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The costs of standardized apprenticeship curricula for training firms

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Abstract

Standardized curricula define the set of skills that must be trained within a training occupation and thus are a key regulatory element of apprenticeship systems. Although clear economic rationales support the usage of such curricula, they necessarily impose costs, especially on firms that train apprentices, but do not use the full set of skills in their productive process and/or train other skills that are not covered by the curriculum. In this paper, we identify the trade-offs involved in setting up training curricula and use data from the most recent survey on the costs and benefits of apprenticeship training among Swiss firms to quantify the associated costs to training firms. On average, training firms state that they do not use 17% of the training content prescribed by the relevant curriculum, and 11% of the companies train additional skills not covered by the curriculum. We show that both kinds of misfit are associated with higher training costs and lower productive output from apprentices. This shows that the regulator imposes costs on firms in order to guarantee broad skills development for apprentices. It also cautions against overly broad curricula that may impose disproportionate costs on firms.

Keywords: Apprenticeship, Curriculum, Firm training

Introduction

In many countries, apprenticeships provide an institutionalized setting for transmitting human capital in the workplace. Economists have wondered why profit-maximizing firms are willing to provide training places voluntarily, because this seemed to contradict the standard notion of human capital theory that firms do not finance general human capital. This apprenticeship puzzle spurred novel contributions to the theoretical literature on firm training (e.g. Stevens 1994, 2001; Acemoglu and Pischke 1999; Wolter and Ryan 2011). Although firms' training incentives and their dependence on market structures are better understood today, the role and effects of the regulatory framework of modern apprenticeship systems have attracted only limited attention in the empirical literature.

Key instrument in regulating apprenticeships in countries such as Austria, Germany, the Netherlands, Norway, and Switzerland are standardized national curricula, which define hundreds of training occupations. These curricula typically specify the duration

of training, the vocational skills that apprentices have to master during training, the final exams, and the certificate awarded.

Standardized vocational curricula are designed to solve three problems of unstandardized on-the-job training. First, the interests of firms and workers with respect to the content of training programs may diverge. Generic skills allow workers to move beyond the training industry and occupation after training. In the case of industry-specific or occupation-specific skills, it is more likely that only a limited number of suitable employers within the same industry value these skills. The labor market for industry-specific skills may thus be monopsonistic, which allows training firms to acquire a part of the return on these skills at the expense of apprentices. Smits (2007) shows that apprentices favor more generic skills because these put a lower bound on post-training wages in the case of imperfect competition for industry-specific skills. However, training firms prefer to keep the proportion of generic skills low, because they can then acquire more of the return on training. Curricula prescribe training in industry- and occupation-specific as well as generic skills to balance the conflicting interests of apprentices and firms.

Secondly, labor markets suffer from incomplete and asymmetric information. The amount and quality of on-the-job training provided by a firm, and thus apprentices' productivity, is hard to observe for other firms. Therefore, without certification, apprentices will not be paid according to their productivity on the labor market after training, which may reduce their effort during training (Acemoglu and Pischke 2000). Moreover, the complexity of vocational training makes it impossible to fully specify its details in a contract between firm and apprentices. Hence, on-the-job training is not legally enforceable and firms are able to renege on the quality of training they promised (Dustmann and Schönberg 2012), jeopardizing apprentices' progress to becoming skilled workers. Curricula standardize the amount and quality of training, which can then be tested in final examinations and certified by national diploma. Thus, standardized curricula make training enforceable and observable for all market actors, which in turn increases the incentives for apprentices and firms for training.

Thirdly, curricula allow firm-based training to be completed with state-run part-time vocational schools, which teach background knowledge in a setting free of the time and efficiency pressures that prevail in companies. Vocational schools provide both general education and occupation-specific knowledge, such as theoretical background on the use and functioning of machinery used in the occupation. Such a system needs coordination between firms and schools to guarantee that, ideally, the same skills are taught in similar sequences. Curricula specify the skills taught in all learning venues and coordinate the development of apprentices' skills in firms and in school. This coordination is important for bridging the gap between theory and practice, even if cooperation between learning venues remains a challenge (e.g. Euler 2020; Faßhauer 2020; Sauli 2021).

Although standardized curricula may enhance market efficiency in general, a few empirical studies have investigated different aspects of curricula and their impact on workers' careers. Eggenberger et al. (2018) compare the skills defined in Swiss vocational education and training (VET) curricula with those required in the overall labor market to determine the specificity of curricula. They find that apprentices profit from more specific skills bundles, because these increase their post-training wage in the learned occupation, but that more specific skills lower occupational mobility. Looking

at institutional characteristics of Swiss VET curricula rather than at the skill bundles specified, Grønning et al. (2020) find that a higher number of days dedicated to practical training is associated with a higher income in the first years after graduating from apprenticeship. In contrast, a higher number of days dedicated to general education is associated with an income advantage 10 years and more after graduation. The impact of VET curriculum modernizations in Germany have been analyzed by Jansen et al. (2017). Their results show that modernizations alone do not influence supply and demand on the apprenticeship market. However, modernizations that increase the heterogeneity of the curriculum, for instance by introducing more options for specialization, do increase both the supply of and the demand for apprentices in the occupation. The authors conclude that curricula that are more flexible allow firms to improve the match between curriculum requirements and firms' needs. However, binding requirements also offer advantages: Rupietta and Backes-Gellner (2019) argue that training firms profit from the faster diffusion of new technologies in the industry when curricula require the training of the corresponding skills, even though this may impose additional training costs in the short run. Schultheiss and Backes-Gellner (2020) confirm that the introduction of new technologies such as computerized numerical control (CNC) and computer aided design (CAD) in Swiss curricula led to an accelerated diffusion of these technologies into jobs in the overall labor market. Janssen and Mohrenweiser (2018) find that introducing CNC machine technology in German curricula harmed incumbent workers' careers, because the new curricula increased the supply of better trained workers.

In this paper, we focus on the restrictions and thus costs that standardized national curricula impose on training firms. Firms face two kinds of costs that arise from the gap between the skills specified in curricula and firms' own skills needs, which depend on their production technology. First, they are required to train all the skills defined in the curriculum even if they do not need all of them in their production processes and need extra effort to train them. Secondly, they have to train additional skills not defined in the curriculum, and thus not taught in vocational school, if they need them for their skilled workers to be optimally productive. Accordingly, our main hypothesis is that both kinds of mismatch between curriculum and firm needs are associated with higher training costs for firms. Moreover, firms may be affected to differing degrees by the two types of mismatch and their costs. The regulating bodies trade off the costs and benefits of broader and narrower curricula for both firms and apprentices. Because narrow curricula might jeopardize apprentices' long-term labor market careers, curricula may be broader than optimal for the average training firm. Our additional hypothesis is thus that the economy-wide costs borne by firms are higher for the mismatch resulting from skills they do not need, than from the mismatch due to skills needed but missing in the curriculum.

We empirically investigate the fit between the content of training curricula and the respective skill needs of training firms in Switzerland using data from the most recent survey on the costs and benefits of apprenticeship training and two measures of fit between curricula and firms' skills needs. Our first measure is firms' assessment of the proportion of the skills defined in the training curriculum that is not relevant to their own production process. Our second measure of fit is whether firms provided apprentices with additional skills that are not contained in the curriculum.

We find that most training firms have to train some skills that they do not deem necessary for their own production processes, but that only a minority trains skills beyond those defined in the curriculum. In line with our hypothesis, both measures of curriculum fit are associated with higher costs from training. Our cost estimations suggest that economy-wide costs for skills not needed exceed those for skills trained beyond those in the curricula. This finding is consistent with our second hypothesis.

Our paper contributes to the literature on firm training. We provide the first estimates of firms' costs resulting from skills standardization through national VET curricula. We also contribute to a better understanding of optimal VET policies, which have to strike a balance between equipping apprentices with transferable skill sets and safeguarding firms' willingness to train apprentices.

The remainder of this paper proceeds as follows. Section “[Apprenticeship curricula and the Swiss case](#)” presents the Swiss apprenticeship system and discusses the definition of skills in vocational curricula. Section “[Data and methods](#)” presents the cost–benefit data and the estimation models used in the analyses. Section “[Results and discussion](#)” reports our empirical findings, and Section “[Conclusion](#)” concludes.

Apprenticeship curricula and the Swiss case

Curricula and apprenticeship training in Switzerland

Switzerland has the highest proportion of work-based education programs on upper secondary level among all OECD countries (Hoeckel et al. 2009). More than 60% of each youth cohort serves an apprenticeship that combines working and learning in firms with vocational schools. Firms offer training places voluntarily and place advertisements for open apprenticeship positions, in the same way as for other vacancies. Firms and candidates (and their parents, in the case of minors) sign a standardized apprenticeship contract, which is then approved by the cantonal VET office.

