Journal of Population Economics (2022) 35:643–675
https://doi.org/10.1007/s00148-021-00846-1

ORIGINAL PAPER

Fluctuations in the wage gap between vocational and general secondary education: lessons from Portugal

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Received: 4 March 2020 / Accepted: 23 March 2021 / Published online: 5 June 2021

Abstract

We document and analyse the wage gap between vocational and general secondary education in Portugal between 1994 and 2013. As Portuguese workers have been educated in different school systems, we have to distinguish between birth cohorts. Analysing the wage gaps within cohorts, we find no support for either the human capital prediction of crossing wage profiles or the hypothesis that general graduates increasingly outperform vocational graduates in late career. We discover that the life-cycle wage profiles have shifted over time. We link the pattern of shifting cohort profiles to changes in the school system and in the structure of labour demand. We conclude that assessing the relative value of vocational education requires assessing how the vocational curriculum responds to changes in economic structure and technology. We show that the decline in assortative matching between workers and firms has benefited vocationally educated workers.

Keywords Vocational wage gap · Worker-firm allocation · Human capital · Returns to education

JEL Classification J31 · I26

Responsible editor: Klaus F. Zimmermann

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1 Introduction

Debates on the relative value of vocational versus general education have a long history among educators, politicians, employers and labour unions and opinion leaders. It is a very broad issue, considering arguments such as intellectual and cultural preparation for adult life, citizenship and lifetime labour market prospects, too broad for analysis in a single sweep. In this paper, we restrict our attention to one aspect of labour market effects: wage differentials.[1] Portugal is an interesting case to study as the division between vocational and general education at the secondary level has not been constant over time and we can study effects of the changes.

We consider only effects at the secondary level. At the primary level, there is usually no distinction between vocational and general education. At the tertiary level, the distinction is not easily made (is all polytechnic vocational and all university, including medicine and architecture, general education?). At the secondary level, the distinction is easier as it is explicitly recognised in the institutional nomenclature. Because we restrict attention to graduates who do not advance to tertiary level, we examine a relatively homogenous population, with the same length of schooling and, as we illustrate below, modest differences in abilities, and possibly ambitions and motivation, certainly when compared to the more common analyses among tertiary graduates.

Vocational education prepares students rather directly for specific occupations and train the students in the skills needed in these occupations. General education teaches more general abstract skills that are not directly related to tasks in particular occupations. Human capital theory predicts that vocational graduates will have an earnings advantage at the start as they need less on-the-job training and that graduates from general education will catch up as their on-the-job investments pay off. The lifecycle earnings profiles will cross as identical schooling length will lead to equal lifetime earnings. The crossing argument is reinforced as general education is commonly also assumed to bring better adaptability to labour market dynamics, and hence, easier switching from decaying to newly emerging technologies. Becker (1994) pointed to this effect by suggesting an advantage for a "liberal" education: "the long payoff period increases the advantage of an education that is useful in many economic environments". This prediction is at the heart of human capital theory in an abstract world that can only be tested in specific institutional environments. In this paper, we offer an analysis for the case of Portugal.[2] Evidence on the relative benefits of vocational and general education is not unambiguous and institutional details may well play a substantial role here. Portugal experienced substantial changes in the division between vocational and general education at the secondary level, which compel us to

[1] Eichhorst et al. (2015) present an institutional overview of systems of vocational training and a survey of their returns estimated in industrialised countries. Carneiro et al. (2010) also gives a comprehensive survey of the economics of vocational education. Zimmermann et al. (2013) survey the literature on the effect of vocational education on unemployment.

[2] We focus specifically on the dimension of risk in a separate paper. Torun and Tumen (2019) consider differences in employment patterns.

analyse the wage gap by education cohorts. As the gap turned out to vary markedly between cohorts, we also analyse this pattern.

