research needs to investigate more closely how the economic and technological developments challenge the functionality of dual apprenticeships and how those apprenticeships can be systematically complemented by continuous education programmes.

Acknowledgements

The authors would like to thank Marco Henriques Pereira for excellent research assistance and Natalie Reid for language consulting. The work on this study was partly funded by the Swiss State Secretariat for Education, Research and Innovation through its “Leading House VPET-ECON: A Research Center on the Economics of Education, Firm Behavior and Training Policies”

Further Reading

- Backes-Gellner, U., & Lehnert, P. (2021). The contribution of vocational education and training to innovation and growth. In *Oxford Research Encyclopedia of Economics and Finance*. <https://doi.org/10.1093/acrefore/9780190625979.013.653>
- Backes-Gellner, U., & Pfister, C. (2019). *The contribution of vocational education and training to innovation: The case of Switzerland* (Study elaborated as part of the report “Research and innovation in Switzerland 2020”, Part C, Study 1). State Secretariat for Education, Research and Innovation. <https://doi.org/10.5167/uzh-183335>
- Backes-Gellner, U., Renold, U., & Wolter, S. C. (2020). *Economics and governance of vocational and professional education and training (including apprenticeship)*. hep.
- Mühlemann, S., & Wolter, S. C. (2019). *The economics of apprenticeship training: Seven lessons learned from cost-benefit surveys and simulation*. Bertelsmann. <https://doi.org/10.11586/2019062>
- Mühlemann, S., & Wolter, S. C. (2021). Business cycles and apprenticeships. In *Oxford Research Encyclopedia of Economics and Finance*. <https://doi.org/10.1093/acrefore/9780190625979.013.655>

- Ryan, P. (2001). The school-to-work transition: A cross-national perspective. *Journal of Economic Literature*, 39(1), 34-92. <https://doi.org/10.1257/jel.39.1.34>
- Wolter, S. C., & Ryan, P. (2011). Apprenticeship. In E. A. Hanushek, S. Machin, & L. Woessmann (Eds.), *Handbook of the economics of education* (Vol. 3, pp. 521-576). Elsevier. <https://doi.org/10.1016/B978-0-444-53429-3.00011-9>

