



Yesterday's model for tomorrow's economy? Dual VET and wage inequality in the knowledge economy

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journals.sagepub.com/home/esp**Patrick Emmenegger**  and **Matthias Haslberger** 

Abstract

Dual vocational education and training (VET) is said to have positive economic effects. However, recent contributions suggest that the rise of the knowledge economy may undermine these positive effects because university-educated workers are better suited for the new knowledge-intensive jobs. This paper provides the first evidence on the relationship between dual VET and wage inequality in mature knowledge economies. Using a new dataset on 37 advanced economies from 1996 to 2020, we find that dual VET is associated with lower levels of wage inequality. This negative association is particularly strong in the lower half of the wage distribution, which suggests that academically weaker students are the main beneficiaries of dual VET. Using three different indicators of the knowledge economy, we find, contrary to the fears often espoused in the literature, no clear evidence that the knowledge economy erodes this negative association between dual VET and wage inequality.

JEL classification:

I24 education and inequality, J24 human capital, skills, occupational choice, labor productivity

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. They are 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 (Bonoli and Emmenegger, 2021; Estevez-Abe et al., 2001; Thelen, 2014), resulting in beneficial economic outcomes, most notably lower youth unemployment

(e.g., Breen, 2005; Rözer and van de Werfhorst, 2020). In dual VET, 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

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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 have proliferated — even in countries with little history of dual VET such as France, Portugal, or Sweden (OECD, 2020).

This paper examines whether dual VET is also associated with lower wage inequality. There are several reasons why this may be the case. Dual VET reduces the relative cost of acquiring additional post-compulsory education for working-class youth and involves employers in the definition of training content, which improves the alignment between training content and employers' skill needs (Breen and Goldthorpe, 1997; Soskice, 1994; Thelen, 2014). Such regular realignment is particularly important in periods of rapidly changing skill needs. In this way, dual VET provides academically weaker students with access to high-quality training in line with labor market demands. Moreover, recent research suggests that dual VET also boosts individuals' soft skills (Basler and Kriesi, 2022; Birkelund, 2022), which are considered to be crucial in a knowledge economy (White et al., 2023). By preparing academically weaker students for more successful labor market careers compared to their peers in non-dual VET contexts, we expect dual VET to be associated with a lower incidence of low-skill work and thereby reduce wage inequality, especially in the bottom half of the distribution (Allmendinger, 1989; Freeman and Schettkat, 2001; Shavit and Müller, 1998).

However, does the rise of the knowledge economy undermine this association? The knowledge economy describes a trend “towards greater dependence on knowledge, information and high skill levels” (OECD, 2005: 28). 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) — 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 which university-educated workers with primarily general skills are argued to be better suited than VET graduates (e.g., Anderson and Hassel, 2013; Hope and Martelli, 2019; Iversen and Soskice, 2019). These developments suggest that dual VET may no longer provide the skills knowledge economies require, and thus becomes increasingly unattractive as an educational path (Abrassart and Wolter, 2020; Di Stasio, 2017) and ceases to boost the wages of non-university-educated workers. In short, a growing number of voices argue that dual VET systems are only a model for yesterday's economy.

However, there is surprisingly little comparative empirical research examining the relationship between dual VET and wage inequality. This dearth of 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 the empirical analysis, we find a robust negative association of dual VET with wage inequality. This negative association is particularly strong in the lower half of the wage distribution, while dual VET seems to have no effect on the upper half. There is no consensus yet on how to measure the extent to which countries have become mature knowledge economies. In the empirical analysis, we capture the knowledge economy through three different indicators: patents in ICT and artificial intelligence (AI) (Raghupathi and Raghupathi, 2017), industry-level ICT capital stocks per hour worked (Kurer and Gallego, 2019), and the composite index developed by Diessner et al. (2025). We find that the negative association between dual VET and wage inequality remains robust at high levels of the knowledge economy for the first indicator and marginally significant for the second, although the negative effect disappears in the case of the third

indicator. Hence, contrary to recent contributions that have questioned the viability of dual VET in the knowledge economy, we find no clear evidence that technological change neutralizes the negative relationship between dual VET and wage inequality. Thus, our analysis suggests that dual VET systems remain a viable model for tomorrow's economy.