Three main partners govern the Swiss VET system. The confederation enacts national laws, especially the law on vocational education and training. The cantons¹ run vocational schools, supervise training firms, and organize final exams. The professional associations represent the interests of their member companies in all profession-specific matters in educational and labor policy and advise member firms on related issues. Many operate training centers, offer further vocational training, and provide experts for the final apprenticeship exams.

Every apprenticeship is in one of approximately 280 training occupations. Each occupation is defined by a national curriculum, which consists of two documents per occupation: a training ordinance and a training plan.² The training ordinance contains all occupation-specific legal provisions, starting with the name of the occupation and the duration of training (2, 3, or 4 years). The training plan contains more details on the skills to be trained and the final exam.

¹ Switzerland is composed of 26 states or cantons.

² The training ordinance (“Bildungsverordnung”, “ordonnance sur la formation”) is enacted by the State Secretariat for Education, Research and Innovation (SERI), while the training plan (“Bildungsplan”, “plan de formation”) is enacted by the professional association that is in charge for the respective occupation, upon approval by the SERI. Examples may be found on a website maintained by the SERI (<https://www.becc.admin.ch/becc/public/bvz/beruf/grundbildungen>). This website also provides a list of all training occupations.

For each occupation, a specialized body called the “commission for occupational development and quality” develops both the ordinance and the plan. Experts in the occupation and stakeholders of VET serve in these commissions. In particular, the professional association provides the commission’s chair.³ Further groups represented are the confederation and the cantons, and often, but not always, trade unions, school representatives and educational experts. The commission defines the skills that apprentices should learn in firms, in vocational school, and at a third learning venue, called the industry course. The latter is organized by the professional association and designed to transmit occupational core skills that complement learning in firms.⁴

Every five years, the commissions have to evaluate their training plans and make sure that they are up-to-date. Revisions may range from minor to fundamental, for instance merging several occupations into one. Depending on its scope, the revision process may take some months or last for several years.⁵ Training plans play a significant role because training firms consult it to see which skills they are supposed to train, as these will be examined at the final exams. In addition, the training plan is helpful for firms that want to recruit skilled workers, because they can look up which skills an applicant has learned in a certain apprenticeship program and check the applicant’s final exam results visible in the grade certificate, which accompanies the federal diploma.

Curricula and firms’ training decision

We will first discuss how firms decide about training given the restrictions imposed by training curricula, and then discuss the commissions’ choice problem when defining skills in curricula in Section “[Defining skills in vocational curricula for training occupations](#)”. Throughout the discussion, we assume that apprenticeships convey mainly general and occupation-specific rather than firm-specific human capital (Wolter and Ryan 2011; Müller and Schweri 2015).

Firms need skilled workers, which they can either train themselves, or recruit from the external labor market (e.g., Aepli and Kuhn 2021). A firm will train, firstly, if the minimal net costs of training are zero or negative, as is the case when the returns from apprentices’ productive work are equal to or higher than gross training costs (Mühlemann and Wolter 2014). Secondly, a firm will also train if future returns cover net training costs.⁶ Employing the firms’ own apprentices as skilled workers generates such returns because it allows firms to forego hiring costs for external recruitment (Blatter et al. 2016). In sum, every firm chooses its optimal mix of training and external recruitment by minimizing the costs of training and hiring, which are determined by firms’ production technologies and the conditions on goods and factor markets.⁷

³ Professional associations are also key in defining the existence and delimitation of occupations. Baumeler et al. (2019) provide a case study of a professional association that was successful in reinstitutionalizing its occupation, the piano maker, against the will of other actors to merge it into an instrument makers’ apprenticeship together with related occupations.

⁴ The national law on VET requires that industry courses are part of every training occupation and every apprentice has to attend. Content and duration, which varies from a total of 7–94 days, are defined in the federal training ordinance and plan for every occupation.

⁵ On the revision process, see SERI (2017). The pedagogics of curriculum development are discussed in Zbinden (2010).

⁶ Acemoglu and Pischke (1999) discuss labor market frictions that allow firms to earn rents on their former apprentices due to a compressed wage structure.

⁷ See Pfeifer and Backes-Gellner (2018) for an application of inventory theory to firms’ training and hiring decisions.

Skill requirements in curricula change the firms' optimal choice by defining three sets of relevant skills: skills that the firm needs and that are part of the curriculum are easiest to train, because VET school and industry course support the training of these skills. A second set of skills needs to be trained, although the firm does not need it. This requirement enters the firms' cost minimization problem as a restriction. It sets a lower bound to the effort necessary to train apprentices. The firm will have to make an additional effort to train such skills, for example by organizing extra sessions to let apprentices learn and exercise skills outside of the regular production processes, which increases costs compared to a situation without curriculum requirements. Such additional training also limits the time available to let apprentices work on productive tasks that are beneficial for the firm, so curriculum requirements reduce the benefit that firms can achieve from apprentices' productive work. In addition, the skills determine apprentices' productivity as skilled workers after training and thus their mobility on the labor market. In monopsonistic labor markets, companies are able to earn rents on their skilled workers (Leuven 2005). If curricula increase apprentices' mobility after training, this will reduce rents for training firms. A third set of skills are those that the firm needs but which are not part of the curriculum.⁸ Because there is no support from school or industry course in this case, firms need to put in additional effort and allow time for apprentices to learn and practice these skills. Again, this will increase training costs and lower apprentices' productive contribution during training.

Because firms are heterogeneous in their production technologies, they experience varying degrees of misfit with curriculum skills even within industries and occupations. For instance, larger firms will likely exhibit a higher diversity of tasks, which decreases the content not used but increases the need for additional skills. Firms at the technological frontier may profit more from training additional skills not yet included in curricula. Firms with mainstream production technology will find less need to train additional skills. We will analyze empirically which firm characteristics are associated with curriculum misfit.

In sum, firms will minimize the cost of training by considering the effort necessary to train all required skills and the scope for productive work by apprentices. Some firms will also choose to train additional skills not prescribed in the curriculum, if these skills increase apprentices' productivity during or after training sufficiently to set off the additional costs. Based on these considerations, we expect that both types of curriculum misfit, training not used by the firm and the training of additional skills, increase gross training costs and reduce benefits from apprentices' productive work. Moreover, we hypothesize that misfit influences the training decision, which should be taken into account when analyzing the association of misfit and training costs. Finally, misfit might also impact the retention of apprentices after training. Firms that use fewer skills might find it more difficult to retain apprentices, because the latter can make more use of their skills in other firms. In contrast, firms that train additional skills may be more interested

⁸ The general nature of curricula may suggest that all firm-specific components of training in firms are such "additional skills". However, production processes as well as training often include firm-specific components as a complement to general skills. Therefore, many training plans incorporate such necessary aspects of firm-specific knowledge, such as "Knowing the operational and organizational structure of the firm" (OdaSanté 2017, p.10). Therefore, we do not consider basic firm-specific knowledge as additional skills that require any extra training effort by companies.

in retaining apprentices and thus willing to pay a higher wage, if the costs of and returns to additional training are shared between firms and apprentices.

Defining skills in vocational curricula for training occupations

The commissions' task of defining occupational curricula for the whole country is far from trivial. At a fundamental level, it entails selecting skill sets from the universe of all possible skill combinations in the labor market. Of course, such skill bundles already exist on labor markets in the form of occupations. The similarities of occupations between countries suggest that the bundling of skills into occupations is not random. It seems plausible that extant production technologies in combination with human physical and cognitive capabilities make some skill bundles more productive than others and that such skill bundles are more likely to crystalize as occupations.⁹ The bodies defining vocational curricula need to take into account production technologies and existing ways of organizing labor, especially existing occupations. However, vocational curricula also define the skill bundles that future skilled workers will possess. Vocational curricula may thus have an impact on production technologies themselves by providing skill bundles and corresponding production processes that would not or would scarcely exist if firms had to decide on training skills on their own.¹⁰ As a point in case, Marsden (1999, chapter 5) argues that firms in countries like Germany focus on training skilled workers and give them an important role in problem-solving activities. In contrast, firms in countries such as France tend to define problem-solving as a management task with less involvement of skilled workers. Thus, workers' skills, training and work organization are interdependent. Our empirical analyses abstract from these interdependencies and skill complementarities, but they should be recalled when thinking about optimal curriculum policies.

