Yesterday's Model for Tomorrow's Economy?

The Effect of Dual VET on Wage Inequality in the Knowledge Economy

Patrick Emmenegger
University of St.Gallen
patrick.emmenegger@unisg.ch

Matthias Haslberger
University of St.Gallen
matthias.haslberger@unisg.ch

Acknowledgments: We are grateful for the feedback we received from Niccolo Durazzi, David Hope, Cathie Jo Martin, and David Weisstanner, as well as the participants of the GOVPET Advisory Board Meeting 2023, the 2023 conference of the Council for European Studies in Reykjavik, the 2023 conference of the Swiss Political Science Association, and the 2023 RC28 Summer Meeting at the University of Michigan. All remaining errors are our own. This work was supported by the Schweizerisches Staatssekretariat für Bildung, Forschung und Innovation (SERI) in the framework of the GOVPET research project.

Corresponding author: Patrick Emmenegger, Müller-Friedberg-Strasse 8, 9000 St.Gallen, Switzerland, patrick.emmenegger@unisg.ch
Non-corresponding co-author: Matthias Haslberger, Müller-Friedberg-Strasse 8, 9000 St.Gallen, Switzerland, matthias.haslberger@unisg.ch

Word count: 9,976

Yesterday's Model for Tomorrow's Economy? The Effect of Dual VET on Wage Inequality in the Knowledge Economy

Abstract

Dual vocational education and training (VET) systems are said to have positive economic effects. However, recent contributions suggest that the rise of the knowledge economy undermines these positive effects because university-educated workers are better suited for the new knowledge-intensive jobs. This paper provides the first evidence on the effect of dual VET on wage inequality in mature knowledge economies. Using a new dataset on 37 advanced economies from 1996 to 2020, we find that dual VET remains associated with lower levels of wage inequality throughout the entire period. The rise of the knowledge economy is positively associated with wage inequality at low levels of dual VET. However, where the dual VET share is high, the rise of the knowledge economy further reduces wage inequality. Contrary to the fears often espoused in the literature, we find no evidence that the knowledge economy undermines the positive effects of dual VET.

JEL Classification: *I24 Education and Inequality, J24 Human Capital; Skills; Occupational Choice; Labor Productivity*

SER Keywords: *inequality; education; technological change; knowledge based economy; skills*

Introduction

Skill formation systems that emphasize dual vocational education and training (VET) have long been praised as a model for countries to emulate. The reason is that dual VET systems are associated with beneficial economic outcomes, most notably lower youth unemployment (e.g., Breen 2005; Rözer and van de Werfhorst 2020). In dual VET systems, training takes place in both schools and firms, typically in the form of apprenticeship schemes. The resulting occupational skills are portable, certified, and standardized beyond the

firm level. Finally, firms and their intermediary associations participate in the financing and administration of training (Busemeyer and Trampusch 2011:14-15). Over the last years, initiatives to expand dual VET systems have proliferated - even in countries with little history of dual VET such as France, Portugal, or Sweden (OECD 2020).

This paper argues that dual VET is also associated with lower wage inequality, and that the rise of the knowledge economy has done little to undermine this association. The knowledge economy describes a trend "towards greater dependence on knowledge, information and high skill levels" (OECD 2005:28). This process has been underway in advanced economies for a long time, but in recent decades, the rise of the knowledge economy has accelerated. Since the 2000s, the literature speaks of mature knowledge economies that depend more on knowledge-intensive activities and intellectual capabilities than physical inputs or natural resources to generate economic growth (Hall 2020).

Unlike previous waves of technological change that increased demand for labor at all skill levels, the current process of technological change - exemplified by the rapid diffusion of information and communications technology (ICT) and artificial intelligence (AI) - is argued to have detrimental consequences for employment and wages of individuals in the middle and at the bottom of the skills distribution (Autor and Dorn 2013). Instead, this literature expects demand to increase for non-routine cognitive tasks. For such high-end jobs, university-educated workers with primarily general skills are argued to be better suited than VET graduates (e.g., Anderson and Hassel 2013; Hanushek et al. 2017; Kristal and Cohen 2017; Hope and Martelli 2019; Iversen and Soskice 2019). Moreover, the technological and organizational changes associated with the transition to knowledge-based economies undermine the industrial relations that underpin successful dual VET systems (Diessner, Durazzi and Hope 2022). Taken together, these developments suggest that dual VET no longer produces the skills that knowledge economies require. In short, a growing number of voices argue that while dual VET systems were a model for yesterday's economy, they are not well suited for tomorrow's economy.

In contrast, we argue that dual VET continues to be associated with lower wage inequality. In fact, we argue that some of the traditional strengths of dual VET have become even more valuable in knowledge economies. Most notably, dual VET lowers the relative cost of acquiring additional post-compulsory education for working-class youth (Breen and Goldthorpe 1997; Estevez-Abe, Iversen and Soskice 2001; Thelen 2014). In this way, dual VET provides academically weaker students with access to high-quality training in line with labor market requirements, including problem-solving in technology-rich environments. Moreover, dual VET involves employers in the definition of training content, which improves the alignment between training content and employers' skill needs. In periods of rapidly changing skill needs, this direct involvement of employers increases in importance. By preparing academically weaker students for more successful labor

market careers compared to their peers in non-dual VET contexts, dual VET lowers the incidence of low-skill work and thereby reduces wage inequality in the bottom half of the distribution (Allmendinger 1989; Shavit and Müller 1998; Freeman and Schettkat 2001).

There is surprisingly little comparative empirical research examining the relationship between dual VET and wage inequality (e.g., Estevez-Abe, Iversen and Soskice 2001; Bradley et al. 2003; Busemeyer 2015). This dearth of empirical evidence is primarily the result of data limitations. Previous research has mostly relied on time-invariant indicators of dual VET, explored short time-series, or worked with small samples, making it difficult to arrive at firm conclusions about the effect of dual VET. Overcoming these data limitations, we have assembled a new dataset on dual VET shares for 37 advanced economies from 1996 to 2020. In recent decades, economies have come into shape as mature knowledge economies. We take account of the extent to which countries have become mature knowledge economies by relying on data on patents in ICT and AI. Unlike other patents, which might also be associated with the 'old' economy, ICT and AI patents capture technological change that allows employers to automate routine tasks.

In the empirical analysis, we find a robust negative effect of dual VET on wage inequality, especially in the lower half of the wage distribution. The knowledge economy seems associated with higher levels of wage inequality, but we observe this effect only in countries with low levels of dual VET. In contrast, where the share of dual VET is high, the rise of the knowledge economy even reduces wage inequality. In other words, contrary to recent contributions that have questioned the viability of dual VET in the knowledge economy, we find no evidence that technological change neutralizes the negative effect of dual VET on wage inequality. In this way, our research answers Gallego and Kurer's (2022:479) call to pay more attention to "differences in education and, particularly, vocational education and training regimes" in research on the effects of the knowledge economy on wage inequality. Our analysis suggests that dual VET systems also remain a model for tomorrow's economy.

This paper is structured as follows. The next section reviews the literature on dual VET in the knowledge economy. Subsequently, we discuss why dual VET reduces wage inequality. The following section presents the dataset and the statistical approach before we discuss the empirical findings. A final section concludes.

Dual VET in a Knowledge Economy

Dual VET has enjoyed broad attention in recent decades (European Commission 2016; OECD 2020) because it is said to straddle the twin demands of supplying relevant skills to employers while offering a reliable point of access for large groups of the population to stable and relatively well-paying jobs (Estevez-Abe, Iversen and Soskice 2001; Thelen 2014). For example, a rich literature argues that dual VET (i) sends employers

clear signals about job seekers' abilities and skills, (ii) gives access to recruitment networks, because students directly interact with prospective employers, and (iii) involves employers in the provision of training, which aligns training content and skill requirements (e.g., Breen 2005; Schulz, Solga and Pollak 2023; Shavit and Müller 1998). All of these factors facilitate the transition from education to the labor market and thus lower youth unemployment (e.g., Rözer and van de Werfhorst 2020; Iannelli and Raffe 2007).

While there is widespread agreement that dual VET reduces youth unemployment, its effect on wage inequality is more disputed. As mentioned, there is little empirical literature that specifically investigates the relationship between dual VET and wage inequality (e.g., Estevez-Abe, Iversen and Soskice 2001; Bradley et al. 2003; Busemeyer 2015). An important exception is research on early tracking and skills differentiation in dual VET, which has been shown to reduce educational mobility and increase occupational status differences (Pfeffer 2008; Bol and Van De Werfhorst 2011, 2013; Heisig, Gesthuizen and Solga 2019), although dual VET might not negatively impact income mobility (Chuard and Grassi 2020).

In recent years, several contributions have argued dual VET no longer provides the skills required for today's economies. In the Fordist period, the symbiotic relationship between dual VET and manufacturing ensured an excellent match between skill supply and demand in what the Varieties of Capitalism literature calls coordinated market economies (Estevez-Abe, Iversen and Soskice 2001). However, in a post-Fordist knowledge economy, "complementarities in production between skilled and semiskilled workers have been replaced by complementarities between skilled workers and new ICTs" (Hope and Martelli 2019:243). Similarly, Iversen and Soskice (2019:180) observe that "industrial production has become increasingly digitalized, decentralized, and dependent on workers with high cognitive and analytical skills, causing demand for employees with university [...] degrees to rise, while VET training has become relatively less important" (see also Wren 2021:274). Moreover, with the manufacturing sectors that dominated Fordist economies becoming progressively less central, growth and employment is primarily created in the service sector, especially at the high end of the skills spectrum with important implications for wage inequality (Autor and Dorn 2013; Oesch and Piccitto 2019). The rise of the knowledge economy has thus arguably weakened the prospects of academically weaker students to gain stable employment in well-paying jobs through vocational training.

The rise of the knowledge economy is not just about skill levels. Rapid technological change also increases the pace of economic change and thus creates uncertainty about the skills firms require in the future. However, dual VET systems' focus on occupation-specific skills presupposes "a degree of certainty as to what one is likely to need and value in the future" (Streeck 1989:92). With uncertainty about firms' future skill needs, individuals are often argued to be better off opting for an academic education because such training provides more general and thus transferable skills (Wren 2013; Iversen and Soskice 2019). In contrast, VET graduates are said to risk ending up with outdated and redundant skills, undermining their ability to find well-paying

work. Hence, dual VET systems' focus on vocational skills - while beneficial for the transition from education to the labor market - may downgrade the provision of general skills shown to be important for individuals' earning abilities across the life cycle, although the empirical evidence for this so-called vocational decline thesis is in fact rather mixed (e.g., Hanushek et al. 2017; Rözer and Bol 2019; Chuan and Ibsen 2022; Schulz, Solga and Pollak 2023; Silliman and Virtanen 2022; Korber and Oesch 2019).

Finally, the rise of the knowledge economy may also weaken the corporatist institutions on which dual VET relies to function (Culpepper and Thelen 2008; Diessner, Durazzi and Hope 2022). Due to new possibilities of high-speed data transfer and further standardization of production processes, it matters increasingly less where tasks are performed. If firms are no longer dependent on a specific institutional environment, characterized by egalitarian wage setting, employment protection legislation, and strong employer associations, firms might refrain from investing in dual VET (Acemoglu and Pischke 1999; Marsden 1999). In short, there is an emerging consensus in the literature that whatever positive effect dual VET might have had on wage equality in the past, this effect has disappeared in knowledge economies or might have even reversed in the most technologically advanced economies.

Why Dual VET Lowers Wage Inequality

We argue that dual VET continues to be associated with lower wage inequality because it strengthens the economic position of academically weaker students, in particular working-class youth. As mentioned, several contributions have shown that dual VET contributes to beneficial employment outcomes because it sends employers clear signals about job seekers' abilities, gives access to recruitment networks, and relies on employer involvement to define training content (e.g., Breen 2005; Schulz, Solga and Pollak 2023; Shavit and Müller 1998). These factors facilitate the transition from education to the labor market, but they also matter for wage inequality.[1] Moreover, none of these factors lose in relevance in the knowledge economy.

Consider the role of employers in the provision of training and the definition of training content. Employer involvement is likely to improve the alignment between training and employers' skill requirements because employers are best positioned to identify current skill needs and translate these needs into training content. In periods of rapidly changing skill needs, such direct involvement of employers in the definition and regular update of training content increases in importance. Because dual VET primarily targets academically weaker students, they are the main beneficiaries of employer involvement (Allmendinger 1989; Shavit and Müller 1998; Thelen 2014).

Table 1 provides some first evidence that training content and skill requirements are more aligned in countries with large dual VET systems. The OECD's Program for the International Assessment of Adult Compe-

tencies (PIAAC) measures three cognitive skills: literacy, numeracy, and problem-solving in technologically-rich environments. Literacy refers to the ability to understand and use information from written texts, whereas numeracy is the ability to use, apply, interpret, and communicate mathematical information and ideas (OECD 2012). In the context of this study, the third cognitive skill is most relevant. The OECD (2012:47) defines problem-solving in technology-rich environments as "using digital technology, communication tools, and networks to acquire and evaluate information, communicate with others, and perform practical tasks." Put differently, this measure captures the additional cognitive skills required in the information age.

Using data on 30 countries from the OECD's PIAAC surveys in 2011/2012, 2014/2015, and 2017, Column 1 of Table 1 shows positive associations between the share of dual VET at upper-secondary level and countries' average scores in problem-solving in technology-rich environments, numeracy, and literacy. While by no means offering conclusive evidence, Table 1 suggests that individuals in countries with large dual VET systems perform comparatively well in all three areas, especially in terms of average numeracy skills and problem-solving skills in ICT-rich environments. Of course, this is not to suggest that university graduates have weak cognitive skills. In general, the PIAAC survey shows that skill levels increase with educational attainment. Problem-solving, numeracy, and literacy skills are no exception to this. Instead, we argue that dual VET systems provide particularly strong incentives and opportunities for academically weaker students to develop their cognitive skills, thus reducing skills dispersion.

[TABLE 1 HERE]

Following Breen and Goldthorpe (1997), we argue that by providing high-quality educational opportunities for academically weaker students, dual VET lowers the relative cost of acquiring additional post-compulsory education, particularly for working-class youth. The reason for this effect is the so-called secondary effect of inequality (the impact of social origin on educational decisions net of performance). Given this additional class-related hurdle to accessing higher education and the relative risk aversion of families, working-class youth are the primary beneficiaries of the attractive and low-risk training opportunities offered by dual VET. In this way, dual VET creates incentives to work hard in school, increases the overall amount of training provided, and contributes to the narrowing of the skills distribution in society, especially in the bottom half of the skills distribution (Pischke 2005; Estevez-Abe, Iversen and Soskice 2001; Silliman and Virtanen 2022; Allmendinger 1989; Shavit and Müller 1998).[2]

The resulting narrower skills distribution should, in turn, lead to lower levels of wage inequality, because workers' wages are influenced by their productivity, which is - at least partly - a function of their skills (Freeman and Schettkat 2001; Checchi and Van De Werfhorst 2018). Put differently, dual VET offers access

to stable and relatively well-paying jobs, and because dual VET primarily recruits among working-class youth, academically weaker students are the main beneficiaries (Thelen 2014; Busemeyer 2015). For example, Chuard and Grassi (2020) show that dual VET weakens the relationship between educational mobility and income mobility because labor market participants with a background in dual VET (associated with low educational mobility) do comparatively well in terms of employment and income growth over the life course (associated with high income mobility), which suggests that dual VET is a comparatively effective form of skill formation.

In line with this argument, Column 2 of Table 1 shows that the three cognitive skills measures in the PIAAC survey - problem-solving, numeracy, and literacy - are less dispersed in countries with large dual VET systems, as reflected by the negative correlations between dual VET shares and our skills dispersion indicators. The relationship is weaker in case of literacy and numeracy skills, which is not surprising. Fully school-based education systems are probably just as good at teaching numeracy and literacy skills as education and training systems that combine school-based and workplace training. However, as Figure 1 shows, in the case of skills that are particularly close to labor market needs such as problem-solving skills in technology-rich environments, the negative relationship between the share of dual VET at upper-secondary level and our measure of skill dispersion within a country is substantial.

[FIGURE 1 HERE]

These patterns suggest that dual VET does an excellent job providing skills relevant for the knowledge economy, and it does so in particular in the lower half of the skills distribution, which is why countries with strong VET systems are characterized by a lower incidence of low-skill or unskilled work (Allmendinger 1989; Shavit and Müller 1998; Freeman and Schettkat 2001; Thelen 2014). On average, countries with large dual VET systems perform at least as well with regard to different cognitive skills as countries relying on more school-based forms of education (see Table 1). Moreover, countries with large dual VET systems feature a lower dispersion of cognitive skills - in particular in case of skills that are particularly close to labor market needs (see Figure 1). Given that cognitive skill levels increase with educational attainment (in all countries covered by the PIAAC survey), we can conclude that dual VET systems primarily impact a country's skills distribution by lifting the floor of the distribution. In short, dual VET systems provide individuals with access to high-quality education and training who would otherwise struggle to obtain comparable amounts of education and training.

This focus on skills relevant for labor markets need not come at the expense of general skills. Modern dual VET systems focus on "broader" skills than often assumed, as they feature a consolidated curriculum in

the first years of an apprenticeship for "adjacent occupations" and an "academic part of vocational training" that "was upgraded to a point where a growing segment of youth were no longer able to meet the ever higher academic demands" (Streeck 2011:23). For this reason, Schulz, Solga and Pollak (2023:15) argue that "skill-use differentials between vocationally and tertiary-educated workers are rather small overall" and that these "observed differences in skill use remain rather stable across career stages." Similarly, Adda and Dustmann (2023:458) demonstrate that vocationally-educated workers accumulate experience in cognitive-abstract tasks throughout their labor market careers, which helps sustain wage growth later in the life cycle, while Silliman and Virtanen (2022:200) show that VET graduates "are no more likely to be employed in occupations at risk of automation or offshoring." In short, the equation of dual VET with few general skills, a focus on routine manual tasks, and the absence of occupational mobility reflects an outdated conception.

Dual VET also has a positive impact on workers' soft skills, which are likely to grow in importance in rapidly changing economic contexts (Silliman and Virtanen 2022). Few contributions on the viability of dual VET have focused on soft skills, although a rich empirical literature has demonstrated their relevance for individuals' labor market performance (Farkas 2003; Heckman and Kautz 2012). Recent research suggests that dual VET boosts individuals' soft skills. For example, based on newly available panel data, Basler and Kriesi (2022) track the level and development of soft skills of youth entering dual VET, school-based VET, and general education tracks at upper-secondary level in Switzerland (for a similar analysis focusing on Denmark, see Birkelund 2022). Figure 2 replicates their main findings.