References

- Acemoglu, D., & Pischke, J.-S. (1998). Why do firms train? Theory and evidence. *The Quarterly Journal of Economics*, 113(1). <https://doi.org/10.1162/003355398555531>
- Aghion, P., Akcigit, U., & Howitt, P. (2014). What do we learn from Schumpeterian growth theory? In P. Aghion, & S. N. Durlauf (Eds.), *Handbook of economic growth* (volume 2B, pp. 515-563). Elsevier. <https://doi.org/10.1016/B978-0-444-53540-5.00001-X>
- Backes-Gellner, U. (1996). *Betriebliche Bildungs- und Wettbewerbsstrategien im deutsch-britischen Vergleich* (International vergleichende Schriften zur Personalökonomie und Arbeitspolitik, Band 5). Rainer Hampp.
- Backes-Gellner, U., & Lehnert, P. (2021). The contribution of vocational education and training to innovation and growth. In *Oxford Research Encyclopedia of Economics and Finance*. <https://doi.org/10.1093/acrefore/9780190625979.013.653>
- Backes-Gellner, U., & Pfister, C. (2019). *The contribution of vocational education and training to innovation: The case of Switzerland* (Study elaborated as part of the report “Research and innovation in Switzerland 2020”, Part C, Study 1). State Secretariat for Education, Research and Innovation. <https://doi.org/10.5167/uzh-183335>
- Backes-Gellner, U., & Tuor, S. N. (2010). Avoiding labor shortages by employer signaling: On the importance of good work climate and labor relations. *ILR Review*, 63(2), 271-286. <https://doi.org/10.1177/001979391006300205>
- Becker, G. S. (1962). Investment in human capital: A theoretical analysis. *Journal of Political Economy*, 70(5), 9-49. <https://doi.org/10.1086/258724>
- Becker, G. S. (1964). *Human capital: A theoretical and empirical analysis, with special reference to education*. National Bureau of Economic Research.
- Beicht, U., Walden, G. & Herget, H. (2004). *Kosten und Nutzen der betrieblichen Berufsausbildung in Deutschland*. Bertelsmann.
- Blatter, M., Mühlemann, S., Schenker, S., & Wolter, S. C. (2016). Hiring costs for skilled workers and the supply of firm-provided training. *Oxford Economic Papers*, 68(1), 238-257. <https://doi.org/10.1093/oeq/gpv050>
- Booth, A. L., & Bryan, M. L. (2007). Who pays for general training in private sector Britain? In S. W. Polachek, & O. Bargain (Eds.), *Aspects of Worker Well-Being* (Research in Labor Economics, Vol. 26, pp. 85-123). Emerald. [https://doi.org/10.1016/S0147-9121\(06\)26003-5](https://doi.org/10.1016/S0147-9121(06)26003-5)
- Cattaneo, M. A. (2011). New estimation of private returns to higher professional education and training. *Empirical Research in Vocational Education and Training*, 3, 71-84. <https://doi.org/10.1007/BF03546499>
- Chuard, P., & Grassi, V. (2021), *Switzer-Land of opportunity: Intergenerational income mobility in the land of vocational education* (first version 2020). Available at SSRN: <https://doi.org/10.2139/ssrn.3662560>
- Dionisius, R., Mühlemann, S., Pfeifer, H., Walden, G., Wenzelmann, F., & Wolter, S. C. (2009). Costs and benefits of apprenticeship training: A comparison of Germany and Switzerland. *Applied Economics Quarterly*, 55(1), 7-37. <https://doi.org/10.3790/aeq.55.1.7>
- Dustmann, C., & Schönberg, U. (2009). Training and Union Wages. *The Review of Economics and Statistics*, 91(2), 363-376. <https://doi.org/10.1162/rest.91.2.363>
- Dustmann, C., & Schönberg, U. (2012). What makes firm-based vocational training schemes successful? The role of commitment. *American Economic Journal: Applied Economics*, 4(2), 36-61. <https://doi.org/10.1257/app.4.2.36>
- Eggenberger, C., & Backes-Gellner, U. (2021). IT skills, occupation specificity and job separations. *Swiss Leading House “Economics of Education” Working Paper No. 172* (first version 2020).
- Eggenberger, C., Janssen, S., & Backes-Gellner, U. (2022). The value of specific skills under shock: High risks and high returns. *Labour Economics, forthcoming*. <https://doi.org/10.1016/j.labeco.2022.102187>