A key decision in developing curricula is to define the width of the skill sets. If the regulators opt for relatively narrow sets of skills for each training occupation, each curriculum will provide a close fit for the few firms that need exactly these skills but only a poor fit for most, which need different and/or additional skills. The VET system will then consist of many training occupations to provide a good fit for many firms with at least one of the training occupations. Even so, more restricted skill sets will result in more firms that want to invest in the additional skills that they require. The alternative is to define fewer training occupations with broader skills sets. Many firms will then have some overlap with their own skill needs. However, in addition to the skills they need, they are also required to train more skills that they do not need in their production processes.¹¹

⁹ Although the emergence of occupations has received some attention in other social sciences (e.g. Adams 2015; Brockmann et al. 2011; Strebel 2021), the economic literature has been largely silent on this issue, with the exception of a few specific topics such as occupational licensing. The literature on the task-based approach (Autor 2013) and the skill weights approach (Lazear 2009) conceptualize occupations as bundles of tasks and skills but treat occupations as exogenous and do not provide a theory of the emergence of occupations as a function of production technologies and resulting skills complementarities. An exception is Ocampo (2018), who develops a "task-based theory on occupations."

¹⁰ Coordination problems between firms may prevent the training of skills for particular production technologies. If so, curricula could serve as coordinating device that increases efficiency in industries by coordinating work organization, infrastructure, and training investments.

¹¹ An alternative would be to give firms some leeway in choosing the skills they want to train from a list in the curriculum, but that would weaken the coordinating and information-providing role of curricula.

Thus, regulators need to trade off the costs of broader and narrower curricula. Although we focus on the associated costs for individual firms in the analyses, the regulators must also account for the benefits of broader curricula, which accrue to apprentices because their market value after training rises (Smits 2007), and to the economy as a whole because of the information value of less diverse curricula for all actors. Narrow curricula with a large number of training occupations and corresponding tracks likely reduce skilled workers' mobility and may also increase the total information load for employers.¹² Thus, assuming that the benefits from apprentices' mobility and standardized information tend to increase with broader curricula, we hypothesize that curricula will be broader than most firms will find optimal for their own needs. We expect that this increase in misfit results in higher economy-wide costs for curricula content not used in firms than costs for training additional skills that are not part of the curriculum taught.

Curricula are updated regularly, as the previous section described. New technologies, globalization, and changes in the regulatory and demographic environments constantly change firms' tasks and skill needs at both micro and macro levels. Therefore, curriculum fit depends not only on broader or narrower skill sets, but also on when the curricula were last updated and firms' position with respect to the technological frontier. The older a curriculum is, the more likely it is that relevant new skills are not yet included. We expect that an increasing number of firms turn to training additional skills as the curricula age. However, when a revision takes place and new skills are included in the curriculum, this may increase the misfit in those firms that are not at the technological frontier. Over time, new technologies spread and more firms start to use the new skills, a process that may even be favored by updated VET curricula (Schultheiss and Backes-Gellner 2020). Hence, we hypothesize that the amount of curriculum content not used by firms will decrease with time elapsed since the revision.

Data and methods

Survey data and variables of interest

The Swiss survey on costs and benefits of training firms (CBS) offers information on in-company training activity, training organization, recruitment of skilled workers, and many other company characteristics. The survey is based on the established methodology of previous German and Swiss surveys (Dionisius et al. 2009; Mühlemann and Wolter 2014).

In spring 2017, a random sample of companies was surveyed, and 5712 training firms and 4064 non-training firms completed the online questionnaire (Gehret et al. 2019). Companies were sampled as random draws from a full population register, stratified by the training occupation and the size of the employer.¹³ For companies training in more

¹² This consideration seems plausible for a country with hundreds of defined VET occupations. The costs and benefits of broad curricula warrant further scrutiny in future studies. At some point, curricula may become too broad for apprentices, because apprentices have limited learning capacities and need enough time to gain experience with tasks and skills. Likewise, if curricula are very broad, the occupation may become very generic, which would offer only limited guidance for firms who want to recruit skilled workers.

¹³ Employers in the agricultural sector and micro companies and enterprises (i.e. companies with only one employee and enterprises with less than three employees) were excluded from the sampling frame and thus are not covered by our sample.

than one occupation, one occupation was chosen beforehand, and the questionnaire pertained to this particular training occupation (Kuhn and Schweri 2019).

For the analyses in this paper, we follow Blatter et al. (2016) and exclude public and non-profit companies, because the cost minimization problem discussed in Section “[Defining skills in vocational curricula for training occupations](#)” may not apply to non-private firms, who might thus react differently to the constraints set by training plans. Of the remaining 6679 firms, we also drop training firms that provided no answer on the two main questions on training plan fit.¹⁴ Thus, we arrive at a sample of 6502 firms, of which 4152 are training firms and 2350 are non-training firms. Missing values in control variables are below 1% for all variables and are treated as separate category of the variables in the estimations.

The questionnaire contained questions about the firm’s view of the federal training ordinance and plan for this occupation. The first variable of interest is the firms’ answer to the following question: “In firm training, it may happen that a part of the training content in the federal training plan is not actually needed in the firm. How large do you estimate is the proportion of training content that is regulated in the official SERI training plan, but not needed in your company?” (own translation). Technically possible answers in the online questionnaire ranged from 0% to 100%. We use this fractional variable and call it “Content not used”. On average, companies in our sample report not using 17% of the skills in the training plan (see panel (a) of Table 1). The survey also asked for concrete examples of contents not used in an open question format. Examples include specific web and application skills for information technologists, sales talks for baker-confectioners, and drawing by hand for draftsmen.

The second variable of interest asked: “Has your company trained additional skills in the apprenticeship year 2016/17, which surpass the content of the official training plan of SERI for the occupation under consideration?” Some 11% of all companies reported training additional skills (see panel (a) of Table 1 again). In addition to this yes-or-no question, companies could give examples in an open question format. Examples include rather firm-specific skills, such as learning about specific products that the training firm produces or sells and aspects of workplace safety, and general skills such as project management skills, training in new digital tools, and language courses.

The main goal of the survey was to collect components of costs and benefits of apprenticeship training from companies. Calculation of the total costs and benefits relies on the general method described in Mühlemann and Wolter (2014) and in Gehret et al. (2019) for the data at hand. Gross costs include apprentices’ wages, the wages for all training personnel (part-time and full-time trainers, administration), material and equipment costs, and other costs (e.g. fees for industry courses). The benefits accrue from apprentices’ productive work during the training period. Firms were asked about the time apprentices spend in their firm with unproductive tasks (e.g. exercises) or productive tasks of two types: tasks that could be performed by unskilled personnel, and tasks that could only be performed by skilled personnel. This allows us to calculate the opportunity costs of apprentices’ productive work: Multiplying the time spent on unskilled

¹⁴ We delete another 54 cases with answers of 80% content not used or more, because such a company would not obtain permission to train from the canton. It is likely that the respondents misread the question.

Table 1 Descriptive statistics, main variables

	Mean	s.d.	Min.	Max.	N
(a) Measures of curriculum (mis)fit					
Content not used	0.170	0.148	0	0.75	4152
Additional skills (yes = 1)	0.109	0.311	0	1	4152
(b) Costs and benefits of training, in CHF					
Gross costs	29,886	11,156	6399	106,797	4152
Productive output	31,989	9698	0	82,411	4152
Net benefit	2,103	14,112	-76,521	58,558	4152
(c) Selected firm-level characteristics					
Firm size					
1–9 Employees	0.452	0.498	0	1	4152
10–49 Employees	0.409	0.492	0	1	4152
50–99 Employees	0.066	0.248	0	1	4152
>100 Employees	0.074	0.261	0	1	4152
Member of professional association (yes = 1)	0.397	0.489	0	1	4142
Efficiency of production (yes = 1)	0.674	0.469	0	1	4130
Attractiveness for specialists (yes = 1)	0.735	0.442	0	1	4131
Affected by digitalization (yes = 1)	0.421	0.494	0	1	4138
Demand good (yes = 1)	0.594	0.491	0	1	4138
(d) Apprentice characteristics					
Share vocational baccalaureate	0.074	0.232	0	1	4152
Share adult	0.047	0.189	0	1	4152
Share short-apprenticeship	0.048	0.193	0	1	4152
Share female	0.387	0.452	0	1	4152

All results are weighted with sampling weights. The dummies for efficiency, attractiveness, and digitalization are all one for firms reporting “very” or “rather” in the respective question and zero otherwise. The lower number of observations among these dummies stem from missing answers on the respective question. Gross costs and productive outputs are firm averages per apprentice and year. Apprentice characteristics show the share of the respective group relative to the total of all apprentices in the company

productive tasks with the wage for unskilled workers in the same firm, and doing likewise for skilled tasks and workers, gives the costs for firms if they wanted to substitute apprentices’ work with work by other personnel in the firm. Because apprentices may not be as productive in skilled tasks as skilled workers, firms were also asked to rate apprentices’ performance levels compared to their skilled workers’ levels, which allows the value of apprentices’ productive work in skilled tasks to be adjusted. Panel (b) of Table 1 shows that annual gross costs and productive benefits per apprentice, averaged across the different occupations and employers, equals CHF 29,886 and CHF 31,989 respectively. The difference between the two yields the firm’s net benefit from training, or net cost if the value is negative. On average, the annual net benefits amount to CHF 2103 per apprentice. Note that these net benefits do not contain benefits that accrue to firms from retaining apprentices as skilled workers after the training period. Therefore, we test whether curriculum fit is associated with a higher or lower apprentice retention rate (see Appendix Table 8 for descriptives).