[FIGURE 2 HERE]

Focusing on individuals' exertion (individuals' ability to use a lot of effort), perseverance (individuals' persistent efforts, including in the face of difficulties), and volition (individuals' willingness to learn and develop), Basler and Kriesi (2022) show that while starting from similar levels, dual VET has the strongest positive effect on these three soft skills. They argue that dual VET facilitates the development of soft skills because learning takes place in work-relevant and concrete settings, and typically involves some form of interaction with other team members or clients. In contrast, in traditional school settings, learning is comparatively abstract and detached from concrete life experiences, which does not affect the development of these soft skills equally positively. Academically weaker students are most likely to benefit from the soft skills enhancing effects of work-relevant learning and concrete settings because they are more likely to enter dual VET than academically stronger students. Moreover, thanks to different instructional methods, dual VET also offers "an important alternative for youth otherwise at risk of dropping out of secondary education" (Silliman and Virtanen 2022:198).

Moreover, the effect of dual VET goes beyond the provision of skills. Skills obtained by means of dual VET are authoritatively certified by governments, business, and unions consisting of a "system of occupations and occupational training profiles that, through publicly supervised examination and certification of acquired skills, allowed for, in principle, unlimited mobility of workers in nationwide sectoral labor markets" (Streeck 2011:5). These processes of certification but also more informal processes of social closure generate labor market advantages for VET graduates, because access to certain occupations and sectors is limited to individuals that possess the relevant educational credentials and can move rather freely in these labor market segments. This 'credentialism' strengthens the position of those who have the ability to access these segments (Weeden 2002), which, in the case of dual VET, are often academically weaker students of working-class origin. However, the overall effect of these processes on wage inequality is more ambiguous because these social closure processes also increase the differentiation between skilled and unskilled workers (Bol and Van De Werfhorst 2011; Heisig, Gesthuizen and Solga 2019). The net effect on wage inequality thus hinges on the extent to which dual VET systems remain inclusive, i.e., accessible for academically weaker students.

In recent years, governments have launched reforms to 'upskill' dual VET to satisfy the skill demands of post-Fordist economies (e.g., Durazzi and Benassi 2020). Such reforms aim to prepare VET graduates for more knowledge-intensive activities, but they may make training less accessible for academically weaker students, thereby reducing these systems' equality-enhancing function (Martin and Knudsen 2010). However, to counter this problem, new programs have been developed to uphold the inclusive nature of dual VET. For example, several countries have introduced short-track apprenticeships, which offer theory-reduced dual training and reduce the training costs for firms but nevertheless lead to recognized certificates (Bonoli and Wilson 2019). In other countries, governments have created and expanded publicly provided alternatives to dual VET for unsuccessful apprenticeship seekers (*blinded*). These state-led apprenticeships mimic traditional dual VET and were introduced and expanded during economic downturns to compensate for declining employer demand for apprentices. However, by now, these state-led apprenticeships have become permanent features of skill formation systems. In addition, governments have spearheaded efforts to revitalize and expand dual VET - not least to the service sector (*blinded*). With the help of such reforms, dual VET systems try to respond to new skill needs, while remaining accessible for candidates with weaker school records.

In short, we argue that there are good reasons for dual VET to be associated with lower wage inequality - also in mature knowledge economies. In the remainder of this paper, we explore this relationship empirically.

Data and Measurement

One substantive contribution of this article is the underlying data collection effort. Previous research on the effects of dual VET has suffered from limitations such as time-invariant data on the role of dual VET or, where time-varying data on VET shares were used, a small number of observations and small samples. Our supplementary data collection effort allows us to rely on a richer dataset. We furthermore propose a different approach to operationalizing the knowledge economy than existing studies. In line with our conceptual focus on digital capabilities, we create an indicator of patenting activity instead of using employment shares in knowledge-intensive sectors. The remainder of this section discusses our approach in detail.

Measuring the Dual VET Share

Due to the vast differences in the organization of national VET systems, comparable data on dual VET shares are not readily available. The most comprehensive data source, the annual "Education at a Glance" reports prepared by the OECD since 1998 (with the exception of 1999), contains many gaps and, in some cases, implausible numbers. Yet, until now, it was the only source for cross-national data on the share of upper secondary students who are enrolled in dual VET programs. For this reason, an additional data collection effort was necessary. Starting from the Cedefop and Eurydice databases, we identified educational tracks that qualify as dual VET. We applied the OECD definition which considers *combined school- and work-based* (hence "dual") programs those in which "less than 75 per cent of the curriculum is presented in the school environment or through distance education. Programmes that are more than 90 per cent work-based are excluded" (OECD 2001:401). We then searched national databases and, where necessary, contacted statistical offices and other authorities to complete our dataset of dual VET shares in OECD countries as much as possible. In some cases, we updated the numbers provided by the OECD with more realistic and consistent time series. The precise approach is discussed in Appendix D, where Figure C1 also shows the coverage. While we were not able to create a fully balanced panel, thanks to this effort we were able to significantly expand the dataset from 448 to 768 (out of 962) country-years and perform our analyses on a larger dataset of dual VET shares than any alternative known to us.

How to Measure the Knowledge Economy?

There are no clear conventions for the definition and measurement of the knowledge economy. The OECD (2005:28) coined the expression knowledge-based economy to describe "trends in advanced economies towards greater dependence on knowledge, information and high skill levels, and the increasing need for ready access to all of these by the business and public sectors." Powell and Snellman (2004:201), on the other hand, define

the knowledge economy as "production and services based on knowledge-intensive activities that contribute to an accelerated pace of technical and scientific advance, as well as rapid obsolescence." In Iversen and Soskice (2019), the focus is on changes in the organization of the production process and associated shifts in skill demand. While all definitions highlight the increased importance of knowledge and skills for economic competitiveness, Powell and Snellman (2004) further emphasize an implication of these trends, an accelerated pace of Schumpeterian creative destruction.

Powell and Snellman (2004) use patent data to document an increase in knowledge production. Patent data as a measure of inventive output and stocks of intellectual capital are widely used in the economics literature (Griliches 1998). However, overall patent counts do not reflect technological advance in what we term mature knowledge economies. As Powell and Snellman (2004) demonstrate, already in the 1990s patenting activity grew disproportionately in sectors associated with the knowledge economy. As knowledge economies have matured, this process has continued. We therefore rely on data on ICT- and AI-related patents as our indicator of the knowledge economy.[3] Unlike overall patent counts, which have remained relatively stable over time, ICT- and AI-related patents have surged since the late 1990s - first the former, and in recent years the latter. Moreover, there is substantial cross-country variation in the timing and intensity of these developments, mirroring the staggered advent of mature knowledge economies. This makes ICT/AI patents a suitable measure for the emergence of mature knowledge economies. We standardise the raw patent counts by population size and z-standardize the resulting values for ease of interpretation.

[FIGURE 3 HERE]

Alternative approaches to operationalizing the knowledge economy consider the production mix, sectoral employment shares, or the ICT-intensity of production in a country. To validate our patents-based measure, we therefore compare it to the Harvard Growth Lab's index of economic complexity,[4] the share of employees working in (high-tech) knowledge-intensive services calculated by Brady, Huber and Stephens (2020) based on EU-KLEMS data,[5] and an indicator of ICT capital per hour worked used by Kurer and Gallego (2019). Our measure correlates closely with the economic complexity index ($r = 0.55$, $p < 0.001$) and the EU-KLEMS shares of people working in knowledge-intensive services classified as *high-tech* ($r = 0.4$, $p < 0.001$) as shown in Figure 3. The correlation with the shares of people working in knowledge-intensive services overall is lower ($r = 0.1$, $p < 0.1$), which is expected since ICT/AI patent output should be related to employment in high-tech services, rather than employment in knowledge-intensive services overall. Finally, our indicator is also meaningfully correlated with ICT capital per hour worked ($r = 0.24$, $p < 0.001$). We successfully replicate our main findings with these alternative indicators (see below).

Outcome Variable: Wage Inequality

Our study focuses on wage inequality before taxes and transfers. Put differently, we examine distribution rather than redistribution, since the latter would dilute the effects of the skill formation system. We expect dual VET to have a particularly strong effect in the lower half of the wage distribution. We therefore focus on the 90/10, 90/50, and 50/10 wage ratios. The latter indicator allows us to specifically test for floor effects, that is, the expectation that dual VET raises the wage floor and thus compresses the lower part of the wage distribution more than it affects wage dynamics at the top. The data are taken from the OECD database. Unfortunately, there are a considerable number of missings, especially before the year 2004.

Control Variables

We incorporate a number of control variables in our models. Most importantly, we control for union density and wage setting coordination, which has been argued to influence both wage inequality (e.g., Kristal and Cohen 2017; Hope and Martelli 2019; Parolin 2021) and dual VET systems (e.g., Acemoglu and Pischke 1999; Marsden 1999; Martin and Swank 2012). These control variables are thus crucial to identify the net effect of dual VET on wage inequality. In addition, we control for unemployment, female labor force participation, and employment protection legislation (Breen 2005; Busemeyer 2015). We also add five variables capturing economic and political developments (GDP p.c., GDP growth, government expenditure, liberal democracy, and left party share in parliament). Finally, we control for openness (FDI inflows and capital openness) and financialization (FIRE value added) of the economy, which the literature has identified as important determinants of wage inequality (e.g., Bradley et al. 2003; Kristal and Cohen 2017). We document all data sources in the appendix (see Table C1).

Statistical Approach

We estimate two-way fixed-effects panel models to test our argument. Country fixed effects are necessary to account for time-invariant country characteristics. We add year fixed effects to prevent the widespread upward trend in inequality from producing a spurious relationship. We note that the two-way fixed-effects model, albeit widely used, does not allow for a causal interpretation of estimated effects (Imai and Kim 2021). We apply the procedure of Arellano (1987) to calculate heteroskedasticity and serial correlation-consistent standard errors. Thus, we estimate the following equation:

$$Y_{cy} = \alpha + \beta_1 VET_{cy} + \beta_2 KE_{cy} + \beta_3 VET_{cy} \times KE_{cy} + \hat{\beta}_4 X_{cy} + u_c + v_y + \epsilon_{cy} \quad (1)$$

Y_{cy} is our measure of wage inequality, α is the intercept, β_1, β_2, and β_3 are the coefficients on the dual VET share, the knowledge economy indicator, and the interaction between the two, and $\hat{\beta}_4 X_{cy}$ represents a vector of control variables. Finally, u_c and v_y capture the country and year fixed effects and e_{cy} is the error term.

Results

Building on previous research, we first use our significantly expanded dataset to test the direct effect of dual VET on wage inequality. In the second part of the analysis, we investigate whether the knowledge economy - measured by ICT/AI patenting activity - moderates the effect of dual VET on wage inequality. To preview our findings: We find a negative effect of dual VET on wage inequality, and our findings suggest that the negative effect on wage inequality might become even stronger in mature knowledge economies.

Before discussing the multivariate results, we first document the bivariate relationships in our data. To this end, we calculate the country averages of the dual VET share and the outcome variables over our sample period. Figure 4 shows that where dual VET is more prominent, wage inequality, as measured by the 50/10, 90/50, and 90/10 wage ratios, tends to be lower. The relationships are to some extent driven by the German-speaking countries and Denmark but remain negative with these countries removed from the sample. If we were to exclude countries with zero dual VET, we would see even stronger relationships.

[FIGURE 4 HERE]

Dual VET Reduces Wage Inequality

Older theoretical and empirical research has argued that dual VET contributes to lower wage inequality (e.g., Breen and Goldthorpe 1997; Estevez-Abe, Iversen and Soskice 2001). However, research on the matter has been scarce since the early 2000s. We now examine whether the negative relationship persists in the knowledge-based growth regime that has since become entrenched in the developed world (Hall 2020).

Figure 5 confirms that this relationship is still present in the 1996-2020 time frame. For better readability and interpretability we present only the standardized coefficients for the dual VET share variable. The full model output (with non-standardized data) can be found in Table A1. In the base models, we control for institutional characteristics, labor market performance, and political variables, whereas in the second set of models we employ additional controls for economic globalization and financialization. Regardless of the set of controls, we find that dual VET is associated with lower overall wage inequality, an effect driven entirely

by wage compression in the lower half of the distribution. A standard deviation (SD) increase in the dual VET share is associated with a reduction in lower-tail inequality by over 0.25 SD and a 0.2 SD decrease in overall wage inequality. The effect of dual VET on upper-tail wage inequality is close to zero and statistically insignificant. To further illustrate these effects, for the US moving from its current education system without dual VET to the German system with close to 50 percent dual VET enrollment at the upper-secondary level is estimated to reduce the 50/10 ratio from around 2 to 1.8 in 2020 - all but closing the gap in lower-tail inequality between the two countries. Our calculations furthermore suggest that with a German-style system, the 90/10 wage ratio in the US would be 0.45 points lower, which, based on the values for 2020, accounts for approximately 30% of the difference between the two countries.[6] Clearly, these are substantively meaningful effects.

Thus, in contrast to earlier studies, we find strong support for the argument that dual VET raises the wage floor and thereby reduces wage inequality in the bottom half of the distribution. In line with this reasoning, a higher dual VET share is not associated with lower inequality in the top half of the distribution as measured by the 90/50 ratio. Hence, the statistically significant effect on overall inequality is entirely driven by the relationship between dual VET and lower-tail inequality. This lends credence to the arguments first advanced by the likes of Allmendinger (1989), Breen and Goldthorpe (1997), and Freeman and Schettkat (2001) that dual VET incentivizes young people with a weaker school record to remain in education and training, thus compressing the skill and ultimately the wage distribution. We now proceed to investigate whether this relationship still holds throughout the transition to the knowledge economy.

[FIGURE 5 HERE]

The Knowledge Economy Strengthens the Relationship between Dual VET and Wage Equality

As advanced economies have come into shape as mature knowledge economies since the 2000s (Hall 2020), it is possible that the observed negative relationship between dual VET and lower-tail wage inequality is a relic from an earlier age that is driven by countries that have least advanced in the direction of mature knowledge economies. Put differently, it may be that the beneficial effect of dual VET on inequality disappears as firms increase their reliance on automation and digitalization. However, if anything, our analyses point in the opposite direction: the robust negative effect of dual VET on lower-tail wage inequality is unaffected by the rise of the knowledge economy, as is lower-tail inequality itself. And while we do find that the knowledge economy tends to be associated with higher inequality in the upper tail of the wage distribution, a higher

dual VET share checks this increase.

We estimate the same model with globalization controls as above, but interact the dual VET share with the knowledge economy (KE) indicator. Figure 6 shows the estimated effect of a 1 SD increase in the dual VET share at low (10^{th} percentile), medium (sample mean), and high (90^{th} percentile) levels of the KE indicator. It shows that dual VET is associated with a compressed lower-tail and overall wage distribution at all KE levels. At low levels, a 1 SD increase is associated with 0.3 SD reduction of the 50/10 ratio. At the 90^{th} percentile of the KE, corresponding to the most advanced economies in recent years, this effect is slightly more pronounced. However, the difference is not itself statistically significant. Thus, we conclude that the relationship between dual VET and the 50/10 wage ratio is essentially unaffected by the transition to the knowledge economy. The other inequality measures show increasing benefits to a high dual VET share in more advanced knowledge economies: the effect of a 1 SD increase in the dual VET share on overall inequality approximately doubles with a move from the 10^{th} to the 90^{th} percentile of the KE indicator. With regard to upper-tail inequality, the figure suggests that dual VET has a positive but insignificant effect at the 10^{th} percentile of the KE indicator and a negative effect at KE levels above the mean which becomes statistically significantly different from zero at KE values around the 90^{th} percentile.

[FIGURE 6 HERE]

[FIGURE 7 HERE]

In Figure 7 we show the estimated effects of a 1 SD increase in the KE indicator for different shares of dual VET enrolment at upper secondary level. We display the estimated effects at a dual VET share of zero, the sample mean (13.3%), and the value for Germany in 2019 (43.0%). We see a similar pattern to Figure 6: the level of the knowledge economy does not significantly affect the 50/10 ratio regardless of the dual VET share, but the marginally significant positive effects of the knowledge economy on the 90/10 and 90/50 ratios turn significantly negative in countries with high dual VET shares such as Germany. To summarize, while the relationship between dual VET and lower-tail wage inequality is unaffected by the knowledge economy, higher levels of the knowledge economy accentuate the beneficial effects of dual VET on upper-tail and overall inequality. On the flipside, while the knowledge economy contributes to higher upper-tail and overall inequality in the absence of a dual VET system, this relationship disappears at moderate levels of dual VET and finally turns negative at the highest observed dual VET shares in our sample. Thus, our analyses suggest that the beneficial relationship between dual VET systems and wage inequality persists in the knowledge economy. In fact, a high dual VET share and an advanced knowledge economy appear to positively reinforce

each other, such that each reduces upper-tail wage inequality at high levels of the other.

Sensitivity Analyses

We conduct a number of sensitivity analyses to illustrate the robustness of our results. Most importantly, to verify that our conclusions are not driven by any individual country, we perform a jackknife procedure where we exclude one country at a time. Figure 8 shows the results for our main outcome of interest, the 90/10 wage ratio. Reassuringly, the results are largely unaffected by excluding individual countries. The coefficient of the dual VET share is always statistically significant, although it appears somewhat weaker when Germany or Hungary are excluded, and stronger when Slovakia is excluded. The coefficients on the knowledge economy indicator and the interaction term are statistically significant in most cases, as in Model 3 of Table A2. This alleviates the concern that the effect we find on overall inequality is carried by the handful of high-dual VET countries in our sample.

[FIGURE 8 HERE]

The remaining sensitivity analyses can be seen in Appendix B. We first perform the same jackknife procedure for the 50/10 and 90/50 ratios. Figures B1 and B2 show that in practically all cases the patterns of statistical significance align with the main analysis in Table A2. We also test the robustness of our models to different sets of control variables by randomly dropping one or two control variables. Figures B3, B4, and B5 show a high degree of robustness to changes in the model specification. In particular the results for the 50/10 and 90/10 ratios, which are most central to our argument, are highly consistent.

Additionally, we address the question whether the effects of dual VET in the knowledge economy differ depending on the trajectory of the dual VET share. To this end, we split the sample into countries where the dual VET share has decreased and those where it has remained constant or increased. Table B1 shows that the relationships are indeed largely symmetrical, except for some differences in statistical significance. Moreover, to address concerns over potential outliers, we restrict the analysis to a more traditional set of advanced democracies, excluding Chile, Mexico, Russia, and Turkey. This does not affect our results, as Table B2 shows. In Table B3 we exclude countries that consistently report a dual VET share of 0, and in Table B4 we drop countries where the dual VET share exhibits large jumps, again finding robust results.