There are several studies of the relative wage effects of general versus vocational education, but results are not unequivocal. Golsteyn and Stenberg (2017) find some evidence for a trade-off between initial advantage for vocational and later advantage for general education in Sweden, while for the UK, Brunello and Rocco (2017b) find evidence only for the group with lower vocational education. Hanushek et al. (2017) find evidence for the trade-off in countries with strong emphasis on apprenticeship programs. Woessmann (2008) and Machin and Vignoles (2005) find that a less developed vocational system acts as a negative signal and that returns are lower. The importance of the institutional structure of education is also stressed in the survey by Carneiro et al. (2010), who acknowledge that returns to vocational education are often high in countries with well-developed and established vocational education/apprenticeships systems (e.g. Acemoglu and Pischke 1999); Heckman (2000) points to the importance of a competitive market for apprentices for higher returns to vocational education. For Portugal, Pereira and Martins (2001) find that with a Mincer earnings function over the period 1982–1995, a lower secondary technical degree always pays more than the academic counterpart and that upper secondary vocational education had a higher payoff than general education in 1994 and 1995. Oliveira (2015) finds that between 1993 and 2009, workers with vocational education initially had a wage advantage over workers with general education, but that wages were higher for workers with general education after some 8 years of experience.

Throughout this literature, a key concern is selectivity: are students in vocational and general education indeed sufficiently comparable on the relevant dimensions? Methods applied and results obtained differ. A strong indication of potential relevance is Malamud and Pop-Eleches (2010), who examine relative benefits during Romania's transition to a market economy, when an educational reform shifted a large proportion of students from vocational training to general education. They conclude, from a regression discontinuity design, that selection was the main driver of differences in labor market returns between graduates of vocational and general schools. Hanushek et al. (2017) use a difference-in-differences estimator and control for individual-level measures of ability and family background, as well as country-specific changes in the size and ability composition of the different education types over cohorts. They also employ propensity score matching. Brunello and Rocco (2017b) apply a fixed-effects estimator and also use detailed information on individual ability and early-life conditions when estimating the parameters of employment and wage profiles. Golsteyn and Stenberg (2017) explore family fixed effects and control for grade point average (GPA) at age 15, i.e. the year prior to enrollment in vocational or general education in a context where students have the same amount of completed schooling, and the programs (whether general or vocational) were not intended to prepare for university studies. Fersterer et al. (2008) instrument time spent in apprenticeship when this time is truncated by firm failure and find no evidence of selectivity bias in OLS estimates of the returns to apprenticeships in Austria.

Selective hiring by firms also plays a crucial role in shaping wage differentials,[3] but the role of worker sorting across firms has been neglected in the general-vocational literature.[4] To the extent that workers with vocational and general education may not be randomly allocated to firms and firms' wage policies are different, this could be an important channel to shape the vocational wage gap. We will uncover a significant role for worker-firm allocation.

From the literature on relative benefits of vocational versus general education highlights, we identify three main challenges: the potential systematic difference between the two groups of individuals, ensuring that the workers of one age cohort are otherwise similar to those of another cohort and allowing for differences in programs and institutions. We deal with each of these issues in a single country where institutions changed over time. We document and interpret changes in the wage differential among graduates from secondary education with a vocational and a general curriculum in Portugal for cohorts born between 1951 and 1994. Marked changes in the institutional structure of education occurred during our period of observation. Before the Carnation Revolution that started in 1974, there was a traditional system with a focus on industrial and craft occupations. After the Revolution, there was a modern system with broader coverage of types of occupation and less vocational content in the curriculum, while during the revolutionary period, the distinction was formally abolished, but in practice often lived on, thus creating a rather fuzzy system.

In our data, we have only access to information on ability and family background for the most recent cohorts. We find modest selectivity effects, precisely because we restrict our population to students who do not advance to tertiary education, and we discuss potential effects in earlier cohorts. We allow for unobserved heterogeneity among individuals by including individual fixed effects. In contrast to the literature, we also include fixed effects to control for heterogeneity among firms. We find that the effect of unobserved firm heterogeneity is clearly more important than the effect of unobserved worker heterogeneity and that the observed evolution of the wage gap can be explained from a change in the assignment pattern of worker fixed effects and firm fixed effects.

The value of our analysis extends beyond Portugal. The issue has universal relevance, and our documentation and analysis expand the catalogue. We start from the human capital prediction that wage profiles for general and vocational education will cross as general education needs more on-the-job training. This is a very general prediction in a stylised theoretical environment that can only be tested in a real-world setting; the prediction has no established empirical status and we add new evidence. Moreover, and perhaps most importantly, we stress the importance of dynamics on the demand side of the labour market, and we are convinced that this importance carries over to other countries.

[3] Abowd et al. (1999) started a very prolific line of research that explores longitudinal linked employer employee datasets to quantify firm effects on wages.

[4] Over the last 50 years, the literature on the returns to schooling has made a noteworthy development; however, the role of worker sorting across employers has not been addressed. An exception is the recent work by Cardoso et al. (2018).