The survey also collected information on training organization, motives, hiring of skilled workers, and further firm characteristics. The last two were also collected for a random sample of non-training firms, plus motives for not training and the training occupation that the firm would most likely train if it chose to. We use the firm

characteristics to account for firm heterogeneity in the estimations. We include the number of employees (four categories), geographic location (seven greater regions, as defined by the FSO), training occupation (29 categories), and the firm's industrial affiliation (NACE, six categories) as controls. In some specifications, we also include an employer's self-assessment with regard to, for example, its attractiveness for specialists. In addition, we control for the average characteristics of the apprentices in the firm: the proportions of adult apprentices, female apprentices, apprentices acquiring a vocational baccalaureate during training, and apprentices who complete the apprenticeship in shorter time than usual (see panel (c) of Table 1 as well as Appendix Table 9 for corresponding descriptives).

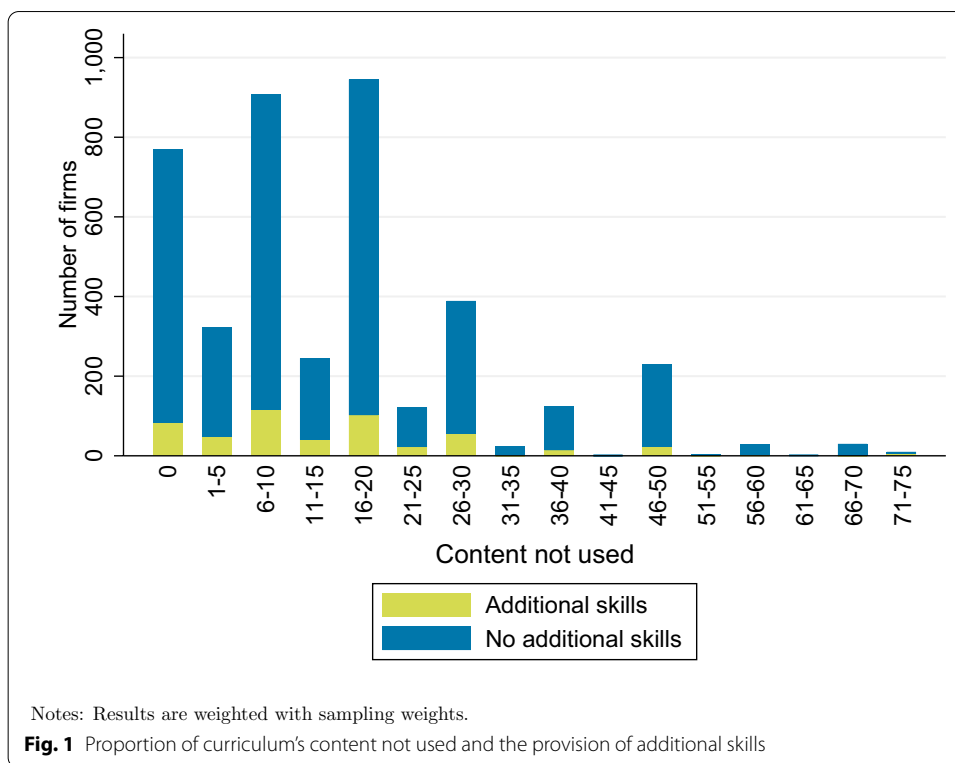
Estimation methods

First, we analyze which firm characteristics are associated with a closer or looser fit between training plans and firms' skill needs, and with the desired frequency of curriculum adjustments. The estimation models depend on the type of the dependent variables. "Content not used" is a fractional variable, for which we estimate a fractional logit model, which accounts for its specific features (Papke and Wooldridge 1996). Dummy dependent variables such as "Additional skills" are estimated using a logit model. Finally, dependent variables with several categories are estimated with multinomial logit models. For all of these nonlinear models, we report average marginal effects (AMEs) in the tables. AMEs are achieved by first calculating the effects of a one unit change of a variable for each observation in the data, and then taking the average of these individual effects across all observations in the sample (e.g. Wooldridge 2010).

Second, we analyze the association of curriculum fit and companies' costs and benefits from training. Firms reported costs and benefits by training year, with a maximum of four training years per firm, depending on the duration of the apprenticeship program. We use OLS regression models with firms as the unit of observation and their costs and benefits per training year and apprentice as dependent variable.¹⁵ However, OLS does not account for the problem that we cannot observe potential costs and benefits or curriculum fit for non-training firms. These firms are relevant because a poor curriculum fit and associated costs may be reasons not to train at all. Hence, we estimate a maximum likelihood selection model (Wooldridge 2010), which models the training decision and the costs and benefits of training jointly. We have to assume, firstly, that training costs and benefits are distributed normally, and secondly, that we have a variable that influences the training decision, but not the costs and benefits of training. We discuss such a variable together with the estimation results in Section 4.

The estimations in this paper are exploratory in nature. As is clear from Section "Firms' assessment of curriculum's fit with their skills needs", many variables correlate with the self-assessed curriculum fit variables (see also Appendix Table 7). Therefore, it is likely that firm characteristics not observed in the data also correlate with fit variables. This may introduce omitted variable bias in the coefficients in the cost-benefit estimations

¹⁵ The models also contain dummy variables indicating the pattern of apprenticeship years in which a firm currently trains apprentices (e.g. "0-1-0" if a firm trains one apprentice in the second year of a three-year program). These dummies differ by construction for different apprenticeship durations. We label these dummies as "apprentice-year pattern dummies" in the estimation tables (where applicable).



in Section “Curriculum fit and firms’ costs and benefits from training”. Therefore, our empirical analyses only provide descriptive results as a starting point for future causal analyses.

Results and discussion

Firms’ assessment of curriculum’s fit with their skills needs

The distribution of our two main variables of interest is shown in Fig. 1. The variable indicating the proportion of a curriculum’s content not used in the firm is strongly skewed to the left; that is, the majority of training firms use most of the training content of the curriculum, in their own production. Only a minority of firms (18.6%) say that they use all content defined in the training curriculum, whereas the two most frequent answers are 10% and 20% of content not used. Another minority of firms trains apprentices even though they state that they do not use a significant part of the training content, with proportions of 30%, 40% and 50%.¹⁶ The mean proportion of content not used is at 17%.

The figure also shows the distribution of the dummy variable indicating whether a firm trains additional skills beyond those defined in the relevant curriculum. Only 11% of firms in the sample confirm that they train additional skills. These firms are spread out over the whole distribution of the variable on content not used, and there is only a small and statistically insignificant correlation between the two variables ($r = -0.003$).

¹⁶ Fig. 1 shows bunching at round values. Respondents seem to use the 0–100 scale rather like a 0–10 scale, probably because they are not able to state their assessment with 1% level precision.