Absent from our comprehensive set of control variables in the main analysis was collective bargaining coverage, despite it having been found important in numerous previous studies (cf. Hope and Martelli 2019). This is because of the limited availability of the variable, which would halve the effective sample size and nullify the benefit of our expanded dataset of dual VET shares. Nevertheless, Table B5 shows that the effect

of dual VET remains robust to controlling for bargaining coverage, although the knowledge economy and interaction terms lose statistical significance. To show that the relationship is really due to dual VET, we run placebo tests where we use the share of school-based VET instead. The resulting coefficients on the 50/10 and 90/10 ratios in Table B6 are only about one third as large as in the analysis with dual VET, and there is no significant interaction with the knowledge economy indicator. Table B7 furthermore shows that our results hold when we lag the dual VET share to account for the fact that individuals who are in dual VET in a given year are not in the labor force yet.

Finally, we repeat our analyses using a different dependent variable and alternative measures of the knowledge economy. While this paper focuses on the underexplored relationship between dual VET and wage inequality, existing research has long linked dual VET to lower youth unemployment (Breen 2005; Rözer and van de Werfhorst 2020). We therefore show in Table B8 that our argument also holds for youth unemployment, although in this case the interaction is not robust to controlling for bargaining coverage.

Researchers often rely on EU-KLEMS data on employment in knowledge-intensive services to operationalize concepts related to the knowledge economy. Despite the limited data availability and our theoretical misgivings about how the indicator penalizes economies with large high-tech manufacturing sectors, in Table B9 we repeat the main analysis using this measure. A much reduced sample size notwithstanding, the key finding that dual VET is associated with reduced lower-tail and overall inequality holds.[7] Kurer and Gallego (2019) furthermore use EU-KLEMS data on industry-level ICT capital stocks per hour worked. Inspired by their approach, we calculate the ICT intensity of production across all sectors using the 2023 release of the EU-KLEMS. Table B10 shows that again, our main finding is replicated. Thus, across numerous operationalizations and samples, our central finding, that dual VET raises the wage floor and reduces lower-tail wage inequality, holds.

Conclusion

Skills and wages are intimately linked. At least in theory, workers' productivity should increase with their skill levels, while workers' wages should correspond to their productivity (the marginal product of their labor in economic theory). Although these relationships are likely to be far from perfect, it is reasonable to expect them to hold on average. In any case, the implication is straightforward. If skill formation systems contribute to the compression of the skills distribution, this should also be reflected in a more compressed wage distribution (lower levels of wage inequality).

Especially dual VET has long been argued to offer a reliable point of access for working-class youth to obtain additional years of training and, later, stable jobs (Thelen 2014). In this way, dual VET has the

potential to change a society's skills distribution, because many of these individuals might otherwise receive little to no additional training beyond compulsory school (Breen and Goldthorpe 1997). Indeed, Freeman and Schettkat (2001) find that compared to the USA, Germany, the 'poster child' of dual VET systems (Culpepper and Thelen 2008), features a more compressed skills distribution. Unlike the USA, they argue, Germany lacks "truly low skill workers" (Freeman and Schettkat 2001:601). But is this effect of dual VET on the skills distribution also reflected in the degree of wage inequality? And if yes, does this relationship still hold in today's mature knowledge economies?

Our paper observes an enduring relationship between dual VET and lower wage inequality. While not unaffected by the rise of the knowledge economy, our findings point in the opposite direction of the oft-repeated fear that the knowledge economy would undermine the beneficial effects of dual VET. In fact, we find a strengthening of the negative effect of the dual VET share on wage inequality. Our counterfactuals illustrate the substantively large impact of dual VET on wage inequality. While systems with high dual VET enrollment at the upper-secondary level like the German one depend on a myriad of factors and cannot easily be transferred to other countries, our findings illustrate the lasting benefits that countries with strong dual VET systems reap, and that these benefits might even be augmented by the transition to a knowledge-based economy. For countries without established dual VET systems, introducing such tracks at the upper-secondary level might alleviate some of the negative effects of the transition to the knowledge economy.

Our study is - to our knowledge - the first to provide strong empirical evidence for the inequality-inhibiting effect of dual VET systems. So far, the rich literature on inequality has paid scant attention to the role of skill formation systems. In many ways, this is surprising. Although the literature highlights that economic growth increasingly depends on skills and knowledge-intensive activities, and that such knowledge-driven growth might have important implications for inequality, the literature has not yet examined how existing skill formation systems might help workers cope with economic change (Özkiziltan and Hassel 2020; Gallego and Kurer 2022). If skill formation systems differ in the way they prepare individuals for the knowledge economy, and there is plenty of reasons to believe that they do, then future research on the drivers of wage inequality would be well advised to take these differences into account.

Notes

1. Youth unemployment increases wage inequality due to the long-term negative effect of early unemployment on earning abilities over the life course (Gangl 2006; Mroz and Savage 2006), but we argue that the impact of dual VET on wage inequality goes beyond such scarring effects.

2. However, dual VET might give rise to social class differences in participation in higher education because it distracts students in the middle of the skill distribution from pursuing a more academic education (Shavit and Müller 1998; Hillmert 2003).

3. Simple patent counts suffer from a number of limitations: the value of patents is skewed, with many inventions having no industrial application and no value to society, home bias tends to bias the share of foreign patents in a country, and increased stringency of patent protections makes over-time comparisons difficult (Dernis, Guellec and van Pottelsberghe 2001). Hence, to ensure the cross-national comparability of our patent counts, we follow Dernis, Guellec and van Pottelsberghe (2001) and use the triadic patent family method. Triadic patent families are defined as "a set of patents taken at the European Patent Office (EPO), the Japan Patent Office (JPO) and the US Patent and Trademark Office (USPTO) that protect a same invention." This eliminates home bias and ensures that predominantly high-value patents are included.

4. The index of economic complexity is a measure based on the diversity and complexity of a country's export basket (Hidalgo and Hausmann 2009). High complexity countries are home to a range of sophisticated, specialized capabilities that few other countries possess. This measure is a promising indicator of realized potential in the knowledge economy, but since it is standardised within years, it is not suitable for over-time comparisons.

5. This measure is currently the most widely used indicator for the knowledge economy. However, in our view, it unduly penalizes economies with a large high-tech manufacturing sector such as Japan and Germany with its exclusive focus on knowledge-intensive *services*. Furthermore, this measure is only available for 18 countries until at most 2015 (2007 for employment in high-tech knowledge-intensive services), severely limiting the scope for analysis.

6. Calculations based on Table A1. For lower-tail inequality: US 50/10 ratio: 2.02; DE 50/10 ratio: 1.79. -0.004 x 50 = -0.2; 2.02 - 1.79 = 0.23; -0.2/0.23 = -0.87. For overall inequality: US 90/10 ratio: 4.84; DE 90/10 ratio: 3.33. -0.009 x 50 = -0.45; 4.84 - 3.33 = 1.51; -0.45/1.51 = -0.30. Needless to say, this is a hypothetical scenario. Production regimes and education systems are naturally slow-moving, and such a massive change would likely require decades to implement and could also lead to unintended consequences.

7. In contrast to the patents indicator, the EU-KLEMS measure is itself (insignificantly) negatively associated with inequality, and the interaction term is positive.

References

Acemoglu, Daron and Jorn-Steffen Pischke. 1999. "Beyond Becker: Training in Imperfect Labour Markets." The Economic Journal 109(453):112–142.

Adda, Jérôme and Christian Dustmann. 2023. "Sources of Wage Growth." Journal of Political Economy 131(2):456–503.

Allmendinger, Jutta. 1989. "Educational systems and labor market outcomes." European Sociological Review 5(3):231–250.

Anderson, Karen M. and Anke Hassel. 2013. Pathways of Change in CMEs: Training Regimes in Germany and the Netherlands. In The Political Economy of the Service Transition, ed. Anne Wren. Oxford University Press pp. 171–194.

Arellano, Manuel. 1987. "Computing Robust Standard Errors for Within-groups Estimators." Oxford Bulletin of Economics and Statistics 49(4):431–434.

Autor, David and David Dorn. 2013. "The Growth of Low-Skill Service Jobs and the Polarization of the US Labor Market." American Economic Review 103(5):1553–97. arXiv: 1011.1669v3 ISBN: 0002-8282.

Basler, Ariane and Irene Kriesi. 2022. "The Development of Informal Competences Between the End of Compulsory School and Early Adulthood." Swiss Journal of Sociology 48(2):285–315.

Birkelund, Jesper Fels. 2022. "Educational Tracking and Personality Formation: Evidence from a Dual System." Social Forces 100(4):1696–1721.

Bol, Thijs and Herman G. Van De Werfhorst. 2011. "Signals and closure by degrees: The education effect across 15 European countries." Research in Social Stratification and Mobility 29(1):119–132.

Bol, Thijs and Herman G. Van De Werfhorst. 2013. "Educational Systems and the Trade-Off between Labor Market Allocation and Equality of Educational Opportunity." Comparative Education Review 57(2):285–308.

Bonoli, Giuliano and Anna Wilson. 2019. "Bringing firms on board. Inclusiveness of the dual apprenticeship systems in Germany, Switzerland and Denmark." International Journal of Social Welfare 28(4):369–379.

Bradley, David, Evelyne Huber, Stephanie Moller, François Nielsen and John D. Stephens. 2003. "Distribution and Redistribution in Postindustrial Democracies." World Politics 55(2):193–228.

Brady, David, Evelyne Huber and John D. Stephens. 2020. "Comparative Welfare States Data Set.".

Breen, Richard. 2005. "Explaining Cross-national Variation in Youth Unemployment." European Sociological Review 21(2):125–134.

Breen, Richard and John H. Goldthorpe. 1997. "Explaining Educational Differentials: Towards a Formal Rational Action Theory." Rationality and Society 9(3):275–305.

Busemeyer, Marius R. 2015. Skills and inequality : partisan politics and the political economy of education reforms in western welfare states. Cambridge: Cambridge University Press.

Busemeyer, Marius R. and Christine Trampusch. 2011. The Comparative Political Economy of Collective Skill Formation. In The Political Economy of Collective Skill Formation, ed. Marius R. Busemeyer and Christine Trampusch. Oxford University Press pp. 3–38.

Checchi, Daniele and Herman G Van De Werfhorst. 2018. "Policies, skills and earnings: how educational inequality affects earnings inequality." Socio-Economic Review 16(1):137–160.

Chuan, Amanda and Christian Lyhne Ibsen. 2022. "Skills for the Future? A Life Cycle Perspective on Systems of Vocational Education and Training." ILR Review 75(3):638–664.

Chuard, Patrick and Veronica Grassi. 2020. "Switzer-Land of Opportunity: Intergenerational Income Mobility in the Land of Vocational Education." SSRN Electronic Journal .

Culpepper, Pepper D. and Kathleen Thelen. 2008. Institutions and Collective Actors in the Provision of Training: Historical and Cross-National Comparisons. In Skill Formation, ed. Karl Ulrich Mayer and Heike Solga. 1 ed. Cambridge University Press pp. 21–49.

Dernis, Hélène, Dominique Guellec and Bruno van Pottelsberghe. 2001. Using Patent Counts for Cross-Country Comparisons of Technology Output. Technical Report 27 OECD.

Diessner, Sebastian, Niccolo Durazzi and David Hope. 2022. "Skill-Biased Liberalization: Germany's Transition to the Knowledge Economy." Politics & Society 50(1):117–155.

Durazzi, Niccolo and Chiara Benassi. 2020. "Going Up-Skill: Exploring the Transformation of the German Skill Formation System." German Politics 29(3):319–338.

Estevez-Abe, Margarita, Torben Iversen and David Soskice. 2001. Social Protection and the Formation of Skills: A Reinterpretation of the Welfare State. In Varieties of Capitalism: The Institutional Foundations of Comparative Advantage, ed. Peter A Hall and David Soskice. Oxford: Oxford University Press.

European Commission. 2016. Developing skills for the labour market: the Riga conclusions : European cooperation in vocational education and training 2015-2020. LU: Publications Office of the European Union.

Farkas, George. 2003. "Cognitive Skills and Noncognitive Traits and Behaviors in Stratification Processes." Annual Review of Sociology 29(1):541–562.

Freeman, Richard and Ronald Schettkat. 2001. "Skill compression, wage differentials, and employment: Germany vs the US." Oxford Economic Papers 3:582–603.

Gallego, Aina and Thomas Kurer. 2022. "Automation, Digitalization, and Artificial Intelligence in the Workplace: Implications for Political Behavior." Annual Review of Political Science 25(1):463–484.

Gangl, Markus. 2006. "Scar Effects of Unemployment: An Assessment of Institutional Complementarities." American Sociological Review 71(6):986–1013.

Griliches, Zvi. 1998. Patent Statistics as Economic Indicators: A Survey. In R&D and Productivity: The Econometric Evidence, ed. Zvi Griliches. Chicago: University of Chicago Press pp. 287–343.

Hall, Peter A. 2020. "The Electoral Politics of Growth Regimes." Perspectives on Politics 18(1):185–199.

Hanushek, Eric A., Guido Schwerdt, Ludger Woessmann and Lei Zhang. 2017. "General Education, Vocational Education, and Labor-Market Outcomes over the Lifecycle." Journal of Human Resources 52(1):48–87.

Heckman, James J. and Tim Kautz. 2012. "Hard evidence on soft skills." Labour Economics 19(4):451–464.

Heisig, Jan Paul, Maurice Gesthuizen and Heike Solga. 2019. "Lack of skills or formal qualifications? New evidence on cross-country differences in the labor market disadvantage of less-educated adults." Social Science Research 83:102314.

Hidalgo, César A. and Ricardo Hausmann. 2009. "The building blocks of economic complexity." PNAS 106(26):6.

Hillmert, S. 2003. "Social Inequality in Higher Education. Is Vocational Training a Pathway Leading to or Away from University?" European Sociological Review 19(3):319–334.

Hope, David and Angelo Martelli. 2019. "The Transition to the Knowledge Economy, Labor Market Institutions, and Income Inequality in Advanced Democracies." World Politics 71(2):236–288.

Iannelli, C. and D. Raffe. 2007. "Vocational Upper-Secondary Education and the Transition from School." European Sociological Review 23(1):49–63.

Imai, Kosuke and In Song Kim. 2021. "On the Use of Two-Way Fixed Effects Regression Models for Causal Inference with Panel Data." Political Analysis 29(3):405–415.

Iversen, Torben and David Soskice. 2019. Democracy and Prosperity : Reinventing Capitalism through a Turbulent Century. Princeton: Princeton University Press.

Korber, Maïlys and Daniel Oesch. 2019. "Vocational versus general education: Employment and earnings over the life course in Switzerland." Advances in Life Course Research 40:1–13.

Kristal, Tali and Yinon Cohen. 2017. "The causes of rising wage inequality: The race between institutions and technology." Socio-Economic Review 15(1):187–212.

Kurer, Thomas and Aina Gallego. 2019. "Distributional consequences of technological change: Worker-level evidence." Research & Politics 6(1):1–9.

Marsden, David. 1999. A theory of employment systems : micro-foundations of societal diversity. Oxford: Oxford University Press.

Martin, Cathie Jo and Duane Swank. 2012. The Political Construction of Business Interests: Coordination, Growth, and Equality. New York, NY: Cambridge University Press.

Martin, Cathie Jo and Jette Steen Knudsen. 2010. "Scenes from a mall: Retail training and the social exclusion of low-skilled workers: Scenes from a mall." Regulation & Governance 4(3):345–364.

Mroz, Thomas A. and Timothy H. Savage. 2006. "The Long-Term Effects of Youth Unemployment." Journal of Human Resources XLI(2):259–293.

OECD. 2001. Education at a Glance: OECD Indicators 2001. Paris: OECD Publishing.

OECD. 2005. Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data. 3rd ed. Paris: OECD Publishing.

OECD. 2012. Literacy, Numeracy and Problem Solving in Technology-Rich Environments: Framework for the OECD Survey of Adult Skills. OECD.

OECD. 2017. "Programme for the International Assessment of Adult Competencies (PIAAC).".

OECD. 2020. Strengthening the Governance of Skills Systems: Lessons from Six OECD Countries. OECD Skills Studies OECD.

Oesch, Daniel and Giorgio Piccitto. 2019. "The Polarization Myth: Occupational Upgrading in Germany, Spain, Sweden, and the UK, 1992-2015." Work and Occupations 46(4):441–469.

Parolin, Zachary. 2021. "Automation, Occupational Earnings Trends, and the Moderating Role of Organized Labor." Social Forces 99(3):921–946.

Pfeffer, F. T. 2008. "Persistent Inequality in Educational Attainment and its Institutional Context." European Sociological Review 24(5):543–565.

Pischke, J.-S. 2005. "Labor Market Institutions, Wages, and Investment: Review and Implications." CESifo Economic Studies 51(1):47–75.

Powell, Walter W. and Kaisa Snellman. 2004. "The Knowledge Economy." Annual Review of Sociology 30:199–220.

Rözer, Jesper and Herman G van de Werfhorst. 2020. "Three Worlds of Vocational Education: Specialized and General Craftsmanship in France, Germany, and The Netherlands." European Sociological Review 36(5):780–797.

Rözer, Jesper J and Thijs Bol. 2019. "Labour Market Effects of General and Vocational Education over the Life-Cycle and across Time: Accounting for Age, Period, and Cohort Effects." European Sociological Review 35(5):701–717.

Schulz, Wiebke, Heike Solga and Reinhard Pollak. 2023. "Vocational education, tertiary education, and skill use across career stages." European Sociological Review .

Shavit, Yossi and Walter Müller. 1998. From school to work. A comparative study of educational qualifications and occupational destinations. Oxford: Clarendon Press.

Silliman, Mikko and Hanna Virtanen. 2022. "Labor Market Returns to Vocational Secondary Education." American Economic Journal: Applied Economics 14(1):197–224.

Streeck, Wolfgang. 1989. "Skills and the Limits of Neo-Liberalism: The Enterprise of the Future as a Place of Learning." Work, Employment and Society 3(1):89–104.

Streeck, Wolfgang. 2011. Skills and Politics: General and Specific. In The Political Economy of Collective Skill Formation, ed. Marius R. Busemeyer and Christine Trampusch. Oxford: Oxford University Press.

Thelen, Kathleen Ann. 2014. Varieties of liberalization and the new politics of social solidarity. New York, NY: .

Weeden, Kim A. 2002. "Why Do Some Occupations Pay More than Others? Social Closure and Earnings Inequality in the United States." American Journal of Sociology 108(1):55–101.

Wren, Anne. 2013. The political economy of the service transition. Oxford scholarship online Oxford: Oxford University Press. Publication Title: The political economy of the service transition.

Wren, Anne. 2021. Strategies for Growth and Employment Creation in a Services-Based Economy: Skill Formation, Equality, and the Welfare State. In Growth & Welfare in Advanced Capitalist Economies: How Have Growth Regimes Evolved?, ed. Anke Hassel and Bruno Palier. Oxford: Oxford University Press pp. 255–288.