- Eggenberger, C., Rinawi, M., & Backes-Gellner, U. (2018). Occupational specificity: A new measurement based on training curricula and its effect on labor market outcomes. *Labour Economics*, 51, 97-107. <https://doi.org/10.1016/j.labeco.2017.11.010>
- Eichhorst, W., Rodríguez-Planas, N., Schmidl, R., & Zimmermann, K. F. (2015). A road map to vocational education and training in industrialized countries. *ILR Review*, 68(2), 314-337. <https://doi.org/10.1177/0019793914564963>
- Geel, R., & Backes-Gellner, U. (2011). Occupational mobility within and between skill clusters: An empirical analysis based on the skill-weights approach. *Empirical Research in Vocational Education and Training*, 3, 21-38. <https://doi.org/10.1007/BF03546496>
- Geel, R., Mure, J., Backes-Gellner, U. (2011). Specificity of occupational training and occupational mobility: An empirical study based on Lazear's skill-weights approach. *Education Economics*, 19(5), 519-535. <https://doi.org/10.1080/09645291003726483>
- Gehret, A., Aepli, M., Kuhn, A., & Schweri, J. (2019). *Lohnt sich die Lehrlingsausbildung für die Betriebe? Resultate der vierten Kosten-Nutzen-Erhebung*. Eidgenössisches Hochschulinstitut für Berufsbildung (EHB).
- Harhoff, D., & Kane, T. J. (1993). Financing apprenticeship training: Evidence from Germany. *NBER Working Paper* No. 4557.
- Harhoff, D., & Kane, T. J. (1997). Is the German apprenticeship system a panacea for the U.S. labor market? *Journal of Population Economics*, 10, 171-196. <https://doi.org/10.1007/s001480050037>
- Hoeschler, P., Balestra, S., & Backes-Gellner, U. (2018). The development of non-cognitive skills in adolescence. *Economics Letters*, 163, 40-45. <https://doi.org/10.1016/j.econlet.2017.11.012>
- Kiener, F., Gnehm, A.-S., Clematide, S., & Backes-Gellner, U. (2019). Different types of IT skills in occupational training curricula and labor market outcomes. *Swiss Leading House "Economics of Education" Working Paper* No. 159.
- Krueger, D., & Kumar, K. B. (2004). Skill-specific rather than general education: A reason for US–Europe growth differences? *Journal of Economic Growth*, 9(2), 167-207. <https://doi.org/10.1023/B:JOEG.0000031426.09886.bd>
- Lazear, E. P. (2009). Firm-specific human capital: A skill-weights approach. *Journal of Political Economy*, 117(5), 914-940. <https://doi.org/10.1086/648671>
- Lehnert, P., Pfister, C., & Backes-Gellner, U. (2020). Employment of R&D personnel after an educational supply shock: Effects of the introduction of Universities of Applied Sciences in Switzerland. *Labour Economics*, 66, Article 101883. <https://doi.org/10.1016/j.labeco.2020.101883>
- Mohrenweiser, J., & Backes-Gellner, U. (2010). Apprenticeship training: For investment or substitution? *International Journal of Manpower*, 31(5), 545-562. <https://doi.org/10.1108/01437721011066353>
- Mohrenweiser, J., Zwick, T., & Backes-Gellner, U. (2019). Poaching and firm-sponsored training. *British Journal of Industrial Relations*, 57(1), 143-181. <https://doi.org/10.1111/bjir.12305>
- Moretti, L., Mayerl, M., Mühlemann, S., Schlögl, P., & Wolter, S. C. (2019). So similar and yet so different: A firm's net costs and post-training benefits from apprenticeship training in Austria and Switzerland. *Evidence-based HRM*, 7(2), 229-246. <https://doi.org/10.1108/EBHRM-08-2018-0047>
- Mueller, B., & Wolter, S. C. (2014). The role of hard-to-obtain information on ability for the school-to-work transition. *Empirical Economics*, 46, 1447-1471. <https://doi.org/10.1007/s00181-013-0709-2>
- Mühlemann, S., Ryan, P., & Wolter, S. C. (2013). Monopsony power, pay structure, and training. *ILR Review*, 66(5), 1097-1114. <https://doi.org/10.1177/001979391306600504>
- Mure, J. (2007). *Weiterbildungsfinanzierung und Fluktuation: Theoretische Erklärungsansätze und empirische Befunde auf Basis des Skill-Weights Approach* (Beiträge zur Personal- und Organisationsökonomik, Band 16). Rainer Hampp.
- Pfeifer, H., & Backes-Gellner, U. (2018). Another piece of the puzzle: Firms' investment in training as production of optimal skills inventory. *Empirical Research in Vocational Education and Training*, 10, Article 6. <https://doi.org/10.1186/s40461-018-0067-6>
- Pfister, C., Koomen, M., Harhoff, D., & Backes-Gellner, U. (2021). Regional innovation effects of applied research institutions. *Research Policy*, 50(4), 88-910. <https://doi.org/10.1016/j.respol.2021.104197>
- Pfister, C., Tuor Sartore, S. N., & Backes-Gellner, U. (2017). The relative importance of type of education and subject area: Empirical evidence for educational decisions. *Evidence-based HRM*, 5(1), 30-58. <https://doi.org/10.1108/EBHRM-05-2015-0019>
- Pregaldini, D., & Backes-Gellner, U. (2021). How middle-skilled workers adjust to immigration: The role of occupational skill specificity. *Swiss Leading House "Economics of Education" Working Paper* No. 193.