This paper is structured as follows. The next section offers some theoretical reflections on the relationship between dual VET and wage inequality in mature knowledge economies. Subsequently, we present the dataset and the statistical approach before we discuss the empirical findings. A final section concludes.

Dual VET and wage inequality

There is a rich literature arguing that dual VET reduces youth unemployment because it sends employers clear signals about job seekers' abilities and skills, gives access to recruitment networks, as students directly interact with prospective employers, and involves employers in the provision of training, which aligns training content and skill requirements (e.g., Breen, 2005; Rözer and van de Werfhorst, 2020; Schulz et al., 2023; Shavit and Müller, 1998). In contrast, the effect of dual VET on wage inequality is more disputed. There is little empirical literature that specifically investigates the relationship between dual VET and wage inequality (exceptions are Bradley et al., 2003; Busemeyer, 2015; Estevez-Abe et al., 2001). Although research shows that early tracking and skills differentiation in dual VET reduce educational mobility and increase occupational status differences (Bol and Van de Werfhorst, 2011; Heisig et al., 2019), dual VET does not negatively impact income mobility (Chuard and Grassi, 2020).

In this section, we argue that dual VET is associated with lower wage inequality because it strengthens the economic position of academically weaker students, in particular working-class youth. Dual VET does so by reducing skills dispersion, especially in the bottom half of the skills distribution, and by providing academically weaker students with labor market-relevant skills.¹

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 is the so-called secondary effect of inequality (the impact of social origin on educational decisions net of performance). Given the additional class-related hurdles to accessing post-compulsory education, 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 and remain engaged with the education system, increases the overall amount of training provided, and ultimately contributes to the narrowing of the skills distribution in society, especially in the bottom half of the skills distribution (Allmendinger, 1989; Busemeyer and Jensen, 2012; Estevez-Abe et al., 2001; Shavit and Müller, 1998; Silliman and Virtanen, 2022; Soskice, 1994; Thelen, 2014).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 (Checchi and van de Werfhorst, 2018; Freeman and Schettkat, 2001; Lam and Liu, 2011). Put differently, dual VET offers access to additional training and thus increases skill provision, and because dual VET primarily recruits among working-class youth, academically weaker students are the main beneficiaries (Allmendinger, 1989; Shavit and Müller, 1998; Soskice, 1994; Thelen, 2014). For this reason, Chuard and Grassi (2020) find 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).

Data from the OECD's Programme for the International Assessment of Adult Competencies (PIAAC) offers some suggestive evidence that the skills distribution is indeed more compressed in countries with high dual VET shares. PIAAC

measures three cognitive skills: numeracy, literacy, and problem-solving in technology-rich environments, defined as “using digital technology, communication tools, and networks to acquire and evaluate information, communicate with others, and perform practical tasks” (OECD, 2012: 47). Fully school-based education systems are probably just as good at teaching numeracy and literacy as education systems that combine school-based and workplace training. However, we expect dual VET to be better at inculcating problem-solving skills. Because employers are best positioned to identify evolving skill needs, their involvement in the definition of training content is likely to improve the provision of labor market-relevant skills in dual VET systems. The PIAAC indicator for problem-solving skills in technology-rich environments is most likely to pick up these labor market-relevant cognitive skills that are required in the information age.

Using PIAAC data on 30 countries in 2011/2012, 2014/2015, and 2017, we find that problem-solving skills are less dispersed in countries with high dual VET shares. Average problem-solving skill levels are positively correlated with dual VET shares (Pearson’s $R = 0.30$, p -value = 0.13). More importantly, however, we find that the coefficient of variation of problem-solving skills is significantly lower in countries with high dual VET shares (Pearson’s $R = -0.41$, p -value = 0.03). The same is true to a lesser extent of numeracy and literacy skills (see Table B1). These patterns suggest that dual VET is effective at providing labor market-relevant skills, and given that dual VET systems primarily target academically weaker students, it is likely that the main beneficiaries are individuals in the lower half of the skills distribution. In this manner, dual VET systems lift the floor of a country’s skills distribution, thus reducing skills dispersion. This is why countries with strong VET systems are characterized by a lower incidence of low-skill or unskilled work (Allmendinger, 1989; Freeman and Schettkat, 2001; Shavit and Müller, 1998; Thelen, 2014). In short, dual VET systems provide both incentives and opportunities for access to high-quality education to academically weaker students who would otherwise struggle to obtain comparable amounts of training.