Özkiziltan, Didem and Anke Hassel. 2020. "Humans versus Machines: An Overview of Research on the Effects of Automation of Work." SSRN Electronic Journal .

Tables

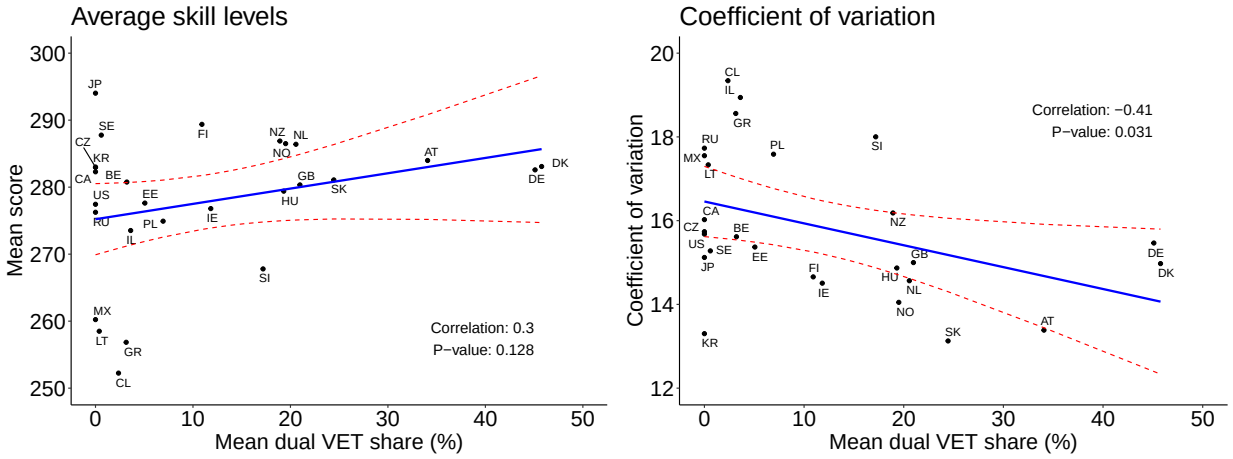
Table 1: Pearson bivariate correlations between dual VET share and skills

	Dual VET share correlation with	
PIAAC skill	Average skill levels	Coefficient of variation in skills
Problem-solving	0.30	-0.41
Numeracy	0.33	-0.12
Literacy	0.19	-0.12

Note: N=30 (numeracy, literacy) and 27 (problem-solving).

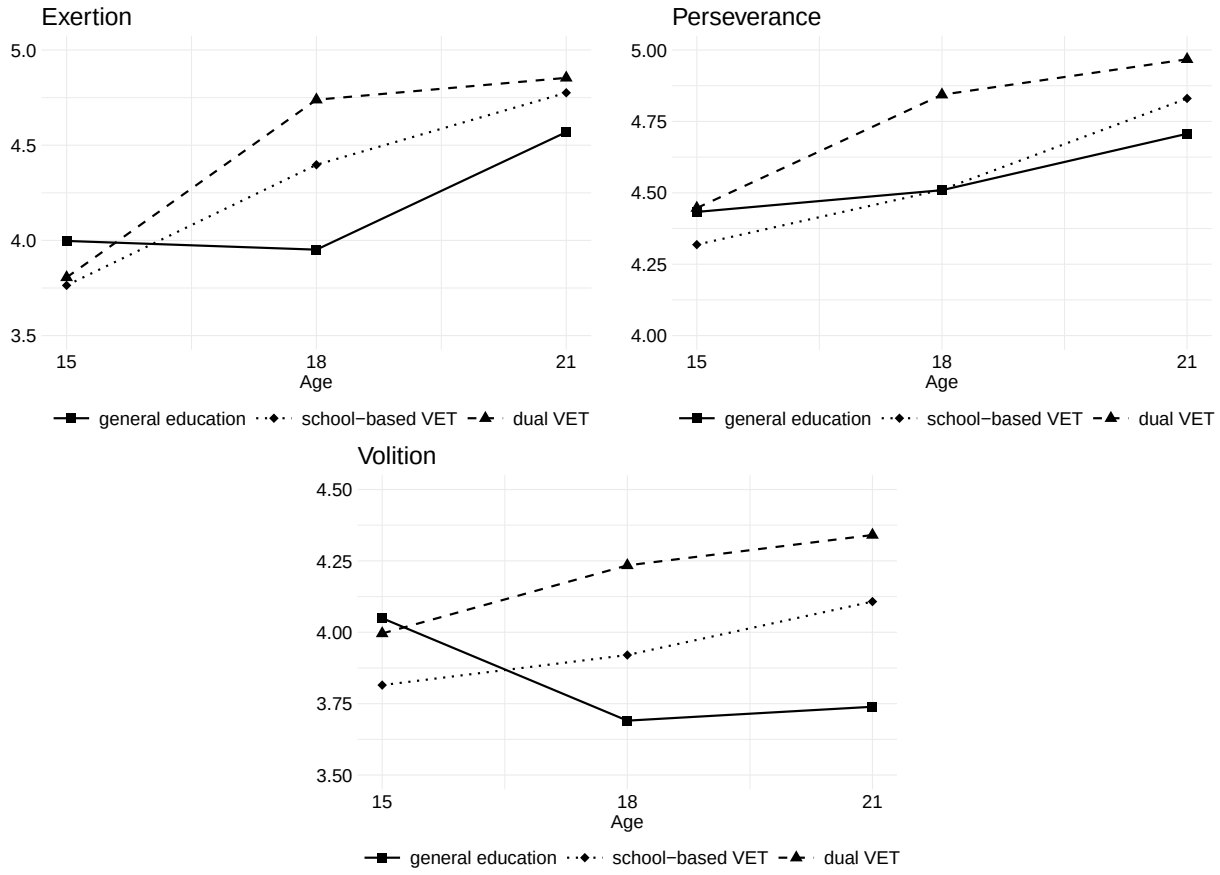
Figures

Figure 1: Relationship between dual VET share and problem-solving skills in technology-rich environments



Source: OECD (2017:PIAAC survey), own calculations.

Figure 2: Development of key competences by school type



Source: Replicated from Basler and Kriesi (2022) based on the Swiss Survey of Children and Youth (COCON). We thank the authors for making their data available.

Figure 3: Correlation of ICT/AI patents p.c. and employment share in high-tech knowledge-intensive services

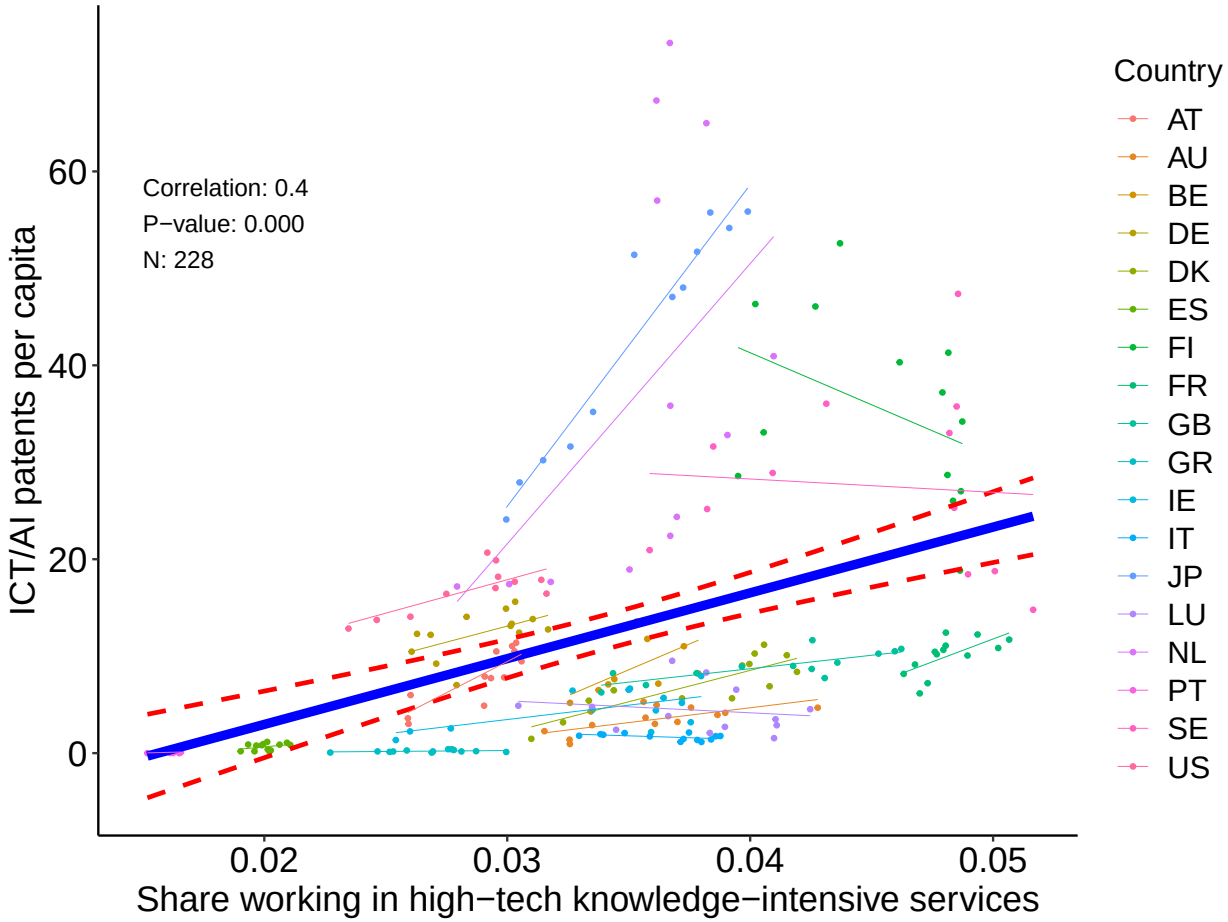
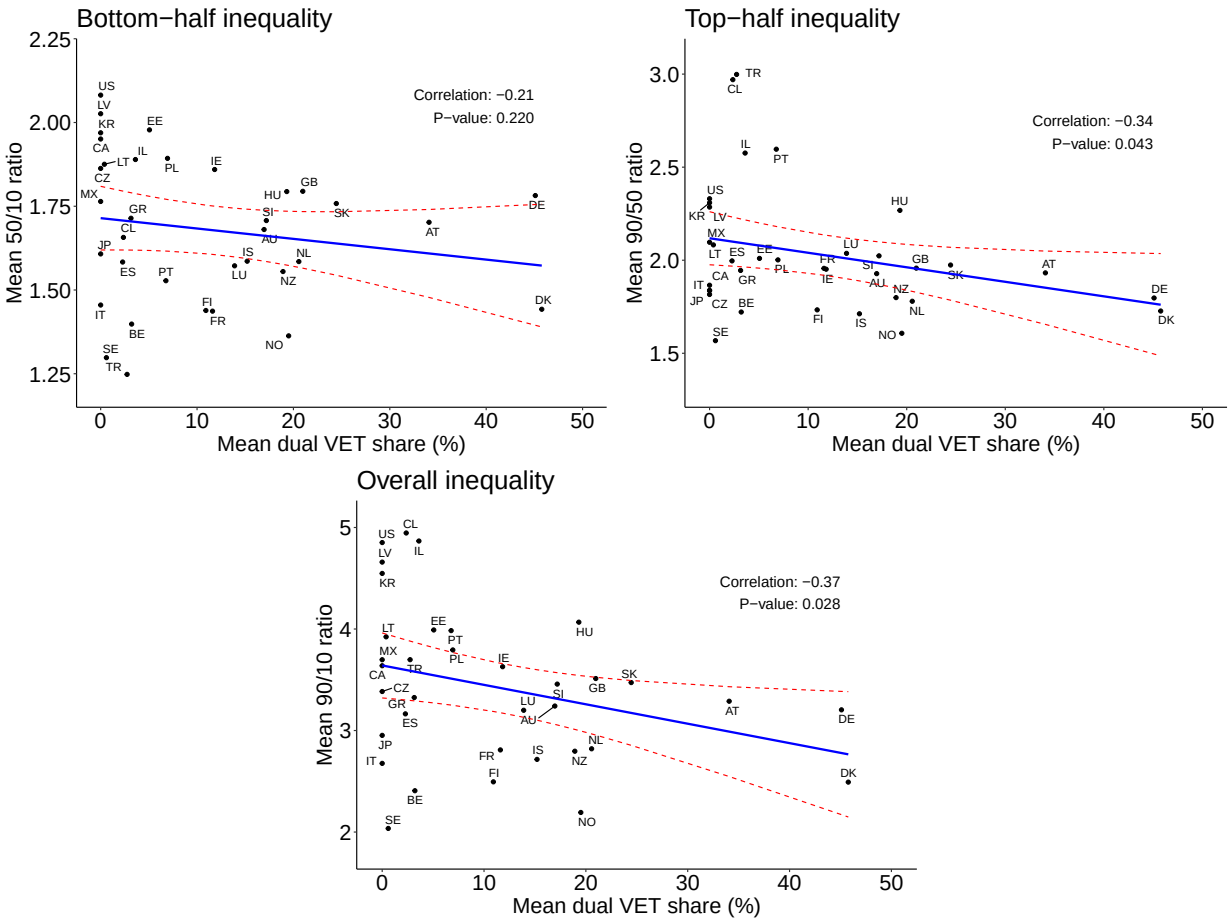
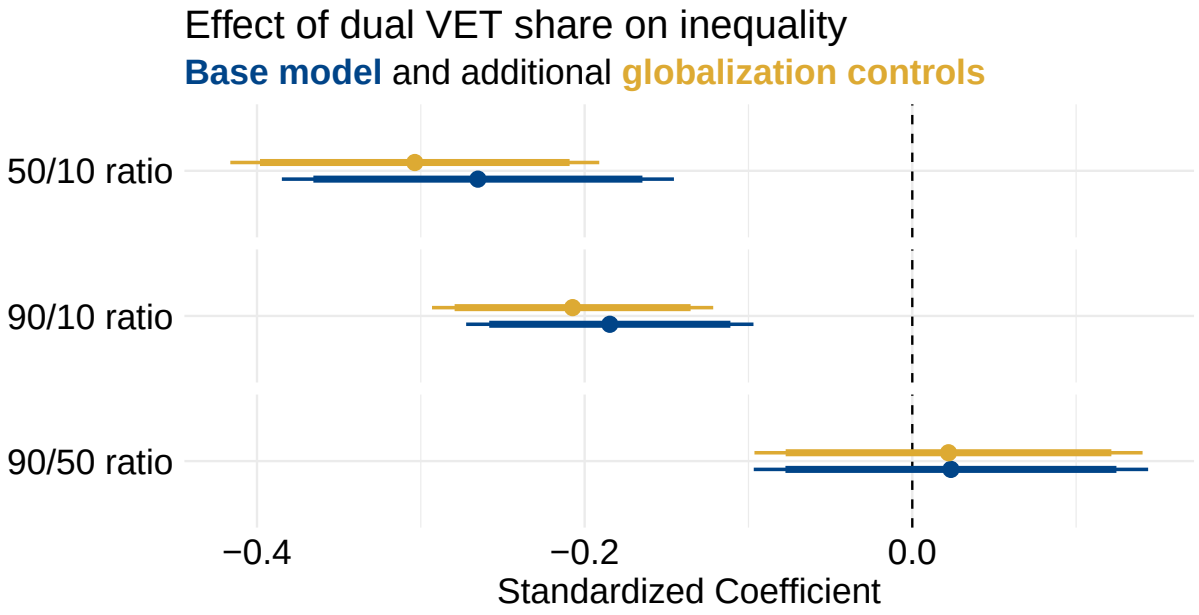


Figure 4: Correlation of dual VET share and wage inequality



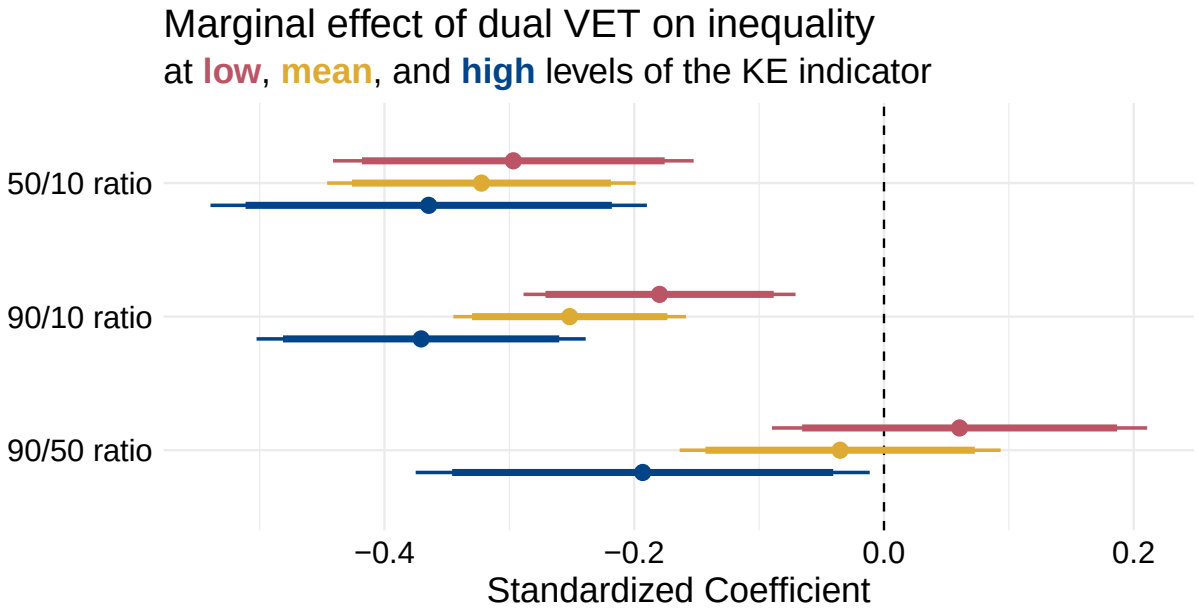
Note: Dots represent country averages calculated from all available years.