Table 2 Firm heterogeneity in curriculum (mis)fit

	Content not used		Additional skills	
	Fractional regression		Logit	
	(1)	(2)	(3)	(4)
Member of prof. association (yes = 1)	-0.026*** (0.007)	-0.026*** (0.007)	0.029** (0.012)	0.029** (0.012)
Attractiveness for specialists (yes = 1)	0.002 (0.009)	0.002 (0.009)	0.021 (0.014)	0.022 (0.014)
Affected by digitalization (yes = 1)	-0.001 (0.007)	-0.001 (0.007)	0.031** (0.014)	0.032** (0.014)
Efficiency of production (yes = 1)	-0.022** (0.008)	-0.022** (0.008)	-0.013 (0.015)	-0.013 (0.015)
Demand good (yes = 1)	-0.005 (0.007)	-0.005 (0.007)	0.015 (0.013)	0.015 (0.012)
10–49 Emp.	-0.008 (0.008)	-0.006 (0.008)	-0.028 (0.014)	-0.026 (0.014)
50–99 Emp.	-0.032** (0.010)	-0.032** (0.010)	-0.005 (0.023)	-0.004 (0.023)
100+ Emp.	-0.024** (0.013)	-0.023* (0.013)	0.015 (0.023)	0.018 (0.023)
Occupation dummies	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes
Greater region dummies	Yes	Yes	Yes	Yes
Apprentice characteristics	No	Yes	No	Yes
(pseudo) R-squared	0.011	0.011	0.075	0.077
Observations	4152	4152	4152	4152

Average marginal effects reported. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively. Standard errors given in parentheses. Results are weighted with sampling weights. The dummies for competitiveness, efficiency, attractiveness, and digitalisation are one for firms reporting “very” or “rather” in the respective question and zero otherwise. Additional apprentice characteristics are shares of adult and female apprentices, of short apprenticeships and apprenticeships with vocational baccalaureate. Occupation, industry and region dummies as shown in Table 9

Apparently, training firms are heterogeneous in terms of curriculum fit with four relevant groups: 42.2% of all firms in our sample need all content (i.e., less than 10% content not needed) and do not train additional skills. Another large group, 45.4%, do not need all content, but do not train additional skills either. 6.4% do train additional skills, but do not use all content in the curriculum, while 5.9% train additional skills and use all content.

We regress the two curriculum fit variables on firm characteristics to identify which types of companies are more likely to report a higher proportion of content not used and additional skills. Member companies of professional associations are less likely to report content not used, according to columns (1) and (2) in Table 2. The better fit with curricula may be a direct consequence of the representation of these companies in the curriculum definition process, during which they are able to influence the contents of curricula through the professional association. However, members of a professional association may also have become members because they have higher skill needs and thus more training content to offer in the first place, for instance because they use more advanced or complex production techniques. In line with this interpretation, firms that assess their efficiency in production as above average are also less likely to report a high proportion of curriculum content not used. Finally, firm size matters; firms with 50 or more employees report less content not used. A likely explanation is that the range of work tasks is broader in larger firms. Therefore, larger firms can rotate apprentices to

different departments and tasks to meet the skills requirements in the curriculum. No other variables¹⁷ that we use to capture firm heterogeneity show significant effects, nor do the apprentice characteristics in model (2).

Columns (3) and (4) of Table 2 address the provision of additional skills. Member firms of professional associations report doing so more often. Contrary to the result from the first two columns, this means a weaker fit between these firms' skills needs and the curricula. A likely explanation is again that member firms use more advanced or complex production technologies, which increases their skill needs. In a similar vein, firms that are more affected by digitalization are more likely to train additional skills. Indeed, some firms provided open-text information that they train IT and software skills additional to the training plan. Neither the other variables in the table nor the additional apprentice characteristics show any significant effects.

Because only membership in professional associations is associated with both measures of fit, we conclude that the two measures of curriculum fit are governed by partly different processes. This is also in line with the zero correlation between the two measures. Nonetheless, the results on efficiency and digitalization suggest that firms that do not need all skills defined in the curriculum are at least partly adversely selected, whereas firms that train additional skills are positively selected.¹⁸

The age of curricula and revisions

Curriculum misfit not only depends on firm heterogeneity, but also on whether the curriculum is up to date.¹⁹ Revisions of curricula are designed to add skills for new technologies, whereas other skills may be outdated and can be canceled or de-emphasized in a new curriculum. Because the confederation limits the number of curricula revised per year to prevent overload, they vary in age. We run a regression to test for the effect of curriculum's age²⁰ on the incidence of misfit and find significant effects: Fig. 2 shows the estimated effects of the years elapsed since the last revision of the curriculum on the means of both measures of misfit.²¹ As expected, an older curriculum is associated with more firms training additional skills, possibly because they want to train skills for new technologies. A recently revised curriculum is associated with more content not used, possibly because many firms do not yet use new technologies and are therefore not yet prepared to train the new skills required by the new curriculum. Although the effects go in the expected direction and are statistically significant, they are not large. The age of curricula is thus only one of many factors for misfit.

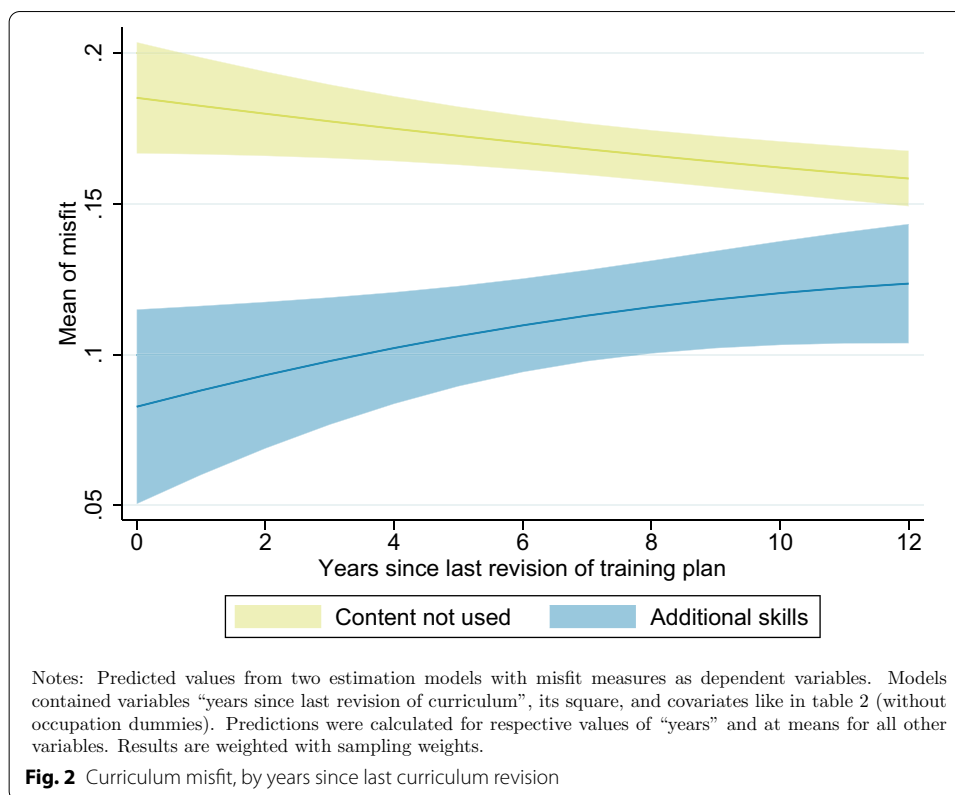
¹⁷ Further variables tested in the models but excluded from the models in this paper for lack of an effect include export exposure, foreign ownership of the firm, self-assessments of technical equipment, competitiveness, innovation capability, profit situation, and return on sales.

¹⁸ We assume here that firms affected by digitalization are more technologically advanced. Of course, digitalization is a multi-faceted process that may also affect firms with more routine technology through automatization.

¹⁹ As the main focus of our analysis is not on the variation between occupations (see Sect. 5.3 in Gehret et al. 2019), but on variation between firms and its association with training costs, we control for occupation when analyzing the fit of the training curriculum for firms' training costs and benefits.

²⁰ We thank our colleagues Miriam Grønning and Irene Kriesi for providing us with age information on training plans from their VET database (for details, see Grønning et al. 2018).

²¹ The underlying regressions are equal to those in Table 2, but contain the variable "years elapsed since the last revision of the relevant curriculum" and its square as independent variables instead of the occupation dummies. The result should thus be interpreted with caution, as the years elapsed variable may pick up further aspects of the correlation between occupation and curriculum misfit. The joint effect (F-test) of years and years squared is significant at the 1% level for content not used and at the 10% level for additional skills.



The cost–benefit survey also contains questions on firms’ view of the optimal frequency of revising the curricula (see also Appendix Table 8). It seems plausible that firms experiencing a misfit of the curriculum with their skill needs are less happy with the current rhythm of curriculum revisions. This is consistent with the results from Table 3. Firms that use only part of the curriculum content are in favor of changing the rhythm of curricula revisions. A change in content not used’ by one standard error (0.148) is associated with a 5.1 percentage point decrease in the probability of favoring the current rhythm ($-0.345 * 0.148$). Paradoxically, some of these firms want revisions to happen more often and others less often. The rationale for less frequent revisions could be that these firms fear the addition of new skills that they do not need. This explanation would be in line with the findings in Fig. 2. Conversely, firms that favor faster revisions might hope that the curriculum contents could be reduced, thus providing a better fit with their own needs.