- Rinawi, M., & Backes-Gellner, U. (2020). Firms' method of pay and the retention of apprentices. *Oxford Economic Papers*, 72(1), 269-291. <https://doi.org/10.1093/oep/gpy074>
- Rinawi, M., & Backes-Gellner, U. (2021). Labour market transitions after layoffs: The role of occupational skills. *Oxford Economic Papers*, 73(1), 76-97. <https://doi.org/10.1093/oep/gpz064>
- Rupietta, C., & Backes-Gellner, U. (2019). How firms' participation in apprenticeship training fosters knowledge diffusion and innovation. *Journal of Business Economics*, 89(5), 569-597. <https://doi.org/10.1007/s11573-018-0924-6>
- Ryan, P. (2001). The school-to-work transition: A cross-national perspective. *Journal of Economic Literature*, 39(1), 34-92. <https://doi.org/10.1257/jel.39.1.34>
- Sachverständigenkommission Kosten und Finanzierung der beruflichen Bildung (1974). *Kosten und Finanzierung der außerschulischen beruflichen Bildung (Abschlußbericht)* (Drucksache 7/1811). Verlag Dr. Hans Heger.
- Sadowski, D. (1980). *Berufliche Bildung und betriebliches Bildungsbudget*. Poeschel.
- Schönfeld, G., Wenzelmann, F., Pfeifer, H., Risius, P., & Wehner, C. (2020). Ausbildung in Deutschland – eine Investition gegen den Fachkräftemangel: Ergebnisse der BIBB-Kosten-Nutzen-Erhebung 2017/18. *BIBB Report* 1/2020.
- Schlegel, T., Pfister, C., & Backes-Gellner, U. (2022). Tertiary education expansion and regional firm development. *Regional Studies*, forthcoming. <https://doi.org/10.1080/00343404.2021.2010695>
- Schultheiss, T., & Backes-Gellner, U. (2021). Updated education curricula and accelerated technology diffusion in the workplace: Micro-evidence on the race between education and technology. *Swiss Leading House "Economics of Education" Working Paper* No. 173 (first version 2020).
- Schultheiss, T., Pfister, C., Gnehm, A.-S., & Backes-Gellner, U. (2021). Tertiary education expansion and task demand: Does a rising tide lift all boats? *Swiss Leading House "Economics of Education" Working Paper* No. 154 (first version 2019).
- Schweri, J., Eymann, A., & Aepli, M. (2020). Horizontal mismatch and vocational education. *Applied Economics*, 52(32), 3464-3478. <https://doi.org/10.1080/00036846.2020.1713292>
- Stevens, M. (1994). A theoretical model of on-the-job training with imperfect competition. *Oxford Economic Papers*, 46(4), 537-562.
- Strupler, M., & Wolter, S. C. (2012). *Die duale Lehre: Eine Erfolgsgeschichte – auch für die Betriebe*. Rüegger.
- Tuor, S., & Backes-Gellner, U. (2010). Risk-return trade-offs to different educational paths: Vocational, academic and mixed. *International Journal of Manpower*, 31(5), 495-519. <https://doi.org/10.1108/01437721011066335>
- von Bardeleben, R., Beicht, U., & Fehér, K. (1995). *Betriebliche Kosten und Nutzen der Ausbildung: Repräsentative Ergebnisse aus Industrie, Handel und Handwerk*. Bertelsmann.
- Wolter, S. C., Schweri, J., & Mühlemann, S. (2006). Why some firms train apprentices and many others do not. *German Economic Review*, 7(3), 249-264. <https://doi.org/10.1111/j.1468-0475.2006.00155.x>
- Wolter, S. C., & Ryan, P. (2011). Apprenticeship. In E. A. Hanushek, S. Machin, & L. Woessmann (Eds.), *Handbook of the economics of education* (Vol. 3, pp. 521-576). Elsevier. <https://doi.org/10.1016/B978-0-444-53429-3.0001-9>