Figure 5: Effect of dual VET, additive models



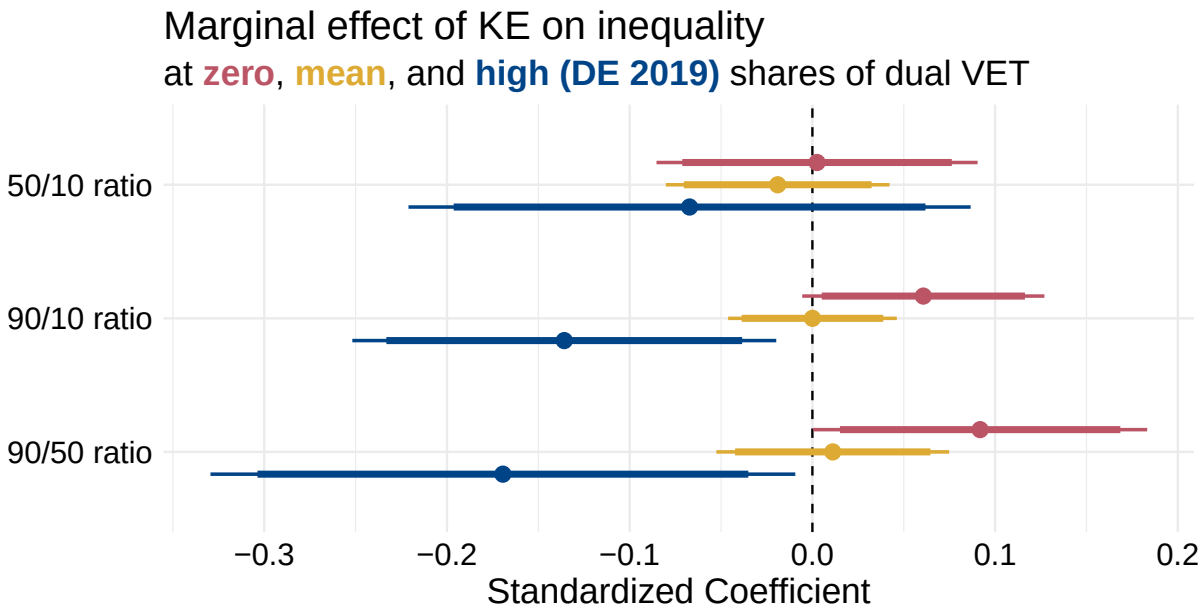
Note: Standardized coefficients with 90% and 95% confidence intervals (thick and thin lines). Coefficients can be interpreted as the standard deviation change in the outcome variable in response to a standard deviation change in the dual VET share. Full (non-standardized) model output in Table A1.

Figure 6



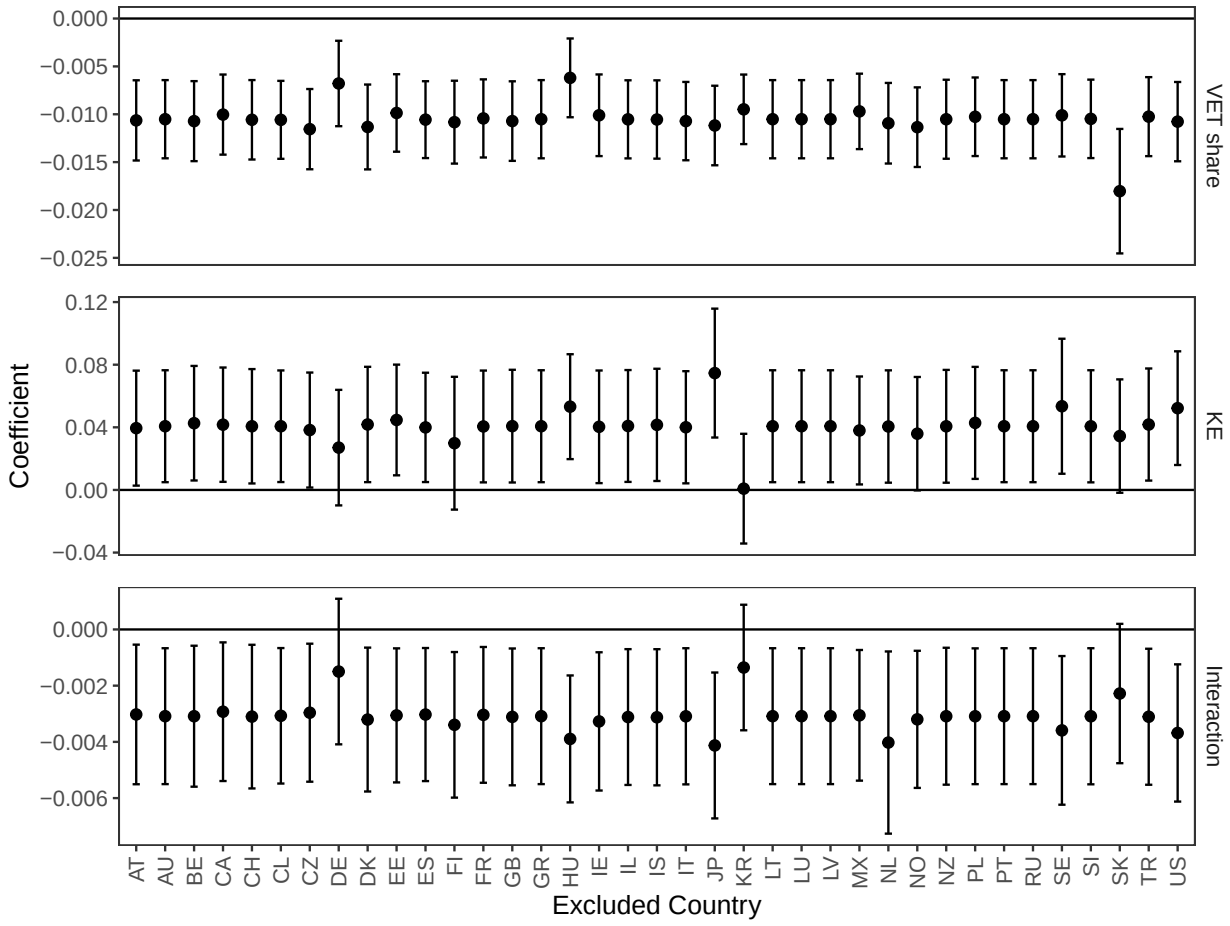
Note: Standardized coefficients with 90% and 95% confidence intervals (thick and thin lines). Coefficients can be interpreted as the standard deviation change in the outcome variable in response to a standard deviation change in the dual VET share at different levels of the knowledge economy. Full (non-standardized) model output in Table A2.

Figure 7



Note: Standardized coefficients with 90% and 95% confidence intervals (thick and thin lines). Coefficients can be interpreted as the standard deviation change in the outcome variable in response to a standard deviation change in the knowledge economy indicator at different levels of dual VET. Full (non-standardized) model output in Table A2.

Figure 8: Jackknife results for 90/10 ratio



Note: The figure replicates Model 3 in Table A2, excluding one country at a time. It shows that the results are not driven by any one individual country.

Appendix: For Online Publication

Contents

A Full Model Output

Table A1: The Effect of Dual VET on Wage Inequality

	Wage ratio:					
	50/10	90/50	90/10	50/10	90/50	90/10
	(1)	(2)	(3)	(4)	(5)	(6)
VET share	−0.004***	0.0004	−0.009***	−0.004***	0.0003	−0.010***
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)
Union density	−0.004***	0.002	−0.002	−0.005***	0.003**	−0.002
	(0.001)	(0.002)	(0.004)	(0.001)	(0.002)	(0.004)
Wage setting coordination	0.004	−0.017	−0.020	0.014	−0.022**	−0.006
	(0.010)	(0.011)	(0.024)	(0.009)	(0.011)	(0.024)
EPL (regular)	0.059**	−0.059*	0.028	0.038	−0.052*	−0.005
	(0.028)	(0.031)	(0.069)	(0.027)	(0.031)	(0.069)
EPL (temp.)	−0.031***	0.017*	−0.036	−0.025***	0.002	−0.044*
	(0.009)	(0.010)	(0.022)	(0.009)	(0.011)	(0.023)
GDP per capita	−0.00000*	0.00001***	0.00001	0.00000	0.00001***	0.00002***
	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)
GDP growth	0.00004	0.004	0.005	0.002	0.003	0.008*
	(0.002)	(0.002)	(0.005)	(0.002)	(0.002)	(0.005)
Gov. expenditure	0.001	−0.005	−0.005	0.005	−0.010**	−0.004
	(0.004)	(0.004)	(0.009)	(0.004)	(0.004)	(0.009)
Female LFP	−0.003	−0.007***	−0.018***	−0.003	−0.007***	−0.017***
	(0.002)	(0.002)	(0.004)	(0.002)	(0.002)	(0.004)
Liberal democracy	0.250***	0.657***	1.254***	0.149*	0.710***	1.123***
	(0.090)	(0.099)	(0.220)	(0.086)	(0.100)	(0.219)
Left party share	−0.0001	−0.0004	−0.0003	0.0001	−0.001*	−0.0001
	(0.0003)	(0.0003)	(0.001)	(0.0003)	(0.0003)	(0.001)
UE rate	−0.003	0.0004	−0.004	−0.003	−0.001	−0.005
	(0.002)	(0.002)	(0.005)	(0.002)	(0.002)	(0.005)
FDI inflows				−0.0005	−0.00003	−0.001
				(0.0004)	(0.0004)	(0.001)
FIRE value added				0.010**	0.010*	0.032***
				(0.004)	(0.005)	(0.011)
Capital openness				−0.046***	0.037***	−0.045*
				(0.009)	(0.010)	(0.023)
Observations	383	383	383	377	377	377
R^2	0.189	0.276	0.294	0.280	0.317	0.339

Note: $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

Table A2: The Effect of Dual VET Persists in the Knowledge Economy

	Wage ratio:		
	50/10	90/50	90/10
	(1)	(2)	(3)
VET share	−0.004***	0.00004	−0.011***
	(0.001)	(0.001)	(0.002)
Knowledge economy	0.001	0.020**	0.041**
	(0.007)	(0.008)	(0.018)
VET x KE	−0.0003	−0.001**	−0.003**
	(0.0005)	(0.001)	(0.001)
Union density	−0.005***	0.003*	−0.003
	(0.001)	(0.002)	(0.004)
Wage setting coordination	0.015	−0.019*	0.001
	(0.009)	(0.011)	(0.024)
EPL (regular)	0.036	−0.055*	−0.014
	(0.027)	(0.031)	(0.069)
EPL (temp.)	−0.026***	0.004	−0.040*
	(0.009)	(0.011)	(0.023)
GDP per capita	0.00000	0.00001***	0.00002***
	(0.00000)	(0.00000)	(0.00000)
GDP growth	0.002	0.003	0.007
	(0.002)	(0.002)	(0.005)
Gov. expenditure	0.005	−0.011**	−0.005
	(0.004)	(0.004)	(0.009)
Female LFP	−0.003	−0.007***	−0.018***
	(0.002)	(0.002)	(0.004)
Liberal democracy	0.146*	0.716***	1.131***
	(0.087)	(0.099)	(0.218)
Left party share	0.0001	−0.001**	−0.0002
	(0.0003)	(0.0003)	(0.001)
UE rate	−0.003	−0.002	−0.006
	(0.002)	(0.002)	(0.005)
FDI inflows	−0.0005	−0.00003	−0.001
	(0.0004)	(0.0004)	(0.001)
FIRE value added	0.010**	0.010**	0.033***
	(0.004)	(0.005)	(0.011)
Capital openness	−0.046***	0.035***	−0.048**
	(0.009)	(0.010)	(0.023)
Observations	377	377	377
R^2	0.282	0.333	0.354

Note: $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

B Sensitivity Analyses

Table B1: The effects of dual VET in the knowledge economy are largely symmetrical

	Dual VET constant or growing			*Dual VET declining*		
	50/10	90/50	90/10	50/10	90/50	90/10
	(1)	(2)	(3)	(4)	(5)	(6)
VET share	−0.005**	−0.003	−0.019***	−0.001	−0.004***	−0.008***
	(0.002)	(0.002)	(0.006)	(0.001)	(0.001)	(0.003)
Knowledge economy	0.003	0.011	0.029	0.016	0.077	0.114
	(0.007)	(0.007)	(0.022)	(0.046)	(0.049)	(0.115)
VET x KE	−0.0002	−0.0004	−0.001	−0.0004	−0.004***	−0.007**
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.003)
Union density	−0.008***	0.005***	−0.005	−0.001	−0.012***	−0.020**
	(0.001)	(0.001)	(0.004)	(0.004)	(0.004)	(0.009)
Wage setting coordination	−0.0003	0.0003	−0.012	0.008	−0.0004	0.004
	(0.014)	(0.014)	(0.044)	(0.011)	(0.011)	(0.027)
EPL (regular)	−0.082**	−0.029	−0.241**	0.038	−0.055	0.021
	(0.038)	(0.038)	(0.117)	(0.041)	(0.043)	(0.102)
EPL (temp.)	0.024**	0.006	0.063*	−0.066***	−0.038*	−0.188***
	(0.012)	(0.012)	(0.037)	(0.020)	(0.021)	(0.050)
GDP per capita	−0.00000	0.00001***	0.00002*	−0.00000	0.00001***	0.00001*
	(0.00000)	(0.00000)	(0.00001)	(0.00000)	(0.00000)	(0.00001)
GDP growth	0.002	0.002	0.009	−0.002	0.0001	−0.006
	(0.002)	(0.002)	(0.006)	(0.003)	(0.004)	(0.009)
Gov. expenditure	0.017***	−0.008*	0.018	−0.009	0.016*	0.006
	(0.004)	(0.004)	(0.013)	(0.009)	(0.010)	(0.023)
Female LFP	−0.014***	−0.003	−0.035***	0.0002	−0.012***	−0.017**
	(0.003)	(0.003)	(0.008)	(0.003)	(0.003)	(0.008)
Liberal democracy	0.300***	0.094	0.739**	−0.524***	2.327***	1.330***
	(0.104)	(0.104)	(0.317)	(0.166)	(0.176)	(0.414)
Left party share	0.0004	−0.0002	0.001	0.002***	−0.003***	−0.001
	(0.0003)	(0.0003)	(0.001)	(0.001)	(0.001)	(0.002)
UE rate	−0.008***	0.005*	−0.006	−0.002	0.003	0.001
	(0.003)	(0.003)	(0.009)	(0.003)	(0.003)	(0.006)
FDI inflows	−0.001**	0.0001	−0.002	−0.0002	0.00000	−0.0004
	(0.0005)	(0.0005)	(0.001)	(0.001)	(0.001)	(0.001)
FIRE value added	−0.003	0.015***	0.022	0.007	0.002	0.009
	(0.006)	(0.006)	(0.017)	(0.007)	(0.007)	(0.017)
Capital openness	−0.050***	0.026**	−0.062**	0.027	−0.028	0.015
	(0.010)	(0.010)	(0.030)	(0.018)	(0.019)	(0.045)
Observations	231	231	231	146	146	146
R^2	0.522	0.311	0.418	0.391	0.838	0.472

Note: $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

Table B2: Advanced Democracies Only

	Wage ratio:		
	50/10	90/50	90/10
	(1)	(2)	(3)
VET share	−0.003***	−0.001**	−0.010***
	(0.001)	(0.001)	(0.002)
Knowledge economy	0.003	0.015***	0.039**
	(0.006)	(0.005)	(0.018)
VET x KE	−0.0004	−0.001***	−0.003**
	(0.0004)	(0.0004)	(0.001)
Union density	−0.006***	0.003***	−0.004
	(0.001)	(0.001)	(0.003)
Wage coordination	0.008	−0.010	−0.004
	(0.008)	(0.007)	(0.023)
EPL (regular)	−0.003	−0.008	−0.046
	(0.024)	(0.020)	(0.067)
EPL (temp.)	−0.047***	−0.001	−0.089***
	(0.010)	(0.009)	(0.029)
GDP per capita	0.00000	0.00001***	0.00001**
	(0.00000)	(0.00000)	(0.00000)
GDP growth	0.003*	−0.001	0.005
	(0.002)	(0.001)	(0.005)
Gov. expenditure	0.001	−0.006**	−0.009
	(0.003)	(0.003)	(0.009)
Female LFP	−0.004***	−0.007***	−0.022***
	(0.002)	(0.001)	(0.004)
Liberal democracy	0.488***	0.125*	1.257***
	(0.085)	(0.071)	(0.237)
Left party share	−0.0002	0.00001	0.00001
	(0.0002)	(0.0002)	(0.001)
UE rate	−0.006***	0.002	−0.008*
	(0.002)	(0.001)	(0.005)
FDI inflows	−0.001*	0.0002	−0.001
	(0.0003)	(0.0003)	(0.001)
FIRE value added	0.014***	−0.001	0.028**
	(0.004)	(0.003)	(0.011)
Capital openness	−0.033***	0.020***	−0.037
	(0.008)	(0.007)	(0.023)
Observations	355	355	355
R^2	0.427	0.340	0.378

Note: $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

Table B3: Excluding Countries Consistently without Dual VET

	Wage ratio:		
	50/10	90/50	90/10
	(1)	(2)	(3)
VET share	−0.004***	0.001	−0.009***
	(0.001)	(0.001)	(0.002)
Knowledge economy	−0.001	0.028**	0.031
	(0.010)	(0.012)	(0.022)
VET x KE	0.0002	−0.002***	−0.003**
	(0.001)	(0.001)	(0.001)
Union density	0.002	−0.001	0.002
	(0.002)	(0.002)	(0.005)
Wage coordination	0.012	−0.024**	−0.013
	(0.009)	(0.011)	(0.021)
EPL (regular)	0.004	−0.085*	−0.045
	(0.036)	(0.044)	(0.083)
EPL (temp.)	−0.085***	0.016	−0.154***
	(0.013)	(0.016)	(0.031)
GDP per capita	0.00000*	0.00000	0.00001**
	(0.00000)	(0.00000)	(0.00001)
GDP growth	−0.001	0.003	−0.0001
	(0.003)	(0.003)	(0.006)
Gov. expenditure	0.017***	−0.024***	0.011
	(0.005)	(0.006)	(0.011)
Female LFP	−0.003	−0.006**	−0.012**
	(0.002)	(0.003)	(0.005)
Liberal democracy	0.130	1.306***	1.809***
	(0.113)	(0.137)	(0.257)
Left party share	0.001**	−0.002**	0.001
	(0.001)	(0.001)	(0.001)
UE rate	−0.004*	−0.001	−0.008
	(0.002)	(0.003)	(0.005)
FDI inflows	−0.0002	−0.0003	−0.0005
	(0.0004)	(0.0005)	(0.001)
FIRE value added	0.001	0.010	0.006
	(0.005)	(0.006)	(0.012)
Capital openness	−0.016	0.040**	0.023
	(0.014)	(0.017)	(0.031)
Observations	244	244	244
R^2	0.465	0.513	0.574