Firms that train additional skills are more likely to favor more frequent curriculum revisions by 5.9 percentage points. It is likely that they would want to update skill definitions and add the skills that they already train to the revised curriculum. For example, firms using the most recent technologies might want the curriculum to cover these technologies as fast as possible. This explanation is in line with the findings in Fig. 2. Further variables (not shown in the table) show significant effects: firms that are more attractive for specialists, those more affected by digitalization and those with a higher share of adult apprentices favor faster revisions. Interestingly, member firms of professional associations and firms that believe that they are particularly efficient favor a slower rhythm

Table 3 Desired frequency of curriculum revisions

	Revision of curriculum		
	Less often	Keep	More often
	(1)	(2)	(3)
Content not used	0.185*** (0.043)	−0.345*** (0.047)	0.160*** (0.027)
Additional skills	−0.008 (0.021)	−0.051** (0.023)	0.059*** (0.011)
Occupation dummies		Yes	
Firm size dummies		Yes	
Industry dummies		Yes	
Greater region dummies		Yes	
Additional firm characteristics		Yes	
Apprentice characteristics		Yes	
Observations		4142	

Average marginal effects derived from a multinomial logit model. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively. Standard errors given in parentheses. Results are weighted with sampling weights. The dependent variable refers to a categorical variable capturing firms' desire to revise the training curriculum less often, more often, or keep the period between two revisions as it is. Occupation, industry and region dummies as shown in Table 9. Additional firm and apprentice characteristics are listed in Table 1

of revisions. In contrast, firms facing high demand and those with higher proportions of female apprentices and apprenticeships with vocational baccalaureate are more often against slower revisions.

Curriculum fit and firms' costs and benefits from training

Earlier studies have shown that in Switzerland, the productive work of apprentices on average outweighs the gross cost of training for firms (e.g. Wolter et al. 2006; Mühlemann and Wolter 2014). Table 1 confirms this finding for our sample of private firms (see Section "Survey data and variables of interest" above on the calculation of the cost-benefit measures). Firms' gross training costs amount to CHF 29,886 and apprentices' productive output to CHF 31,989 per training year. The difference of these two numbers gives firms' net benefits from training of an average of CHF 2103 per year and apprentice.

How does a mismatch between a firm's skills needs and skills specified in the curriculum affect these training costs? Table 4 shows that firms' gross costs of training are about CHF 290 per year higher if they do not use 10% of the curriculum content. There are two possible reasons for this result. Costs may be higher because the firm has to invest additional effort in training skills not needed in the firm's production process, which is our main hypothesis. But costs may also be higher if firms that do not need all curriculum contents differ systematically from other firms in characteristics that also affect costs and benefits from training, which leads to the classic omitted variable bias. We add further controls to the estimation in the model shown in column (2) to see whether these change the coefficient associated with the variable for content not used. The coefficient does not decrease, suggesting that it is robust to the inclusion of additional information. Column (3) shows that firms that do not use all the content of curricula obtain a lower productive output from their apprentices. The difference is about CHF 300 per year for 10% of curriculum content not used. A likely

Table 4 Firms' costs and benefits from apprenticeship training (OLS)

	Gross cost in Swiss Francs		Productive output in Swiss Francs		Net benefit in Swiss Francs	
	(1)	(2)	(3)	(4)	(5)	(6)
Content not used	2937.6*** (1108.0)	3197.7*** (1112.4)	-3203.1*** (959.2)	-3057.0*** (964.2)	-6140.7*** (1456.7)	-6254.8*** (1461.3)
Additional skills	1049.7** (526.3)	811.9 (526.0)	-1429.9*** (455.6)	-1325.4*** (455.9)	-2479.6*** (692.0)	-2137.3*** (691.0)
Constant	25720.4*** (3615.4)	23615.4*** (3632.3)	36564.7*** (3129.9)	37469.3*** (3148.4)	10844.4** (4753.5)	13853.9*** (4771.6)
Apprentice-year pattern dummies	Yes	Yes	Yes	Yes	Yes	Yes
Occupation dummies	Yes	Yes	Yes	Yes	Yes	Yes
Firm size dummies	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Greater region dummies	Yes	Yes	Yes	Yes	Yes	Yes
Additional firm characteristics	No	Yes	No	Yes	No	Yes
Apprentice characteristics	No	Yes	No	Yes	No	Yes
R-squared	0.167	0.177	0.174	0.182	0.100	0.113
Observations	4152	4152	4152	4152	4152	4152

Coefficients are OLS estimates. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively. Standard errors given in parentheses. Results are weighted with sampling weights. Gross costs, productive outputs, and net benefits in columns (1) to (6) are firm averages per apprentice and year. Occupation, industry and region dummies as shown in Table 9. Additional firm and apprentice characteristics are listed in Table 1

explanation is that these firms have to spend time training a skill not used in their production process, which reduces apprentices' productive hours. Also, such firms may have less work that is suited to letting apprentices be productive. As with gross costs, an alternative explanation is variables omitted from the estimation that bias the coefficient. Column (4) shows that adding various variables hardly changes the result. Columns (5) and (6) show the results for net benefits. As these are the difference between productive output and gross costs, the results follow logically from the earlier ones: net benefits are lower by more than 600 CHF if a firm does not use 10% of the curriculum content, and controlling for additional variables does not change this result.

Firms that train additional skills have only slightly higher gross costs, but obtain significantly lower productive output from apprentices and thus also realize lower net benefits from training. A likely explanation is that the additional training reduces the time in which apprentices are able to do productive work. Again, the coefficients are robust to including additional firm and apprentice characteristics. Some of these further variables

(not shown in the table) affect net costs and benefits: large firms, those more attractive for specialists, more affected by digitalization, and with more short apprenticeships and apprenticeships with vocational baccalaureate face higher net training costs, on average.²²

A concern for the results in Table 4 is that they are biased due to the selective sample.²³ Specifically, we can only observe costs and benefits of training firms, yet curriculum fit is likely to influence whether a firm trains or not. It may then be significant in the regression with the selected sample even if it does not belong in the population equation of training costs and benefits (Heckman 1979). Therefore, Table 5 shows a selection model that models the training decision and the costs and benefits simultaneously. The training equation contains a variable that does not enter the costs and benefit equations for better identification. The variable used is the same as in Mühlemann et al. (2007) and Blatter et al. (2016) and indicates whether a firm reports difficulties in recruiting suitable skilled workers. This variable is an indicator of labor market tightness from the firm's perspective. If the labor market is tight, firms have greater incentives to train apprentices and retain them as skilled labor. A tight labor market will thus affect the training decision, but not the costs or benefits of training, which do not include benefits from retaining apprentices (see Section "Survey data and variables of interest").

The results in Table 5 broadly confirm the earlier results for curriculum content not used. Note that Table 5 only shows the estimates related to the outcome variables; the selection part of the model is shown in Appendix Table 11. The highly significant point estimate implies that a 10% increase in content not used is associated with CHF 670 lower net benefits. The coefficients for gross costs and productive output also become somewhat higher in absolute terms than in Table 4. The selection model estimates for additional skills are slightly lower in absolute terms than the OLS estimates, but the effects of additional skills on productive output and net benefits remain significant.

The estimation results on net benefits from training allow us to estimate the total costs faced by the population of private Swiss training firms resulting from the two types of mismatch between curricula and skills needs. Extrapolating from the estimates for net benefits in Table 4, these costs amount to CHF 42.4 million (confidence interval: 22.6, 62.2) per year for contents not used, and CHF 10.6 million (ci: 4.6, 16.6) for additional skills. These amounts may seem small if we compare them to the total gross training cost, which totals CHF 4, 3 billion if we extrapolate the mean from Table 1 to all private training firms in Switzerland in 2016. Nonetheless, the mean of net costs is close to zero for many training firms (see Table 1 again), which means that even limited additional costs or foregone benefits may matter for their training decision. Keeping in mind that these extrapolations are back-of-the-envelope calculations due to our lack of causal estimates, the marked difference between the total costs for the two types of curriculum misfit is noteworthy. The calculation suggests that the costs borne by training firms due

²² We have also run the regressions with a sample that includes not-for-profit and public sector companies, see Table 10 in the Appendix. The results are qualitatively very similar. The main deviations are found in the gross cost regression: the point estimate for contents not used becomes smaller, the estimate for additional skills becomes larger. It seems that the training costs of non-market companies are less sensitive to restrictions, but that these companies spend more when training additional skills.

²³ Appendix Table 10 replicates the results including state and non-profit organizations. This hardly changes our estimates.