Importantly, this focus on labor market-relevant skills does not come at the expense of general skills. Dual VET focuses on “broader” skills than often assumed, because apprenticeships feature consolidated curriculums in the first years 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 et al. (2023: 741) argue that “skill-use differentials between vocational and tertiary-educated workers are only small to modest” and that these “observed skill use differentials 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” (see also Durazzi and Tonelli, 2024).

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 and constitute 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). This practice of certification alongside informal processes of social closure generates labor market advantages for VET graduates because access to certain occupations and sectors is limited to individuals who possess the relevant educational credentials and who can then move rather freely in these labor market segments. This ‘credentialism’ strengthens the position of those who can 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 ambiguous because social closure also increases the differentiation between skilled and unskilled workers (Bol and van de Werfhorst, 2011; Heisig et al., 2019). The net effect on wage

inequality thus hinges on the extent to which dual VET — despite reforms to ‘upskill’ dual VET to satisfy the skill demands of post-Fordist economies (e.g., Durazzi and Benassi, 2020; Emmenegger et al., 2023) — remains inclusive, i.e., accessible for academically weaker students (Martin and Knudsen, 2010).

To address this challenge, governments have developed new programs to uphold the inclusive nature of dual VET (Durazzi and Geyer, 2022). 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 publicly provided alternatives to dual VET for unsuccessful apprenticeship seekers (Carstensen et al., 2022). These state-led apprenticeships were expanded during economic downturns to compensate for declining employer demand for apprentices, but by now, they 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 (Graf et al., 2023). 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.

Recent empirical work also suggests that dual VET boosts workers’ soft skills, which have been shown to matter for individuals’ labor market performance (Heckman and Kautz, 2012; Silliman and Virtanen, 2022), especially in mature knowledge economies (White et al., 2023). Based on newly available panel data, Basler and Kriesi (2022) compare soft skills of youth entering dual VET, fully school-based VET, and general education tracks at upper-secondary level. Focusing on individuals’ exertion (ability to use a lot of effort), perseverance (persistent efforts, including in the face of difficulties), and volition (willingness to learn and develop), they find that while individuals start from similar levels, dual VET has the strongest positive effect on soft skills. They argue that dual VET facilitates the development of soft skills because learning takes place in workplace 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 soft skills equally positively (Birkelund, 2022). Academically weaker students are the main beneficiaries of these soft skills-enhancing effects 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).

Dual VET and the knowledge economy

There are thus good reasons for dual VET to be associated with lower wage inequality, but does this relationship still hold in mature knowledge economies? In recent years, some contributions have raised doubts about the ability of dual VET to provide the skills modern economies require. For instance, Hope and Martelli (2019: 243) argue that while in the Fordist period, the symbiotic relationship between dual VET and manufacturing ensured an excellent match between skill supply and demand, in post-Fordist knowledge economies, “complementarities in production between skilled and semiskilled workers have been replaced by complementarities between skilled workers and new ICTs.” 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.” Finally, Autor and Dorn (2013) argue that in knowledge economies, employment is primarily created at the extremes of the skills spectrum, with negative implications for the prospects of academically weaker students to gain stable employment in well-paying jobs through vocational training. However, it should be noted that there are also notable contributions that challenge these pessimistic predictions (e.g., Durazzi and Tonelli, 2024; Haslberger, 2021; Oesch, 2015; Silliman and Virtanen, 2022).

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. Against this background, individuals are often argued to be better off opting for an academic education because such training provides more general skills (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 occupation-specific skills — while beneficial for the transition from education to the labor market — may limit 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., Chuan and Ibsen, 2022; Hanushek et al., 2017; Korber and Oesch, 2019; Rözer and Bol, 2019; Schulz et al., 2023; Silliman and Virtanen, 2022).