Note: ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

Table B4: Excluding Large Jumps in the Dual VET Series

	Wage ratio:		
	50/10	90/50	90/10
	(1)	(2)	(3)
VET share	−0.002*	−0.003	−0.009**
	(0.001)	(0.002)	(0.004)
Knowledge economy	0.005	0.017*	0.050***
	(0.007)	(0.009)	(0.018)
VET x KE	−0.001	−0.001*	−0.004***
	(0.0005)	(0.001)	(0.001)
Union density	−0.005***	0.003	−0.002
	(0.001)	(0.002)	(0.003)
Wage coordination	0.008	−0.013	−0.008
	(0.009)	(0.012)	(0.025)
EPL (regular)	0.016	−0.065*	−0.088
	(0.027)	(0.036)	(0.073)
EPL (temp.)	−0.021**	0.002	−0.032
	(0.009)	(0.012)	(0.023)
GDP per capita	−0.00000	0.00001***	0.00001**
	(0.00000)	(0.00000)	(0.00000)
GDP growth	0.002	0.003	0.007
	(0.002)	(0.002)	(0.005)
Gov. expenditure	−0.004	−0.005	−0.020**
	(0.004)	(0.005)	(0.010)
Female LFP	−0.002	−0.008***	−0.016***
	(0.002)	(0.002)	(0.004)
Liberal democracy	−0.183**	0.853***	0.486**
	(0.089)	(0.116)	(0.237)
Left party share	−0.0002	−0.0005	−0.001
	(0.0003)	(0.0003)	(0.001)
UE rate	−0.001	−0.003	−0.003
	(0.002)	(0.002)	(0.005)
FDI inflows	−0.001*	−0.0002	−0.002*
	(0.0004)	(0.001)	(0.001)
FIRE value added	0.010**	0.011**	0.036***
	(0.004)	(0.005)	(0.011)
Capital openness	−0.039***	0.032***	−0.040
	(0.009)	(0.012)	(0.025)
Observations	349	349	349
R^2	0.247	0.352	0.250

Note: Excluding countries with large jumps in the dual VET series (HU and SK). $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

Table B5: Controlling for Bargaining Coverage

	Wage ratio:		
	50/10	90/50	90/10
	(1)	(2)	(3)
VET share	−0.008***	0.004*	−0.015***
	(0.002)	(0.002)	(0.005)
Knowledge economy	−0.006	0.011	0.002
	(0.012)	(0.015)	(0.029)
VET x KE	−0.001	−0.001	−0.003
	(0.001)	(0.001)	(0.002)
Union density	−0.008***	0.003	−0.009
	(0.003)	(0.003)	(0.007)
Wage setting coordination	0.015	−0.010	0.025
	(0.023)	(0.029)	(0.058)
Collective bargaining coverage	0.006***	−0.002	0.011*
	(0.002)	(0.003)	(0.006)
EPL (regular)	0.032	−0.103**	−0.071
	(0.037)	(0.047)	(0.093)
EPL (temp.)	−0.026	0.016	−0.041
	(0.025)	(0.032)	(0.063)
GDP per capita	0.00000	0.00001**	0.00003**
	(0.00000)	(0.00001)	(0.00001)
GDP growth	0.002	−0.001	−0.001
	(0.003)	(0.004)	(0.008)
Gov. expenditure	−0.002	−0.013	−0.028
	(0.008)	(0.011)	(0.021)
Female LFP	−0.001	−0.012***	−0.017**
	(0.003)	(0.004)	(0.009)
Liberal democracy	−0.085	0.973***	0.963***
	(0.116)	(0.149)	(0.294)
Left party share	0.001*	−0.0003	0.002
	(0.0004)	(0.001)	(0.001)
UE rate	−0.006	0.003	−0.008
	(0.004)	(0.005)	(0.009)
FDI inflows	−0.0001	−0.001	−0.001
	(0.001)	(0.001)	(0.001)
FIRE value added	0.012	0.010	0.035*
	(0.008)	(0.010)	(0.019)
Capital openness	−0.055***	0.020	−0.098**
	(0.016)	(0.020)	(0.040)
Observations	192	192	192
R^2	0.444	0.430	0.481

Note: $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

Table B6: Placebo Test with School-Based VET Shares

	Wage ratio:					
	50/10	90/50	90/10	50/10	90/50	90/10
	(1)	(2)	(3)	(4)	(5)	(6)
VET share	−0.001***	−0.001**	−0.004***	−0.001***	−0.001*	−0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Knowledge economy				−0.008	0.009	0.010
				(0.017)	(0.018)	(0.041)
VET x KE				0.0002	−0.00004	0.0002
				(0.0004)	(0.0004)	(0.001)
Union density	−0.006***	0.002	−0.010**	−0.006***	0.002	−0.010**
	(0.002)	(0.002)	(0.004)	(0.002)	(0.002)	(0.004)
Wage setting coordination	0.013	−0.020	−0.004	0.013	−0.022*	−0.008
	(0.011)	(0.013)	(0.028)	(0.011)	(0.013)	(0.028)
EPL (regular)	0.019	−0.055	−0.037	0.018	−0.053	−0.031
	(0.032)	(0.035)	(0.078)	(0.032)	(0.036)	(0.078)
EPL (temp.)	−0.026**	−0.001	−0.048*	−0.027***	0.001	−0.046*
	(0.010)	(0.011)	(0.025)	(0.011)	(0.012)	(0.026)
GDP per capita	0.00000	0.00001**	0.00001**	0.00000	0.00001**	0.00001**
	(0.00000)	(0.00000)	(0.00001)	(0.00000)	(0.00000)	(0.00001)
GDP growth	0.001	0.003	0.005	0.001	0.003	0.005
	(0.002)	(0.002)	(0.005)	(0.002)	(0.002)	(0.005)
Gov. expenditure	0.002	−0.010**	−0.005	0.002	−0.009*	−0.003
	(0.004)	(0.005)	(0.010)	(0.004)	(0.005)	(0.011)
Female LFP	−0.004*	−0.006**	−0.015***	−0.004*	−0.006**	−0.014***
	(0.002)	(0.002)	(0.005)	(0.002)	(0.002)	(0.005)
Liberal democracy	0.246***	0.769***	1.443***	0.246***	0.775***	1.459***
	(0.093)	(0.103)	(0.227)	(0.094)	(0.104)	(0.228)
Left party share	0.001	−0.001*	0.001	0.001*	−0.001*	0.001
	(0.0003)	(0.0003)	(0.001)	(0.0003)	(0.0003)	(0.001)
UE rate	−0.005**	−0.003	−0.013**	−0.005**	−0.003	−0.014***
	(0.002)	(0.002)	(0.005)	(0.002)	(0.002)	(0.005)
FDI inflows	−0.0002	0.00001	−0.0002	−0.0002	−0.00002	−0.0003
	(0.0004)	(0.0005)	(0.001)	(0.0004)	(0.0005)	(0.001)
FIRE value added	0.008*	0.007	0.024**	0.008*	0.007	0.025**
	(0.005)	(0.005)	(0.012)	(0.005)	(0.005)	(0.012)
Capital openness	−0.052***	0.034***	−0.059**	−0.051***	0.033***	−0.061**
	(0.010)	(0.011)	(0.024)	(0.010)	(0.011)	(0.025)
Observations	342	342	342	342	342	342
R^2	0.239	0.296	0.301	0.240	0.299	0.303

Note: $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

Table B7: Analysis with Lagged VET Share

	Wage ratio:					
	50/10	90/50	90/10	50/10	90/50	90/10
	(1)	(2)	(3)	(4)	(5)	(6)
Lagged VET share	−0.004***	0.001	−0.009***	−0.004***	0.0003	−0.010***
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)
Knowledge economy				0.002	0.023***	0.046**
				(0.007)	(0.008)	(0.018)
Lagged VET x KE				−0.001	−0.002***	−0.004***
				(0.001)	(0.001)	(0.001)
Union density	−0.005***	0.004**	−0.001	−0.005***	0.003**	−0.001
	(0.002)	(0.002)	(0.004)	(0.002)	(0.002)	(0.004)
Wage setting coordination	0.012	−0.017	0.0004	0.014	−0.015	0.007
	(0.011)	(0.012)	(0.027)	(0.011)	(0.012)	(0.027)
EPL (regular)	0.036	−0.049	0.006	0.032	−0.057*	−0.015
	(0.029)	(0.033)	(0.073)	(0.029)	(0.033)	(0.072)
EPL (temp.)	−0.026***	0.003	−0.044*	−0.026***	0.006	−0.038
	(0.010)	(0.011)	(0.024)	(0.010)	(0.011)	(0.024)
GDP per capita	0.00000	0.00001***	0.00001**	0.00000	0.00001***	0.00001***
	(0.00000)	(0.00000)	(0.00001)	(0.00000)	(0.00000)	(0.00001)
GDP growth	0.002	0.003	0.007	0.001	0.002	0.005
	(0.002)	(0.002)	(0.005)	(0.002)	(0.002)	(0.005)
Gov. expenditure	0.005	−0.010**	−0.004	0.005	−0.010**	−0.005
	(0.004)	(0.004)	(0.010)	(0.004)	(0.004)	(0.010)
Female LFP	−0.003	−0.007***	−0.018***	−0.003*	−0.007***	−0.020***
	(0.002)	(0.002)	(0.004)	(0.002)	(0.002)	(0.004)
Liberal democracy	0.195**	0.707***	1.209***	0.190**	0.707***	1.203***
	(0.086)	(0.099)	(0.217)	(0.087)	(0.097)	(0.215)
Left party share	0.0002	−0.001*	−0.0001	0.0002	−0.001**	−0.0003
	(0.0003)	(0.0003)	(0.001)	(0.0003)	(0.0003)	(0.001)
UE rate	−0.003	−0.002	−0.008	−0.003	−0.002	−0.007
	(0.002)	(0.002)	(0.005)	(0.002)	(0.002)	(0.005)
FDI inflows	−0.0003	−0.00005	−0.0005	−0.0003	−0.0001	−0.0005
	(0.0004)	(0.0004)	(0.001)	(0.0004)	(0.0004)	(0.001)
FIRE value added	0.010**	0.008	0.030***	0.010**	0.008	0.030***
	(0.005)	(0.005)	(0.011)	(0.005)	(0.005)	(0.011)
Capital openness	−0.052***	0.037***	−0.060**	−0.051***	0.036***	−0.061**
	(0.009)	(0.011)	(0.024)	(0.010)	(0.011)	(0.024)
Observations	366	366	366	366	366	366
R^2	0.268	0.304	0.328	0.270	0.327	0.351

Note: ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

Table B8: Alternative Dependent Variable: Youth Unemployment

	(1)	(2)	(3)	(4)
VET share	−0.069***	−0.081***	−0.124***	−0.133***
	(0.020)	(0.021)	(0.035)	(0.035)
KE		0.460**		0.183
		(0.215)		(0.285)
VET x KE		−0.030***		−0.021
		(0.011)		(0.013)
Union dens.	−0.043	−0.041	0.060	0.065
	(0.034)	(0.034)	(0.053)	(0.054)
Wage coord.	0.585***	0.627***	0.366	0.452
	(0.168)	(0.168)	(0.295)	(0.298)
Bargaining cov.			0.067***	0.068***
			(0.018)	(0.018)
EPL (reg.)	−0.294	−0.417	0.872	0.678
	(0.586)	(0.585)	(0.831)	(0.836)
EPL (temp.)	−0.026	−0.044	0.615	0.551
	(0.226)	(0.225)	(0.399)	(0.400)
GDP pc	0.00004	0.00004	−0.0001*	−0.0001*
	(0.00004)	(0.00004)	(0.0001)	(0.0001)
GDP growth	−0.096***	−0.105***	−0.068	−0.085
	(0.037)	(0.037)	(0.065)	(0.066)
Gov. exp.	−0.148*	−0.160*	−0.514***	−0.551***
	(0.085)	(0.086)	(0.128)	(0.134)
Female LFP	0.125***	0.115***	0.121**	0.112*
	(0.037)	(0.037)	(0.058)	(0.058)
Liberal dem.	−0.835	−0.958	−3.796	−3.999*
	(1.888)	(1.882)	(2.353)	(2.376)
Left share	0.018***	0.017***	0.025***	0.025***
	(0.006)	(0.006)	(0.008)	(0.008)
UE rate	1.916***	1.910***	2.070***	2.063***
	(0.037)	(0.037)	(0.051)	(0.052)
Observations	499	499	281	281
R^2	0.902	0.904	0.925	0.926

Note: $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

Table B9: Alternative Knowledge Economy Indicator: Employment in Knowledge-Intensive Services (EU-KLEMS)

	Wage ratio:		
	50/10	90/50	90/10
	(1)	(2)	(3)
VET share	−0.004**	−0.003	−0.011*
	(0.002)	(0.002)	(0.006)
KE (EU-KLEMS employment)	−0.232	−0.415	−1.324
	(0.289)	(0.369)	(0.965)
VET x KE	0.008**	0.004	0.023*
	(0.004)	(0.005)	(0.012)
Union density	0.0003	0.008***	0.019***
	(0.002)	(0.003)	(0.007)
Wage coordination	−0.001	−0.015*	−0.031
	(0.006)	(0.007)	(0.020)
EPL (regular)	−0.056	−0.039	−0.160
	(0.042)	(0.053)	(0.139)
EPL (temp.)	−0.063***	0.007	−0.123**
	(0.016)	(0.020)	(0.053)
GDP per capita	−0.00000	0.00001*	0.00002
	(0.00000)	(0.00000)	(0.00001)
GDP growth	−0.003	0.0005	−0.004
	(0.002)	(0.003)	(0.007)
Gov. expenditure	−0.004	−0.003	−0.012
	(0.004)	(0.005)	(0.014)
Female LFP	−0.003*	−0.006***	−0.017***
	(0.002)	(0.002)	(0.006)
Liberal democracy	0.138	0.103	0.986
	(0.274)	(0.350)	(0.916)
Left party share	−0.001*	−0.0001	−0.002
	(0.001)	(0.001)	(0.002)
UE rate	−0.0003	0.001	0.004
	(0.002)	(0.002)	(0.006)
FDI inflows	0.0004	−0.0002	0.001
	(0.0003)	(0.0004)	(0.001)
FIRE value added	−0.002	−0.013*	−0.024
	(0.005)	(0.007)	(0.017)
Observations	144	144	144
R^2	0.525	0.485	0.461

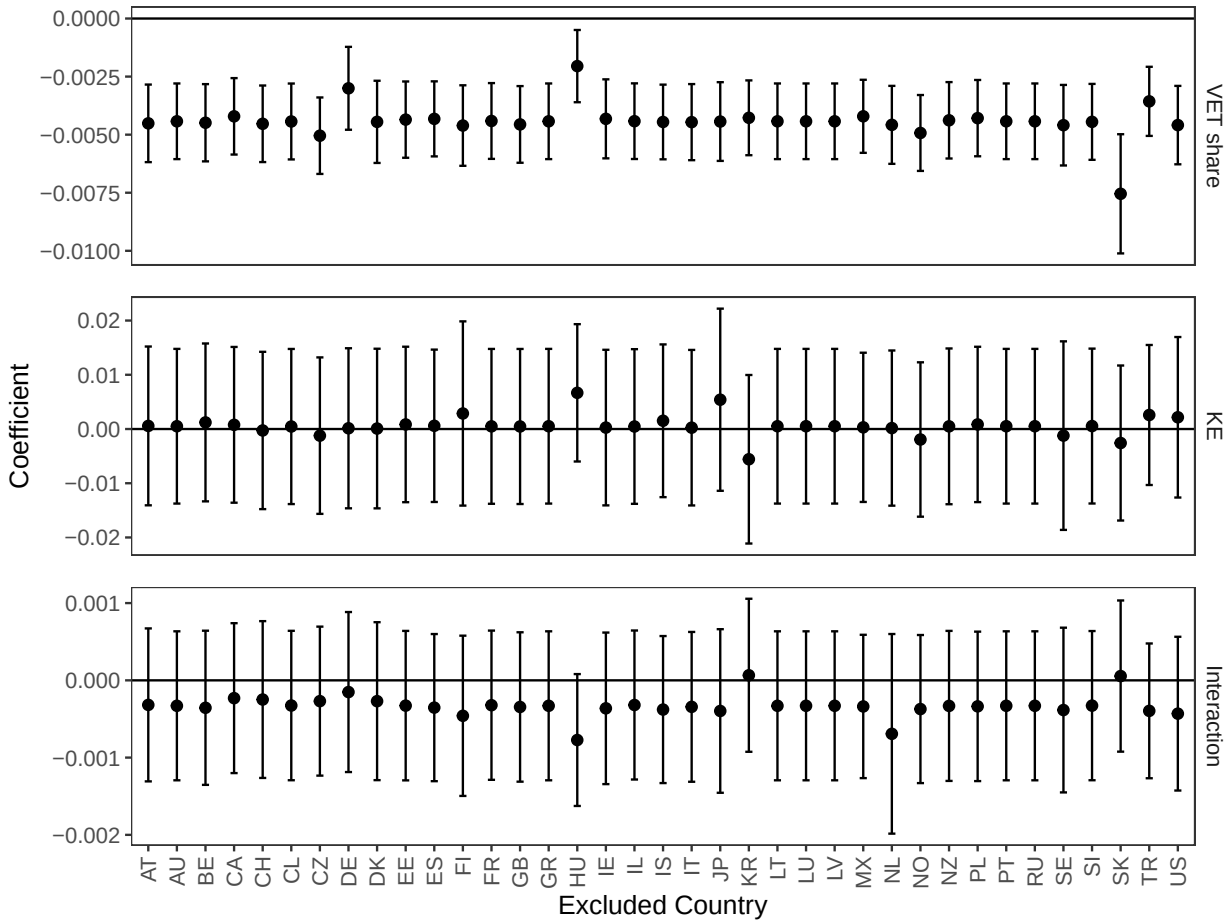
Note: ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

Table B10: Alternative Knowledge Economy Indicator: ICT Capital Stock Per Hour Worked (EU-KLEMS)

	Wage ratio:		
	50/10	90/50	90/10
	(1)	(2)	(3)
VET share	−0.001**	0.0001	−0.002
	(0.001)	(0.001)	(0.002)
KE (EU-KLEMS capital)	−0.001***	−0.001*	−0.004***
	(0.0003)	(0.0003)	(0.001)
VET x KE	−0.00001	−0.00001	−0.00003
	(0.00001)	(0.00001)	(0.00002)
Union density	−0.005***	0.004***	0.001
	(0.001)	(0.001)	(0.004)
Wage coordination	0.010	−0.013**	−0.006
	(0.007)	(0.006)	(0.018)
EPL (regular)	−0.031	0.013	−0.071
	(0.024)	(0.021)	(0.064)
EPL (temp.)	−0.044***	0.006	−0.072***
	(0.010)	(0.009)	(0.027)
GDP per capita	0.00000	0.00000**	0.00001*
	(0.00000)	(0.00000)	(0.00000)
GDP growth	0.002	−0.0003	0.005
	(0.002)	(0.002)	(0.005)
Gov. expenditure	−0.002	−0.011***	−0.022**
	(0.004)	(0.003)	(0.009)
Female LFP	−0.001	−0.007***	−0.016***
	(0.001)	(0.001)	(0.004)
Liberal democracy	0.534***	0.117	1.306***
	(0.120)	(0.107)	(0.319)
Left party share	0.0004	−0.0003	0.0003
	(0.0003)	(0.0002)	(0.001)
UE rate	−0.003*	0.003**	0.002
	(0.002)	(0.001)	(0.004)
FDI inflows	−0.0004	0.0005	−0.00001
	(0.0003)	(0.0003)	(0.001)
FIRE value added	0.012***	−0.006*	0.011
	(0.004)	(0.003)	(0.010)
Capital openness	−0.012	0.036***	0.060*
	(0.012)	(0.010)	(0.031)
Observations	262	262	262
R^2	0.589	0.472	0.613