Table 5 Firms' costs and benefits from apprenticeship training (Heckman estimates)

	Gross costs in Swiss Francs		Productive output in Swiss Francs		Net benefit in Swiss Francs	
	(1)	(2)	(3)	(4)	(5)	(6)
Content not used	2978.0** (1412.6)	3013.9** (1420.1)	-3705.2*** (1234.2)	-3675.0*** (1179.2)	-6693.0*** (1851.4)	-6700.0*** (1831.1)
Additional skills	827.0 (593.8)	581.3 (588.9)	-1318.7*** (486.7)	-1159.9** (489.3)	-2137.9*** (779.9)	-1739.9** (773.5)
Constant	27908.4*** (3266.6)	26074.7*** (3301.5)	37398.0*** (3746.0)	38752.1*** (3750.1)	9071.4** (3906.0)	12659.0*** (3800.7)
Rho	-0.171*** (0.043)	-0.151*** (0.051)	-0.067 (0.080)	-0.053 (0.050)	0.131** (0.058)	0.084 (0.053)
Apprentice-year pattern dummies	Yes	Yes	Yes	Yes	Yes	Yes
Occupation dummies	Yes	Yes	Yes	Yes	Yes	Yes
Firm size dummies	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Greater region dummies	Yes	Yes	Yes	Yes	Yes	Yes
Additional firm characteristics	No	Yes	No	Yes	No	Yes
Apprentice characteristics	No	Yes	No	Yes	No	Yes
Observations	6399	6399	6399	6399	6399	6399
Observations (censored)	2256	2256	2256	2256	2256	2256
Observations (uncensored)	4134	4134	4134	4134	4134	4134

Estimates from outcome equation of Heckman two-step procedure (selection equation estimates in Appendix Table 11). ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively. Standard errors given in parentheses. Results are weighted with sampling weights. Gross costs and productive outputs are firm averages per apprentice and year. A dummy indicating whether a firm reports facing difficulties finding specialists on the labor market is included in the selection equation ($p < 0.01$ in all models), but excluded from the costs and benefits regressions. Occupation, industry and region dummies as shown in Table 9. Additional firm and apprentice characteristics are listed in Table 1

to curricula requiring more skills than the training firms need exceed the costs borne by firms for training additional skills that are lacking from curricula.²⁴

Net benefits as calculated in the analyses above do not account for benefits after the training period. However, companies may profit from retaining apprentices as skilled workers if they are able to pay them a wage below their productivity. In monopsonistic labor markets, training firms earn a rent on the workers they trained (Acemoglu and Pischke 1999). In the cost–benefit survey, firms were asked about their retention strategy:

²⁴ If we discretize the content-not-used variable by using a dummy for whether there was content not used or not, the point estimate of extrapolated costs is slightly lower at CHF 28.9 million, but still higher than for additional skills. The reason for the lower point estimate for content not used is the loss of information at the intensive margin, which is important for this variable with only 18.6% of firms using 100% of the curriculum contents.

Table 6 Retention of apprentices and premature contract terminations

	Logit		Fractional regression			
	Retain apprentices mostly		Share apprentices retained one year		Share contract termination	
	(1)	(2)	(3)	(4)	(5)	(6)
Content not used	-0.147* (0.077)	-0.101 (0.071)	-0.120** (0.054)	-0.078 (0.048)	0.038** (0.019)	0.032* (0.018)
Additional skills	0.035 (0.027)	0.027 (0.028)	0.022 (0.019)	0.013 (0.019)	0.008 (0.007)	0.010 (0.007)
Occupation dummies	Yes	Yes	Yes	Yes	Yes	Yes
Firm size dummies	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Greater region dummies	Yes	Yes	Yes	Yes	Yes	Yes
Additional firm characteristics	No	Yes	No	Yes	No	Yes
Apprentice characteristics	No	Yes	No	Yes	No	Yes
Pseudo R-squared	0.117	0.131	0.059	0.073	0.044	0.053
Observations	4138	4138	4152	4152	4152	4152

Average marginal effects reported. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively. Standard errors given in parentheses. Results are weighted with sampling weights. The dependent variable in columns (1) to (2) is a dummy being one for firms that plan to retain apprentices after the apprenticeship period in the “majority of cases”, and zero otherwise. The dependent variable in columns (3) to (4) refers to the self-reported share of apprentices that still work at their training firm one year after they completed their apprenticeship. The dependent variable in columns (5) to (6) refers to the self-reported share of premature apprenticeship contract terminations. Occupation, industry and region dummies as shown in Table 9. Additional firm and apprentice characteristics are listed in Table 1

whether they intend to keep their apprentices on most of the time, sometimes, or only in exceptional cases.

In Table 6, we test whether curriculum misfit is associated with firms’ retention of apprentices after training. As expected, companies that do not use all the content of the curriculum are less likely to say that they want to keep apprentices. This is in line with the explanation that such firms are more production-oriented: they rely on the productive contribution of apprentices to cover training costs and not on earning a return after the training period. Likewise, the proportion of apprentices actually staying in the training firm is lower among these firms. Both effects are statistically significant in the basic specification (columns 1 and 3) but become insignificant when adding apprentice and other firm characteristics (columns 2 and 4). Furthermore, we expected firms that train additional skills to be more interested in retaining apprentices. Although these firms are

indeed slightly more likely to keep apprentices according to the point estimates, these are not statistically significant in columns (1) to (4). Looking at the further variables (not shown), we find that larger firms, members of professional associations, firms affected by digitalization and more efficient firms want to retain more apprentices and are also able to do so. Firms with a higher proportion of female and adult apprentices are less successful in retaining apprentices.

Finally, Table 6 shows another element not accounted for in the costs and benefits from Table 4. Pre-mature terminations of apprenticeship contracts are costly for apprentices and firms, and firms cannot retain apprentices that dropped out during training. According to columns (5) and (6), firms that do not use all the content of a curriculum have a higher rate of premature contract terminations. This may be because these firms are worse at training the skills that they do not need themselves, which could reduce apprentices' chances of completing their training. Alternatively, these firms may differ in other respects not controlled for in the estimations, but related to premature contract terminations, such as the firms' overall quality of human resources policies. Members of professional associations have fewer such terminations, whereas firms with a higher proportion of adult apprentices have more (not shown).

Conclusion

Apprenticeship systems rely on national curricula to standardize the amount and quality of training, which reduces problems of incomplete and asymmetric information in the labor market. However, the design of this regulation must take into account the costs and benefits for training firms and apprentices. In this paper, we focus on the (mis)fit between curriculum content and firms' skill needs, and the costs associated with this misfit. On average, private training firms in Switzerland consider 17% of the content of training plans for apprenticeships as not relevant to their production processes. Some 11% of all private training firms train additional skills that are not part of their apprentices' training plan.

We find that companies using most or all of the skills in the curriculum are more often members of the professional association and consider their efficiency in production processes above average. Companies training additional skills are also more likely to be members of the professional association, are more affected by digitalization, and more likely to support more frequent revisions of curricula. These patterns are consistent with the hypothesis that companies not using all the skills of the curriculum have simpler production processes and thus more limited skills needs, whereas the opposite is true for companies that train additional skills. However, the fact that there is no correlation between the two measures of curriculum fit also shows that they do not measure a single dimension of mismatch between curriculum and skill needs, which indicates very heterogeneous skill needs. We also find some effect of the duration since the revision of a curriculum: when a curriculum becomes older, fewer firms report content not used,

but more firms train additional skills. The curriculum revision processes might also offer opportunities in future research to analyze the causal relationship between actual changes in skills prescriptions, their (mis)fit with firms' skill needs and the influence on training costs and decisions.

In line with our main hypothesis, both measures of curriculum fit are associated with higher gross costs for companies and reduced productive output by apprentices, and thus with reduced net benefits from training. We cannot claim causal identification, but our results are robust to the inclusion of many firm and apprentice characteristics. They are also confirmed in selection models that account for the fact that our estimation sample excluded non-training firms, which may not train because of a mismatch of their skills needs with existing curricula. In sum, these results indicate a cost-increasing effect of skills that are defined in vocational curricula, but not used in training firms' production processes, and vice versa. We find somewhat mixed evidence on the correlation of curriculum mismatch with the retention of apprentices after training.

Extrapolating from the net cost regression, we find that the economy-wide cost for training firms from curricula requiring more skills than the firms need exceeds the economy-wide cost of training skills that are lacking in curricula. Thus, the skills prescribed in curricula affect those firms more that would prefer to train a smaller set of skills than those firms that would prefer additional skills. This finding is consistent with the hypothesis that skill sets in Swiss VET curricula are broader than optimal for the average firm. This suggests that curricula have been designed to ensure the transferability of apprentices' skills in the labor market and to include skills needed for new technologies. In sum, apprentices' benefits from broader skills sets may thus outweigh the additional costs for training firms. However, our findings also caution against defining arbitrarily broad curricula that might increase misfit with firms' skills needs and thus become too costly for many companies to train.