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 et al., 2022; Strebel et al., 2021). An important literature argues that dual VET co-evolved with systems of industrial relations that favor wage compression (Busemeyer and Iversen, 2011; Trampusch, 2010). However, 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 may refrain from investing in dual VET (Acemoglu and Pischke, 1999; Marsden, 1999). Consequently, this literature expects the negative effect of dual VET on wage inequality to become weaker as collective bargaining institutions recede (Busemeyer and Iversen, 2011).

In short, several studies suggest that, although dual VET may have reduced wage inequality in the past, this effect is disappearing in mature knowledge economies. The remainder of this paper will therefore explore two hypotheses. The first

hypothesis suggests that dual VET shares are associated with lower levels of wage inequality, especially in the bottom half of the wage distribution, whereas the second hypothesis expects this negative association to weaken as countries come into shape as mature knowledge economies.

Analytical approach

Data

Our study focuses on wage inequality before taxes and transfers, where the distributive effects of the skill formation system are most visible. We analyze the 90/10, 50/10, and 90/50 wage ratios. We expect dual VET to be particularly strongly associated with lower inequality in the bottom half of the wage distribution. The 50/10 ratio allows us to test for such 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.

Our main independent variable is the share of upper secondary students who are enrolled in dual VET programs, lagged by one year to account for the fact that a given year's dual VET share captures students who are not yet working full-time. Due to the vast differences in the organization of national VET systems, comparable data 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. 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% of the curriculum is presented in the school environment or through distance education. Programmes that are more than 90% 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 D1](#) 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. This data collection effort constitutes the first substantive contribution of this article.³

In the second part of the analysis, we investigate whether the knowledge economy affects the relationship between dual VET and wage inequality. 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.” In [Iversen and Soskice \(2019\)](#), the focus is on changes in the organization of the production process and associated shifts in skill demand, while [Powell and Snellman \(2004: 201\)](#) further emphasize “an accelerated pace of technical and scientific advance, as well as rapid obsolescence.”

To accommodate these different conceptions of the knowledge economy, we use three different measures. Our first indicator, with the most comprehensive coverage, is the number of ICT- and AI-related patents per capita, using the triadic patent family method. Patent data as a measure of inventive output and stocks of intellectual capital are widely used in the economics literature ([Griliches, 1998](#); [Raghupathi and Raghupathi, 2017](#)). Our focus on ICT and AI patents reflects the origin of recent advances in the knowledge economy in these sectors. Second, [Kurer and Gallego \(2019\)](#) use EU-KLEMS data on industry-level ICT capital stocks per hour worked as a measure of digitalization. Building on their approach, we calculate the ICT intensity of production across all sectors using the 2023 release of the EU-KLEMS. This indicator captures the degree to which the intellectual capital

encapsulated in patents is translated into economic activity, but provides less comprehensive coverage than the patents measure. Finally, [Diessner et al. \(2025\)](#) propose a novel composite indicator which encompasses data on ICT capital and a wider range of patents, as well as industrial robots and three separate components for employment in ISCO major groups 1–3. Using their index, our coverage is yet more limited, but it introduces the important aspect of changing employment patterns in the knowledge economy. However, this is a double-edged sword as occupations are closely linked to individuals’ education levels, thus making this indicator partly endogenous to our dual VET data.

As baseline control variables, we include union density and wage setting coordination, which have been argued to influence both wage inequality and dual VET systems. It is therefore important to account for collective bargaining systems in order to isolate the effect of dual VET on wage inequality through the skills distribution. Moreover, we add controls for unemployment, female labor force participation, and employment protection legislation. We also account for five variables capturing economic and political development (GDP per capita, GDP growth, government expenditure, liberal democracy, and left party share in parliament), and three variables related to globalization (FDI inflows, capital openness, and FIRE value added). We document all data sources in [Table C1](#).