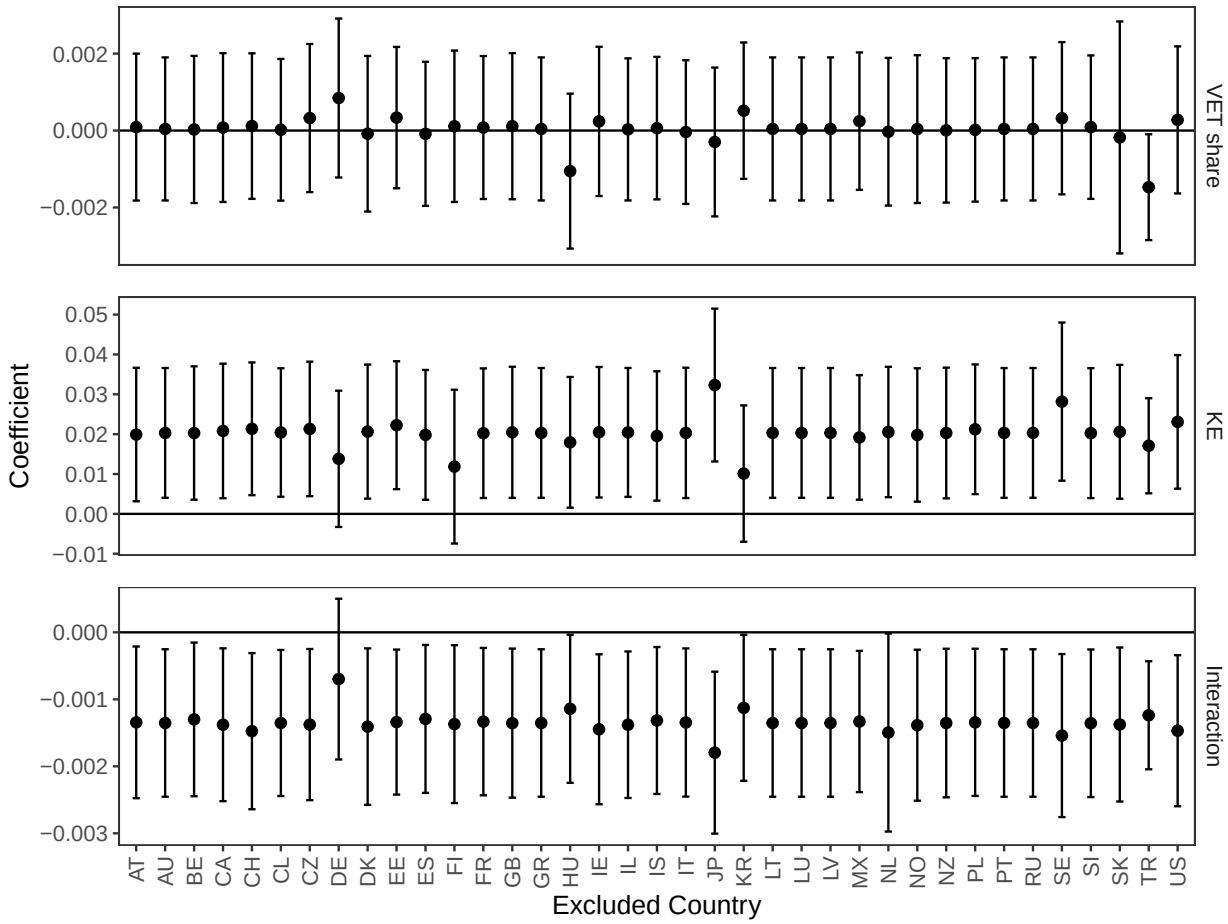
Note: ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

Figure B1: Jackknife results for 50/10 ratio - countries



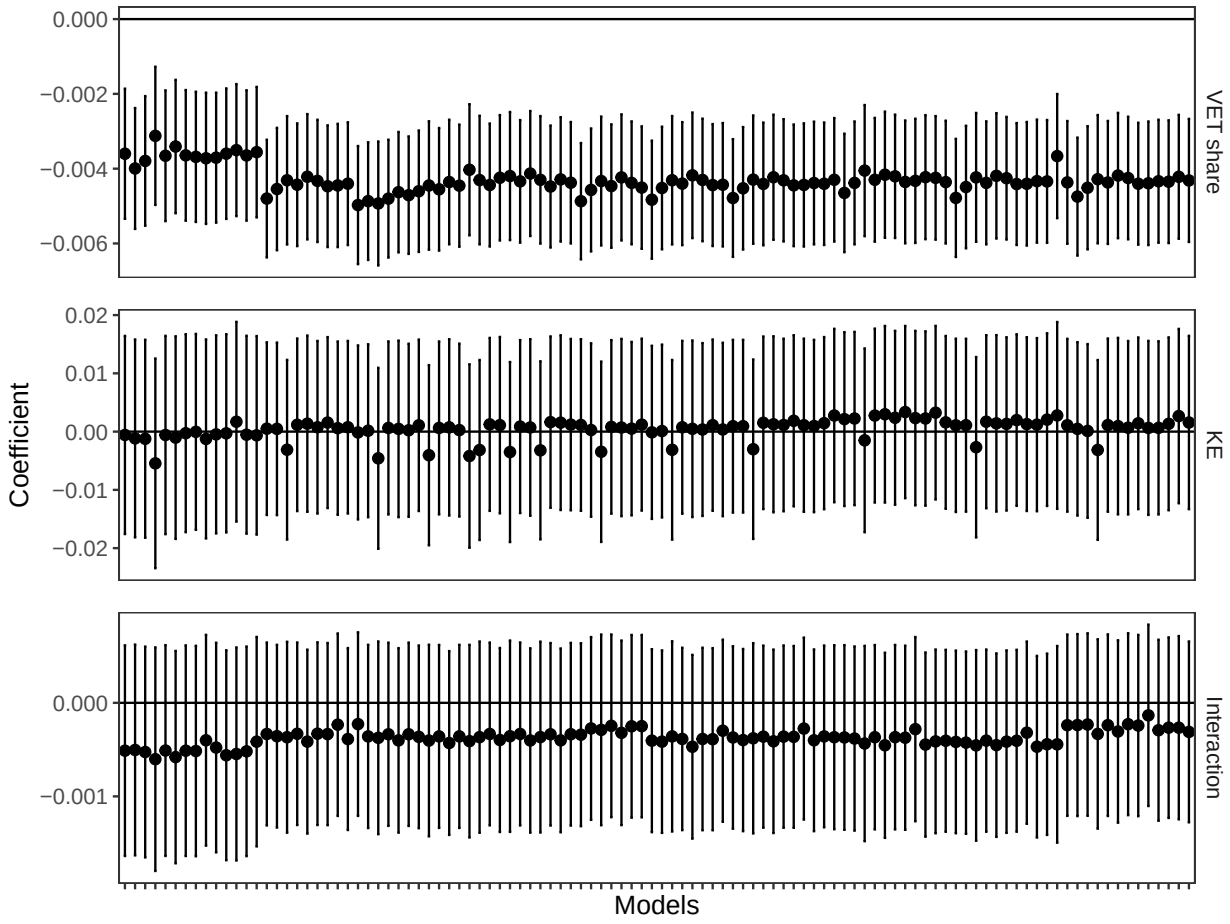
Note: The figure replicates Model 1 in Table A2, excluding one country at a time. It shows that the results are not driven by any one individual country.

Figure B2: Jackknife results for 90/50 ratio - countries



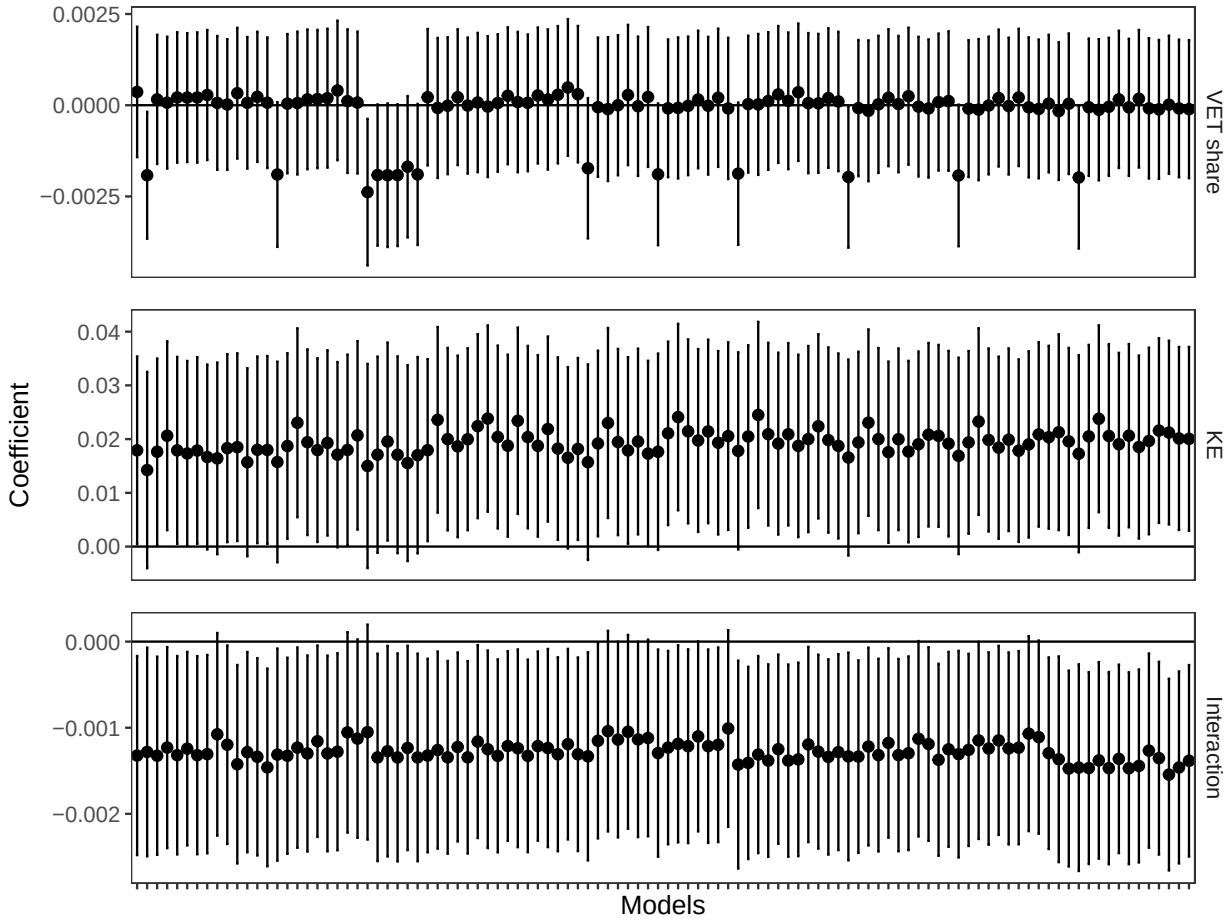
Note: The figure replicates Model 2 in Table A2, excluding one country at a time. It shows that the results are not driven by any one individual country.

Figure B3: Jackknife results for 50/10 ratio - controls



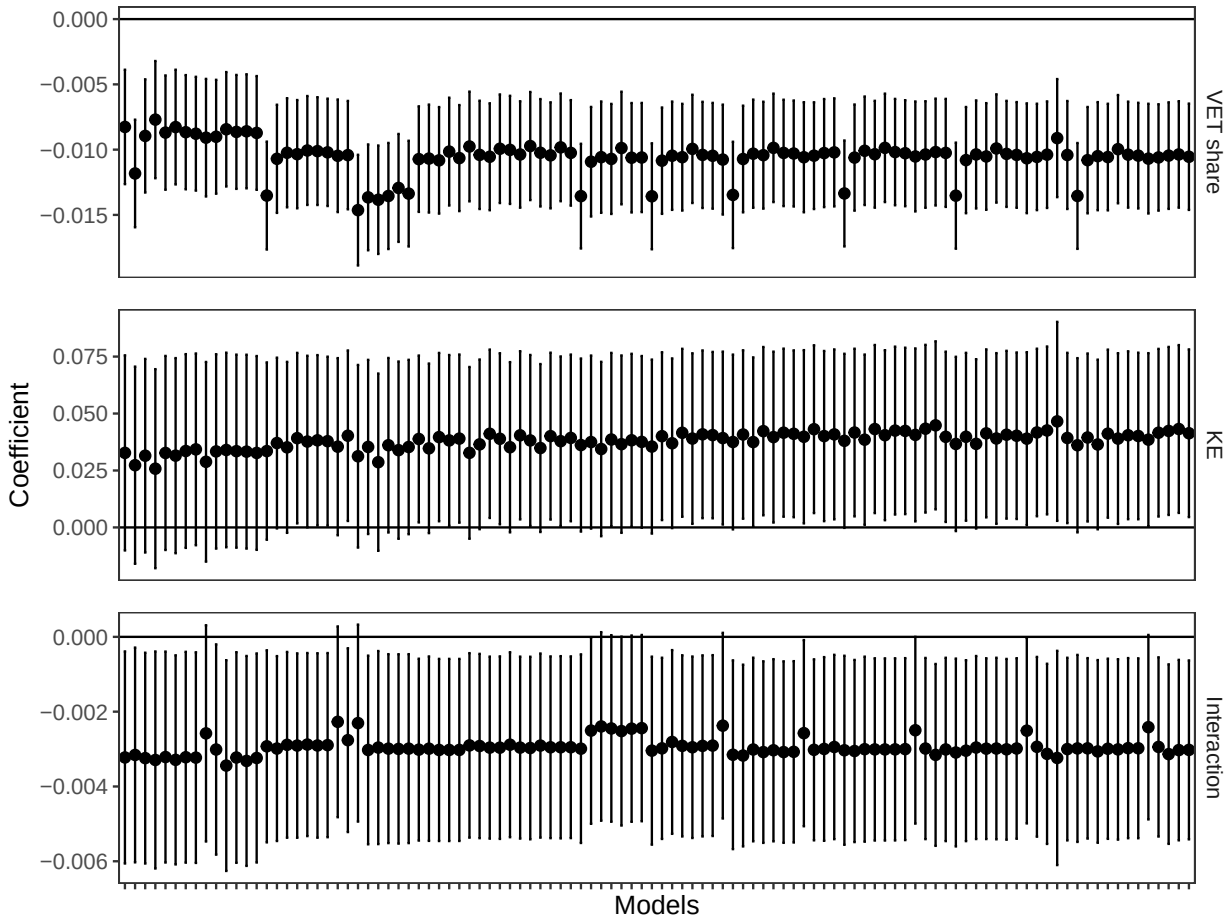
Note: The figure replicates Model 1 in Table A2, excluding one or two control variables at a time. It shows that the results are robust to changes in model specification.

Figure B4: Jackknife results for 90/50 ratio - controls



Note: The figure replicates Model 2 in Table A2, excluding one or two control variables at a time. It shows that the results are mostly robust to changes in model specification.

Figure B5: Jackknife results for 90/10 ratio - controls



Note: The figure replicates Model 3 in Table A2, excluding one or two control variables at a time. It shows that the results are robust to changes in model specification.

C Variable Definitions

Table C1: Variable definitions and sources

Variable	Definition	Source
bar_cov	Collective bargaining coverage (share of workers covered by valid collective agreements in force)	OECD/AIAS ICTWSS database
coord	Coordination of wage setting	OECD/AIAS ICTWSS database
dvet_share	Dual VET share of all upper seconary enrolment.	see Appendix D
epl_reg	Strictness of dismissal regulation for workers on regular contracts (both individual and collective dismissals), version 1	OECD.Stat
epl_temp	Strictness of regulation of temporary contracts, version 1	OECD.Stat
fdi	Foreign direct investment, net inflows (% of GDP)	World Bank
fire	Percentage of total value added of the FIRE sectors (finance, insurance, and real estate). Data compiled according to the 2008 System of National Accounts (SNA).	OECD
gdpgr	Annual percentage growth rate of GDP at market prices based on constant local currency	World Bank
gdppc	GDP per capita (constant 2015 USD)	World Bank
gov_exp	General government final consumption expenditure (% of GDP)	World Bank
htke_share	Employment share in high-tech knowledge-intensive services	CWS
ict_capphw	ICT capital stock per hour worked	EU-KLEMS
kaopen	Openness to cross-border capital transactions	Chinn & Ito (2006)
ke_share	Employment share in knowledge-intensive services	CWS Data Set
leftshare	Seat share of leftist parties in the lower chamber	V-Parties

Continue on the next page

Table C1: Variable definitions and sources (cont.)

Variable	Definition	Source
lfp_female	Female labor force participation rate (% of female population ages 15-64, modeled ILO estimate)	ILOSTAT
libdem	V-Dem liberal democracy score	V-Dem
pop	Total population	World Bank
ue_rate	Unemployment rate	OECD.Stat
udensity	Trade union density, defined as the number of net union members (i.e excluding those who are not in the labour force, unemployed and self-employed) as a proportion of the number of employees.	OECD/AIAS ICTWSS database
z_patents_comp_pc	ICT- and AI-related patents per capita, z-standardized. We include patents that belong to Triadic Patent Families (OECD definition): i.e. sub-set of patents all filed together at the EPO, at the Japanese Patent Office (JPO) and at the USPTO, protecting the same set of inventions. Reference country: Inventor(s)'s country(ies) of residence. Reference date: Priority date. Projected values for 2018 - 2020.	OECD.Stat
*_lit	Mean/SD/CV of PIAAC literacy score	PIAAC
*_num	Mean/SD/CV of PIAAC numeracy score	PIAAC
*_ratio	90/10, 50/10, and 90/50 gross earnings ratios	OECD.Stat
*_sol	Mean/SD/CV of PIAAC problem solving in technology-rich environments score	PIAAC

D The Dual VET Share Dataset

This appendix details how we expanded the dual VET share dataset, which covers the period from 1996 - 2020. The dataset covers the following countries: AU, AT, BE, CA, CL, CZ, DK, EE, FI, FR, DE, GR, HU, IS, IE, IL, IT, JP, KR, LV, LT, LU, MX, NL, NZ, NO, PL, PT, RU, SK, SI, ES, SE, CH, TR, GB, US. We apply the OECD definition which considers *combined school- and work-based programmes* those in which "less than 75 per cent of the curriculum is presented in the school environment or through distance education. Programmes that are more than 90 per cent work-based are excluded" (OECD 2001:401).