Appendix

See Tables [7](#), [8](#), [9](#), [10](#) and [11](#).

Table 7 Descriptive statistics by curriculum misfit

	Content not used ≤ 10				Content not used > 10			
	Additional skills		Additional skills		Additional skills		Additional skills	
	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.
(a) Cost and benefits of training, in CHF								
Gross costs	28,804	10,622	30,200	10,771	30,698	11,447	31,571	12,551
Productive output	32,600	9431	30,762	9923	31,906	9779	29,254	10,470
Net benefit	3795	13,209	562	13,775	1209	14,527	-2317	16,443
(b) Selected firm characteristics								
Firm size								
1–9 Employees	0.461	0.499	0.502	0.501	0.435	0.496	0.502	0.501
10–49 Employees	0.407	0.491	0.306	0.462	0.427	0.495	0.355	0.479
50–99 Employees	0.061	0.240	0.074	0.262	0.067	0.250	0.067	0.251
> 100 Employees	0.070	0.255	0.118	0.323	0.071	0.257	0.076	0.266
Member of prof. association (yes = 1)	0.468	0.499	0.490	0.501	0.320	0.467	0.486	0.501
Attractiveness for specialists (yes = 1)	0.727	0.446	0.780	0.415	0.685	0.465	0.757	0.430
Affected by digitalization (yes = 1)	0.443	0.497	0.455	0.499	0.411	0.492	0.480	0.501
Efficiency of production (yes = 1)	0.740	0.439	0.698	0.460	0.655	0.476	0.699	0.459
Demand good (yes = 1)	0.575	0.494	0.676	0.469	0.580	0.494	0.585	0.494
(c) Apprenticeship characteristics								
Share voc. baccalaureate	0.067	0.227	0.080	0.218	0.078	0.233	0.088	0.242
Share adult	0.040	0.173	0.059	0.206	0.051	0.200	0.061	0.200
Share short-apprenticeship	0.040	0.179	0.079	0.247	0.050	0.194	0.069	0.229
Share female	0.368	0.452	0.440	0.433	0.393	0.454	0.425	0.464
Observations	1731		244		1866		262	

All results are weighted with sampling weights. The dummies for efficiency, attractiveness, and digitalization are all one for firms reporting “very” or “rather” in the respective question and zero otherwise. The lower number of observations among these dummies stem from missing answers to the question. Gross costs and productive outputs are firm averages per apprentice and year. Apprentice characteristics show the size of the respective group as a share of all apprentices in the company

Table 8 Descriptive statistics, additional outcome variables

	Mean	s.d.	Min.	Max.	N
Frequency of curriculum revision					
Less often (yes = 1)	0.245	0.430	0	1	4142
Keep (yes = 1)	0.670	0.470	0	1	4142
More often (yes = 1)	0.085	0.278	0	1	4142
Retention of apprentices					
Retain apprenticeships mostly (yes = 1)	0.0395	0.489	0	1	4138
Share apprentices in firm after one year	0.401	0.367	0	1	4152
Premature contract termination					
Share contract termination	0.063	0.133	0	1	4152

All variables are weighted with sampling weights. “Frequency of curriculum revision” refers to a categorical variable with the categories less often, keep, and more often; in this table displayed as three distinctive dummies. The dependent variable “retain apprenticeships mostly” is a dummy with one for firms that plan to retain apprentices after the apprenticeship period in the “majority of cases”, and zero otherwise. The variable “share apprentices in firm after one year” captures the share of apprentices that work at their training firm within one year after they completed their apprenticeship. The variable “share contract termination” captures the share of premature apprenticeship contract terminations

Table 9 Descriptive statistics, control variables

	Fraction
Industries (NACE)	
NACE A-E	0.168
NACE F	0.171
NACE G-I	0.344
NACE J-L	0.055
NACE M-P	0.156
NACE Q-S	0.105
Greater regions	
Lake Geneva	0.187
Espace Mittelland	0.248
Northwestern Switzerland	0.114
Zurich	0.131
Eastern Switzerland	0.156
Central Switzerland	0.123
Ticino	0.040
Occupations	
Automotive assistant	0.003
Automotive mechatronics technician	0.016
Automotive technician	0.030
Bricklayer	0.020
Cabinet-maker	0.030
Carpenter	0.016
Construction electrician	0.009
Commercial employee	0.175
Cook	0.023
Dental assistant	0.031
Draughtsman	0.051
Electrician	0.032
Gardener	0.016
Hairdresser	0.019
Information technologist	0.030
Logistics experts	0.022
Medical secretary and assistant	0.026
Painter	0.020
Pharmacy assistant	0.010
Plumber	0.019
Polymechanic technician	0.022
Restaurant specialist	0.007
Retail assistant	0.019
Retail professional	0.127
Specialist in hotel housekeeping	0.003
Social care worker	0.009
Other two year apprenticeships	0.024
Other three year apprenticeships	0.078
Other four year apprenticeships	0.114

All results are weighted with sampling weights. The dummies for competitiveness, efficiency, attractiveness, and digitalisation are all one for firms reporting “very” or “rather” in the question and zero otherwise. The lower number of observations among these dummies stem from missing answers to the respective question. Such missing observations are treated as an own categorical value in the estimations below

Table 10 Firms' costs and benefits from apprenticeship training (OLS, including non-profit companies and government authorities)

	Gross cost in Swiss Francs		Productive output in Swiss Francs		Net benefit in Swiss Francs	
	(1)	(2)	(3)	(4)	(5)	(6)
Content not used	2002.0** (954.1)	1800.7* (956.6)	-3159.8*** (849.8)	-3175.1*** (852.5)	-5161.8*** (1264.2)	-4975.8*** (1267.1)
Additional skills	1400.2*** (442.8)	1186.4*** (443.5)	-1088.9*** (394.3)	-973.7** (395.2)	-2489.1*** (586.6)	-2160.0*** (587.4)
Constant	25804.8*** (3088.5)	24142.0*** (3098.9)	36338.1*** (2750.7)	36841.4*** (2761.6)	10533.2** (4092.1)	12699.4*** (4104.6)
Apprentice-year pattern dummies	Yes	Yes	Yes	Yes	Yes	Yes
Occupation dummies	Yes	Yes	Yes	Yes	Yes	Yes
Firm size dummies	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Greater region dummies	Yes	Yes	Yes	Yes	Yes	Yes
Additional firm characteristics	No	Yes	No	Yes	No	Yes
Apprentice characteristics	No	Yes	No	Yes	No	Yes
R-squared	0.161	0.172	0.162	0.171	0.085	0.097
Observations	5484	5484	5484	5484	5484	5484

Coefficients are OLS estimates. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively. Standard errors given in parentheses. Results are weighted with sampling weights. Gross costs, productive outputs, and net benefits in columns (1) to (6) are firm averages per apprentice and year. Occupation, industry and region dummies as shown in Table 9. Additional firm and apprentice characteristics are listed in Table 1

Table 11 Heckman selection equation (complements table 5)

	D=firm trains					
	Gross costs in Swiss Francs		Productive output in Swiss Francs		Net benefit in Swiss Francs	
	(1)	(2)	(3)	(4)	(5)	(6)
Difficulties finding specialists	0.533*** (0.052)	0.500*** (0.059)	0.526*** (0.052)	0.492*** (0.059)	0.529***(0.052)	0.494*** (0.059)
Constant	0.156 (0.465)	-0.160 (0.469)	0.164 (0.470)	-0.121 (0.476)	0.188(0.471)	-0.129 (0.476)
App.-year pattern dummies	Yes	Yes	Yes	Yes	Yes	Yes
Occupation dummies	Yes	Yes	Yes	Yes	Yes	Yes
Firm size dummies	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Greater region dummies	Yes	Yes	Yes	Yes	Yes	Yes
Additional firm characteristics	No	Yes	No	Yes	No	Yes
Apprentice characteristics	No	Yes	No	Yes	No	Yes
Observations	6399	6399	6399	6399	6399	6399
Observations (censored)	2256	2256	2256	2256	2256	2256
Observations (uncensored)	4134	4134	4134	4134	4134	4134

***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively. Standard errors given in parentheses. Results are weighted with sampling weights. Gross costs and productive outputs are firm averages per apprentice and year. Heckman estimates reported. The dummy indicating whether a firm reports difficulties finding specialists on the labor market is excluded from the second step, i.e. the outcome equation. Occupation, industry and region dummies as shown in Table 9. Additional firm and apprentice characteristics are listed in Table 1

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Authors' contributions

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Availability of data and materials

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Declarations

Competing interests

The authors declare that they have no competing interest.

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