Statistical estimation

We estimate two-way fixed effects panel models with country and year fixed effects to account for time-invariant country characteristics and to prevent the widespread upward trend in inequality from producing a spurious relationship. We apply the procedure of [Arellano \(1987\)](#) to calculate heteroskedasticity and serial correlation-consistent standard errors. Thus, we estimate the following equation:

$$Y_{cy} = \alpha + \beta_1 VET_{cy-1} + \beta_2 X_{cy} + u_c + v_y + \epsilon_{cy}$$

Y_{cy} is our measure of wage inequality, α is the intercept, β_1 is the coefficient on the lagged dual VET

share, and $\beta_2 X_{cy}$ 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. To capture the moderating role of the knowledge economy, we add the terms $\beta_3 KE_{cy}$ and $\beta_4 VET_{cy-1} \times KE_{cy}$ to the equation. We note that the two-way fixed-effects model, albeit widely used, does not allow for a causal interpretation of estimated coefficients (Imai and Kim, 2021).

Results

We first use our significantly expanded dataset to test the direct relationship between dual VET and wage inequality. In the second part of the analysis, we investigate whether the knowledge economy moderates the relationship between dual VET and wage inequality. To preview our results: We find — in line with our first hypothesis — a robust negative association between dual VET and wage inequality, but in contrast to our second hypothesis, we find no clear evidence that the knowledge economy neutralizes this relationship.

Research on the relationship between dual VET and inequality has been scarce since the early 2000s (e.g., Estevez-Abe et al., 2001). We argued that dual VET raises the wage floor and thereby reduces wage inequality in the bottom half of the distribution. In line with this reasoning, Figure 1 shows that there is a robust negative relationship between the lagged dual VET share and the 50/10 wage ratio in the 1996–2020 time frame. 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. Regardless of the set of controls, the negative relationship holds. For better comparability of the coefficients, we standardized the wage ratios. Thus, the coefficients indicate that a 1 percentage point increase in the dual VET share is associated with a decrease of the 50/10 ratio by about 1.3 to 1.6% of a standard deviation in the following period. To illustrate the implications of these estimates, for the United States moving from its current education system without dual VET to the German system with close to 50% dual VET enrollment at the

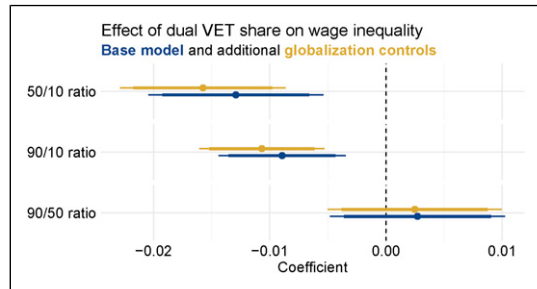


Figure 1. Effect of dual VET, additive models. Coefficients with 90% and 95% confidence intervals (thick and thin lines). Wage ratios are standardized for comparability. Coefficients can thus be interpreted as the standard deviation change in the outcome variable in response to a unit change in the lagged dual VET share. Full output in Table A1.

upper-secondary level is projected to reduce the 50/10 ratio from 2.02 to 1.83 in 2020 — all but closing the gap in lower-tail inequality between the two countries.⁴ Clearly, these are substantively meaningful results.

Further consistent with our theoretical argument, 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 association with overall inequality as captured by the 90/10 ratio is entirely driven by the effect on the lower tail of the wage distribution. This lends credence to the arguments first advanced by the likes of Allmendinger (1989), Breen and Goldthorpe (1997), Freeman and Schettkat (2001), and Soskice (1994) who suggested 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.

As advanced economies have come into shape as mature knowledge economies, it is possible that the beneficial impact of dual VET on lower-tail wage inequality disappears as firms increase their reliance on automation and digitalization. We now test this argument using three different knowledge economy indicators. However, contrary to hypothesis 2, there

is no clear evidence that the knowledge economy undermines the relationship between dual VET and lower-tail wage inequality. At different levels of the knowledge economy, the marginal effect of the lagged dual VET share on the 50/10 ratio is robustly negative for one of the indicators, marginally negative for the second, and insignificant for the third.