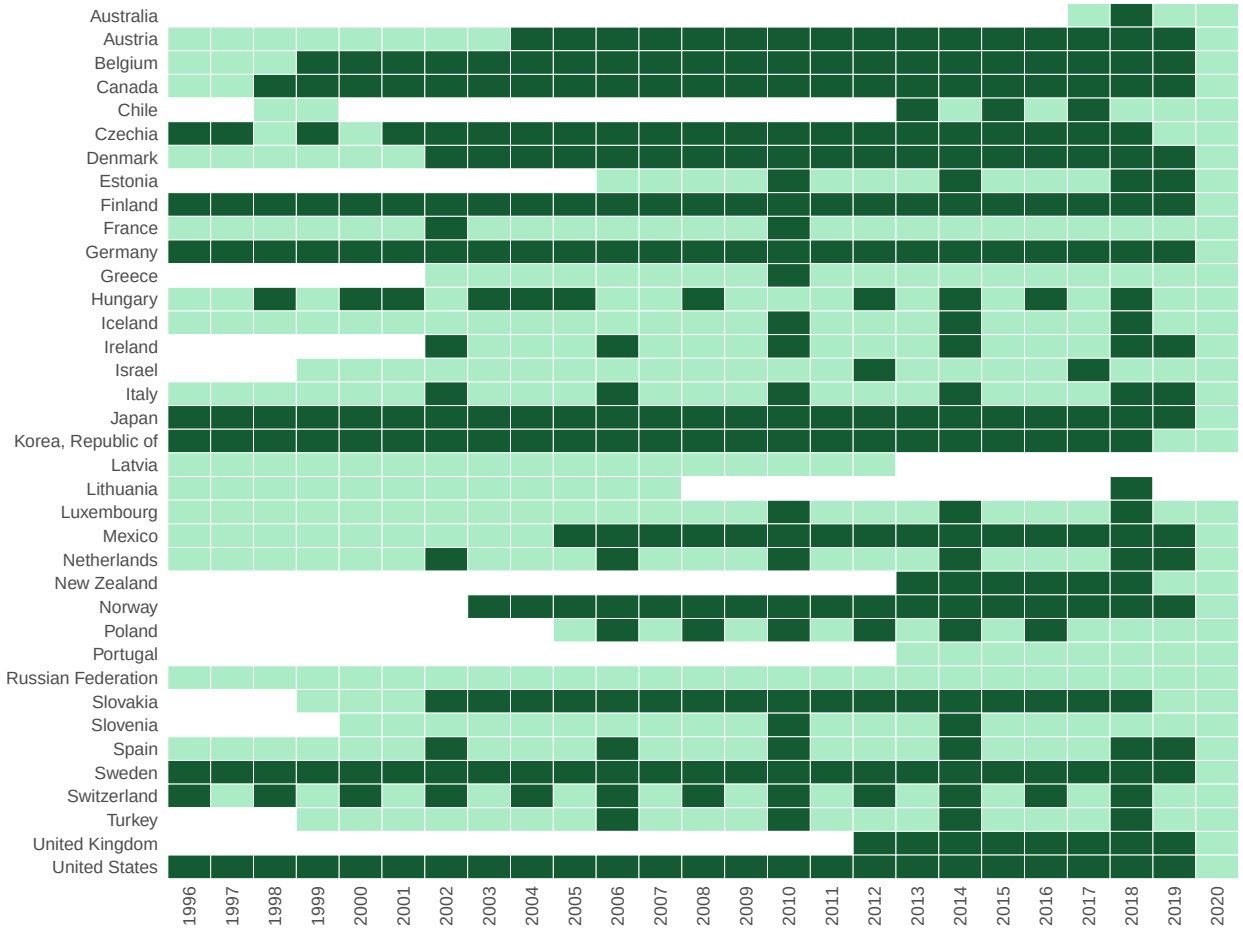
We first collected all dual VET share data from the OECD "Education at a Glance" reports (1998, 2000 - 2012). For the period 2013 - 2020, we relied on data from the OECD.stat database. This basic dataset covers 448 of the 925 country-years. However, the OECD data contain many missing observations and various missingness codes that are unsuitable for quantitative analysis. Hence, we consulted the Cedefop and Eurydice websites to verify the nature of the country's VET system. Based on the information gathered, we searched national databases and contacted national statistical offices or education authorities to obtain enrolment data (with varying success). This allowed us to add an additional 84 country-years with dual VET shares greater than zero. We furthermore coded the dual VET share in country-years where no organised form of dual VET existed as "0", replacing missing observations or missingness codes in the OECD data. This applies to 220 country-years. In 64 country-years, we furthermore updated or corrected the data provided by the OECD. To fill gaps of one or two years in the time series, we used linear interpolation (24 country-years). In total, we are thus able to provide data for 768 of the 925 country-years in the dataset. In the following, we describe the process for each country in the sample. The data are available on (website to be specified upon publication).

Figure C1 provides an overview of the coverage of our dataset. It also shows that, despite the fairly comprehensive coverage (light green), missing covariates—especially wage data—reduce the number of observations included in the main models (dark green). Figure C2 plots the evolution of dual VET shares by country. Excluding countries where large jumps occur (Slovakia and Hungary) does not change the results, see Table B4.

Australia

The OECD provides data for the years 2017 to 2020. We could not retrieve additional data for dual VET at upper secondary for Australia from national sources.

Figure C1: Coverage of the dual VET share dataset



Note: The figure shows the coverage of our dual VET share dataset. Dark green country-years are included in the main models in Table A1. Light green country-years are included in the dataset, but not in the estimations in the paper due to missing covariates.

Austria

A complete and consistent time series is provided by the OECD.

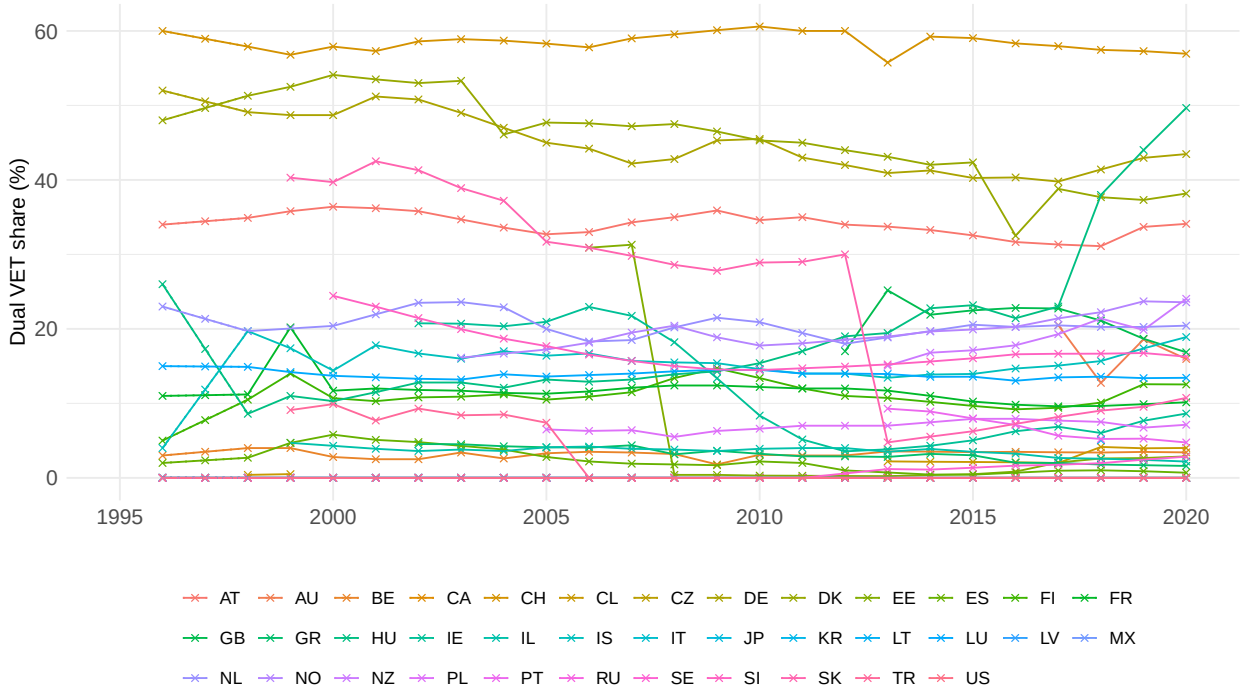
Belgium

A complete and consistent time series is provided by the OECD.

Canada

No organised form of dual VET exists in Canada, although there are Youth Apprenticeship Initiatives at sub-national level. Yet, these initiatives seem to be a marginal phenomenon. Hence, we code Canada as "0" throughout.

Figure C2: Evolution of dual VET shares



Chile

The OECD provides data on Chile for the years 1998/1999 and the period 2013-2020. We could not retrieve additional data for dual VET at upper secondary for Chile from national sources.

Czech Republic

For the Czech Republic, the OECD offers a time-series from 1996 to 2016. However, there is strong variation over time, in particular from 2012 to 2013. However, according to Cedefop, Czech apprenticeships are typically school-based VET. There is also an additional, less demanding educational track at upper secondary level. However, Cedefop argues that also these tracks "cannot be considered as apprenticeships" because VET schools are solely responsible for organising the practical part of the training, and even where employers are in fact involved, students do not have a formal contract with employers. Hence, we code the Czech Republic as "0" throughout, replacing the OECD data.

Denmark

A complete and consistent time series is provided by the OECD.

Estonia

The OECD provides data on Estonia for the periods 2006-2010 and 2013-2020. We have interpolated the values for 2011 and 2012. The value drops from 2007 to 2008 and then begins a slow recovery.

Finland

A complete and consistent time series is provided by the OECD.

France

A complete and consistent time series is provided by the OECD.

Germany

A complete and consistent time series is provided by the OECD.

Greece

The OECD data only contain the values for 2013 and 2014. We calculated our own time series of dual VET shares for 2002 - 2020 using information on the number of apprentices provided by Cedefop and data on upper secondary enrollment provided by the OECD (2013-2020) and the World Bank (2002-2012). Enrollment data for the years 2008/09 were interpolated.

Hungary

A complete time series is provided by the OECD. The recent jump in dual VET enrolment is due to a larger share of VET being classified as work-based following reforms that increased the amount of training in companies.

Iceland

A complete and consistent time series is provided by the OECD.

Ireland

The OECD provides a handful of observations that vary widely and are rather implausible (such as a jump from 10% to 36% from 2017 to 2018). We therefore create our own time series (2002 - 2020) based on OECD data on total enrolment in upper secondary education and enrolment in apprenticeships. The dynamics

of the resulting time series correspond to qualitative descriptions of the Irish dual VET system (implosion around the Financial Crisis and subsequent recovery).

Israel

The OECD provides data for the years 1999 and 2001 to 2020. We have interpolated the value for 2000.

Italy

No organised form of dual VET exists in Italy. Hence, we code Italy as "0" throughout.

Japan

No organised form of dual VET exists in Japan. Hence, we code Japan as "0" throughout.

Republic of Korea

No organised form of dual VET exists in South Korea. Hence, we code South Korea as "0" throughout.

Latvia

In Latvia, apprenticeship programmes were introduced in 2015 (with some pilots since 2013). The apprenticeship scheme is available for all VET programmes at EQF levels 2 to 4. Previously, VET was school-based but also heavy on WBL (see Cedefop). However, despite several requests, we were unable to procure enrolment data for the apprenticeship scheme from the Latvian Statistics Office, only overall VET and upper secondary enrolment from Eurostat.

The OECD provides data from 2013 onwards, but the 40% in OECD Stat are highly questionable. They appear to count all VET (including school-based WBL) as dual VET (see also Eurostat), going back to 2010 and 2005 (before the apprenticeship scheme was introduced). This may be justified given the high share of WBL, but it would deviate from our coding practice in the other countries and the definition in the OECD reports where practical instruction has to take place outside the school to be considered work-based VET. For this reason, we code the period before the introduction of the apprenticeship scheme as "0" and recode the subsequent period to missing until we can find reliable data.

Lithuania

The OECD collects enrolment data for Lithuania only since 2013, but the dual VET share is missing even then. An apprenticeship scheme was introduced in 2008; before then, all VET programmes were school-based, albeit with a heavy dose of WBL (see Cedefop). The Statistical Office does not provide statistics that

distinguish between different types of VET, only overall VET and overall upper secondary. The situation is thus similar to Latvia. Cedefop lists the number of apprentices in 2018, which amounts to 5% of all upper secondary pupils. The Period before the introduction of the apprenticeship scheme is coded as "0" and the subsequent period as missing, with the exception of 2018.

Luxembourg

A complete and consistent time series is provided by the OECD.

Mexico

No organised form of dual VET exists in Mexico. Hence, we code Mexico as "0" throughout.

Netherlands

Except for a few years which we interpolate (1999, 2001, 2011), the OECD provides a complete time series from 1996 to 2012 based on Eurostat data. Later, dual VET enrolment is no longer recorded separately by Eurostat, only total upper secondary VET (available 2015 - 2020). Hence, we can only fill the series if we make an assumption about the share of dual VET of all upper secondary VET in 2015 – 2020. We can either assume it has remained approximately the same as in 2005 (29.5%) and 2010 (31.1%) or extrapolate the trend. Data from the ministry show that the share of (dual) BBL students has risen compared to (school-based) BOL students over the 2014 – 2021 time frame, albeit from a lower baseline. We therefore opt for the conservative approach and assume that a constant share of 30% of upper secondary VET students are in dual programmes. This results in a continuation of the trendless fluctuation of the time series that is observed in the OECD data until 2012.

New Zealand

The VET system in New Zealand is organised somewhat differently than in European countries, with various different qualification levels that can be reached either through workplace-based industry training (including traineeships and apprenticeships) or through provider-based establishments (VET schools). Most importantly, New Zealand classifies VET as tertiary education. Hence, while we found data on the total number of apprentices and on total upper secondary enrolment, we are not 100% certain that this is the correct denominator. Still, we include the data for 2013 – 2020 for the time being (apprenticeship data are available from 2001, so the series can probably be extended). The other remaining question is whether trainees should also be classified as undergoing work-based VET. The data documentation states that "Trainees are non-apprentice industry training learners. Their main programme with an organisation does not meet the

New Zealand Apprenticeships level and credit criteria". Including them would take the total dual VET share based on current calculations to approximately 60%, which seems unrealistically high. There is, furthermore, a large share of older learners among the trainees (more than 6 out of 10 are 30 years or older), while only 2 out of 7 apprentices are over 30 years old. This also suggests that it is appropriate to focus on apprentices for the dual VET share of upper secondary education (possibly even with an age cut-off), or use an age cut-off when combining trainees and apprentices.

Norway

In Norway, most vocational programmes are structured as 2+2: 2 years in school with 20% - 35% WBL which may take place in-school or in-company, followed by 2 years of fully workplace-based training. The system has been in place in more or less the present form since at least 1994 (Cedefop). Instead of the OECD enrolment data which show a gradual increase from 13% in 2005 to 17% in 2016 and then a sudden, unexplained jump to 35% in 2017, we use data on apprentices (2003 – 2020) and total upper secondary pupils (2001 – 2020) directly from Statistics Norway. These data show a more gradual increase from 16% in 2003 to 24% in 2020.

Poland

An almost complete time series is provided by the OECD from 2005 to 2020, with the value for 2014 interpolated.

Portugal

For the entire period, the OECD reports various missing value codes for Portugal. However, a number of different VET pathways exist. In most, WBL is rather limited and provided in school. Apprenticeship programmes which are aimed at young people aged up to 25 and include 40% in-company WBL also exist since 1984, according to Cedefop. Furthermore, between 2013 and 2016 existed the short-lived *cursos vocacionais* which can also be considered a form of dual VET. Data are available in the annual statistical reports of the Ministry of Education from 2013 onwards. We are unable to calculate the dual VET share for the earlier period.

Russia

No organised form of dual VET exists in Russia. Hence, we code Russia as "0" throughout.

Slovak Republic

A complete time series is provided by the OECD for the period 1999 - 2020. The dual VET share shows a marked drop from 2012 to 2013, after which it starts to increase again. This likely reflects a change in the classification of programmes as work-based by the OECD.

Slovenia

The OECD reports provide data for a handful of years from 2006 onwards, but most years are coded as "magnitude is either negligible or zero" or "missing value; data cannot exist". According to Cedefop, there are different types of upper secondary VET with variable shares of work-based training. Whether programmes are considered work-based or school-based depends on the treatment of work-based learning in the school context. SPI and NPI entail at least 35% WBL. Both are mostly offered as a school-based path, but SPI also has an apprenticeship path. However, even the school-based paths involve a significant portion of in-company training. In school-based SPI, 60% of the 40% WBL are in-company (total 24%). In NPI, 20% of the 35% - 40% WBL are in-company (total 7% - 8%). In apprenticeship SPI, 90% of the 60% WBL are in-company (total 54%).

Data differentiating between school-based and apprenticeship SPI are not available. However, even school-based SPI devotes almost a quarter of instruction time to in-company training. We therefore use the share of all upper secondary students who are enrolled in SPI as the measure of dual VET. Data are available from the Slovenian Statistical Office for the period 2000 – 2020. The share of SPI has declined from 24% to 16% during this period. The data conflict with the OECD data in the few years where the OECD has provided data, but we believe that ours is the more appropriate reading of the Slovenian VET system.

Spain

An almost complete time series is provided by the OECD, with the value for 2013 interpolated.

Sweden

The apprenticeship-based version of VET was only introduced in 2011 (see Cedefop); until then, the dual VET share is zero. The OECD provides enrolment data from 2013, we interpolate the value for 2012.

Switzerland

An almost complete time series provided by the OECD, with the missing value for 2008 interpolated.

Turkey

The OECD reports dual VET shares between 7 and 10% from 1999 until 2005. Afterwards, the OECD reports that the "magnitude is either negligible or zero". According to Eurydice, Turkish VET may involve internships but not workplace training in the proper sense. Hence, we code the dual VET share as "0" from 2006 onwards.

United Kingdom

Consistent OECD data available 2012 - 2020. No older data found.

United States

No organised form of dual VET exists in the United States. Hence, we code the United States as "0" throughout.