We estimate the same model with globalization controls as above, but interact the dual VET share with one of our three knowledge economy indicators: ICT/AI patents, ICT capital per hour worked, and the composite knowledge economy index of [Diessner et al. \(2025\)](#). [Figure 2](#) shows the estimated marginal effect of the dual VET share on wage inequality at low (10th percentile), medium (sample mean), and high (90th percentile) levels of the respective knowledge economy indicator. For ICT/AI patents, it shows that a percentage point increase in the lagged dual VET share is associated with a reduction of the 50/10 ratio by about 1.5 to 2% of a standard deviation at all levels of the indicator. For ICT capital, the marginal effect of dual VET is smaller, at about 1% of a standard deviation, but remains marginally statistically significant across the distribution of the indicator, despite a 30% smaller sample. Lastly, when interacting the dual VET share with the composite knowledge economy index, the marginal effect of dual VET is not statistically significant at any level of the index — but this is based on a sample 40% smaller than that used in the model with the patents indicator. Moreover, since data on occupational employment shares feature prominently in this index, this raises concerns about endogeneity with regard to education. Crucially, the composite knowledge economy index can be disaggregated into two sub-dimensions which capture countries' reliance on knowledge-intensive services and advanced manufacturing, respectively ([Diessner et al., 2025](#)). However, notwithstanding arguments about persistent complementarities between VET and manufacturing in the knowledge economy ([Durazzi, 2021](#); [Durazzi et al., 2025](#)), we find no difference between the marginal effect of dual VET in the two types of knowledge economy (see [Figure B2](#)).

To summarize, despite prominent arguments which imply that dual VET might no longer contribute to lower wage inequality in the knowledge economy, we find no consistent evidence for the

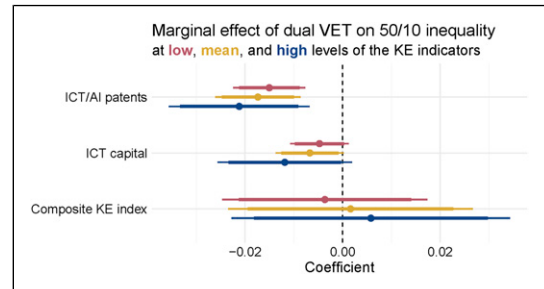


Figure 2. Marginal effect of dual VET, interaction models. Coefficients with 90% and 95% confidence intervals (thick and thin lines). Coefficients can be interpreted as the change in the 50/10 ratio in response to a unit change in the lagged dual VET share at the 10th, 50th, and 90th percentile of the respective knowledge economy indicator. Full output in [Table A2](#).

disappearance of this relationship. Depending on how the knowledge economy is operationalized, the marginal effect of dual VET on lower-tail wage inequality is either negative or null even at the highest levels of the knowledge economy, but in no case is there a reversal of the relationship.

Sensitivity analyses

We conduct a number of sensitivity analyses to illustrate the robustness of our results, which can be seen in [Appendix B](#). 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 B3](#) shows that the results are largely unaffected by excluding individual countries. We also test the robustness of our models to different sets of control variables by randomly dropping one or two control variables. [Figure B4](#) shows a high degree of robustness to changes in the model specification.

Additionally, we exclude countries that consistently report a dual VET share of zero ([Table B3](#)), and in [Table B4](#) we drop countries where the dual VET share exhibits large jumps, finding robust results in all cases. [Table B5](#) shows that the association between dual VET and wage inequality remains robust to controlling for bargaining coverage despite limited data availability. Placebo tests where we use the share of school-based VET suggest that the result

is indeed driven by dual VET (Table B6). Finally, we show in Table B7 that we can replicate existing research on youth unemployment with our data (e.g., Breen, 2005; Rözer and van de Werfhorst, 2020).

Conclusion

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 schooling (Breen and Goldthorpe, 1997). Indeed, Freeman and Schettkat (2001: 601) find that compared to the USA, Germany — the 'poster child' of dual VET systems (Culpepper and Thelen, 2008) — lacks "truly low skill workers" and features a more compressed skills distribution. Skills and wages are intimately linked. Workers' productivity increases with their skill levels, while workers' wages should correspond to their productivity. Although these relationships are certainly not perfect, the implication is straightforward. If dual VET contributes to the compression of the skills distribution, this should also be reflected in lower wage inequality.

Our paper demonstrates an enduring sizable relationship between dual VET and lower wage inequality. Moreover, our findings do not support the oft-repeated fear that the knowledge economy undermines the benefits of dual VET. 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 point to the lasting benefits that countries with strong dual VET systems reap, and that these benefits continue to be relevant in mature knowledge economies.

Dual VET is associated with low levels of wage inequality, but this relationship is not set in stone. For dual VET to remain a model for tomorrow's economy, it needs to be constantly adapted to changing skill requirements. What skills will be needed in the future is fundamentally uncertain, but there is evidence that the skills provided by dual VET will continue to be in high demand from businesses (Durazzi and Tonelli, 2024; OECD, 2020; Pavlova, 2017) and individuals who view VET skills as insurance against technology risk

(Haslberger and Bajka, 2025). In any case, such 'upskilling' reforms will continue to be necessary, but as argued in this paper, they carry a risk. While they prepare VET graduates for more knowledge-intensive activities, they may make training less accessible for academically weaker students (Martin and Knudsen, 2010).

Thus, at a general level, our findings suggest that in contemporary capitalism, efficiency and equity goals are not necessarily opposed to each other. Despite its focus on providing skills that align with employers' demands, dual VET contributes to egalitarian labor market outcomes because it strengthens the economic position of academically weaker students, particularly working-class youth. Consequently, dual VET can straddle the twin demands of supplying labor market-relevant skills while contributing to social inclusion. However, whether dual VET continues to have an equality-enhancing function depends on the ability of policymakers to balance efficiency and inclusion objectives (c.f. Bonoli and Emmenegger, 2021; Carstensen and Ibsen, 2021).

Our research also has implications for the broader literature on the social investment state, which has thus far paid little attention to dual VET (but see Pavolini and Seeleib-Kaiser, 2022). Our findings suggest that dual VET could play an important role in skills-oriented social investment policies to counteract wage inequality. Conversely, countries without dual VET systems could attempt to replicate the success of dual VET by involving employers in the definition of labor market-relevant skills or by developing systems of state-led apprenticeships as part of their social investment strategies (Carstensen et al., 2022). Moreover, although we found the marginal effect of dual VET to be the same in service- and manufacturing-intensive knowledge economies based on the sub-dimensions of the composite knowledge economy index, in light of research pointing to complementarities between dual VET and advanced manufacturing (Durazzi et al., 2025), we believe that more detailed sector-specific analyses that for instance consider the sectoral composition of the dual VET share and sectoral wage shares, could be a fruitful avenue for further research.

Our study is — to our knowledge — the first to provide strong empirical evidence for an association

between dual VET and lower wage inequality. 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 (Gallego and Kurer, 2022; Özkiziltan and Hassel, 2020). If skill formation systems differ in the way they prepare individuals for the knowledge economy — and there are 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.

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Data Availability Statement

The dual VET shares dataset is available for other researchers to use on Harvard Dataverse: <https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/DG7PB9>

Supplemental material

Supplementary material for this article is available online.

Notes

1. Dual VET affects wage inequality also through youth unemployment because of the long-term negative effects of early unemployment on earning abilities over the life course (Mroz and Savage, 2006). However, we argue that the impact of dual VET on wage inequality goes beyond such scarring effects.
2. However, dual VET may give rise to social class differences in participation in higher education because it distracts students in the middle of the skills distribution from pursuing such an education (Hillmert, 2003; Shavit and Müller, 1998).
3. The dataset is available for other researchers to use on Harvard Dataverse: <https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/DG7PB9>.
4. Calculations based on Table A1. US 50/10 ratio: 2.02; DE 50/10 ratio: 1.79; SD 50/10 ratio: 0.24. $-0.016 \times 50 = -0.8$; $-0.8 \times 0.24 = -0.19$; $2.02 - 0.19 = 1.83$.

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