We make several specific contributions to the literature. First, we find that the common shape of the wage gap profile by age is weakly u-shaped: the gap first increases, then tends to decrease. Second, in our specific institutional environment, we find that the wage gap profiles shift over time also in a u-shaped pattern: the distance among cohorts first increases, then decreases. Third, we show that (unobserved) heterogeneity among firms is more important than unobserved heterogeneity among workers for explaining the wage gap. Fourth, we find that a decline in assortative matching between firm fixed effects and worker fixed effects is an important factor in understanding the evolution of the wage gap over time. Fifth, we interpret the observed profile shifts within the interaction of the dynamics of the restructuring of the Portuguese economy and changes in the school system.

The paper is organised as follows. We present a brief history of the Portuguese school system in Section 2 and indicate how the differentiation between vocational and general education at the secondary level has evolved. We discuss the labour market and wage setting in Section 3, and describe our data and address selectivity issues in Section 4. In Sections 5 and 6, we analyse, respectively, the unconditional vocational wage premium dynamics and the changing gaps between cohorts. Section 7 concludes. An online appendix in Hartog et al. (2021) provides a detailed description of the international standard classification of occupations (ISCO) and additional empirical results that have been omitted from the main text and Appendix.

2 The system of education in our sample period

General and vocational education are two different species. Vocational education is commonly described as preparing the graduate for direct entry into particular occupations or jobs, whereas general education is of a broader nature, less focused on specific job skills and generally requiring additional job specific training when entering the labour market. General education at the secondary level also functions as preparation for more extended education at the tertiary level, more so than vocational education. Thus, secondary general education attracts the abler students intending to continue to the advanced level. For proper comparison, we will only consider graduates from secondary education who do not move on to obtain an advanced degree. Below, we will show that students in general education (in earlier classes) who do not continue to advanced education have only marginally better scores on several academic performance measures. That suggests that their potential productivity level right upon graduation would not differ much from that of vocational graduates, and the same would hold for their potential wages.

With higher on-the-job investment for general graduates, and presumably higher investment costs charged to the employee, human capital theory would predict lower starting wages for general graduates.[5] Thus, human capital theory leads us to predict

[5]The argument would be reinforced if general graduates' investment has a higher share of general rather than specific on-the-job training and by Becker (1994)'s classical argument would lead to a larger share of the cost passed on the employees.

a wage profile with larger experience slope for the general graduate and a lower starting wage, i.e. crossing wage profiles. The argument may be more complicated, however, if there is comparative advantage, with the general graduate more productive in jobs following general education and the vocational graduate more productive in jobs following vocational education.

We compare the labour market outcomes for graduates with either general or vocational upper secondary education. Both tracks take the same formal number of years to complete.[6] We only consider graduates who obtain no further degrees. Hence, as in all datasets that use highest degree completed, they may have gone straight to work after obtaining their secondary degree or have tried advanced education but failed. Trying advanced education is rather uncommon after secondary vocational education, even nowadays, but is more common among graduates from secondary general education, and has become more common over time. Hence, the sample of vocational graduates can be taken as a fairly representative sample of those who attend secondary vocational education only, but our sample of general secondary graduates most likely contains a larger and possibly increasing fraction of graduates who also have attended some tertiary education but failed to graduate.

Our selection starts with the cohort born in 1951. For older cohorts, the school system was unbalanced in the sense that general education had a lower and an upper level, while vocational education had only lower secondary level. This implies that meaningful comparison of graduates would have to deal with differences in length of education, a complication we preferred to avoid.

On basis of its legal and institutional arrangements, we distinguish the evolution of the secondary school system in three periods or cohorts: the traditional, the fuzzy and the modern.[7] In Appendix, Fig. 7 and Table 4 provide the details.

The traditional school system covers birth cohorts 1951–1961 and labour market entry years 1969–1979 (with entry at age 18, with 11 years of schooling starting at age 7). There were two cycles of general (basic) education, and then a bifurcation in a general track (the lyceum) and a vocational track. Both take 5 years, in two tranches. Both general and vocational secondary education were highly selective. Admission was based on results in admission exams, separately for general and vocational. Access to a vocational school did not simply follow after failing admission for general education, but required to pass the separate admission exam. Results from the national exam when leaving primary education (after 4th grade) were also taken into account. Participation in extended education, beyond primary was quite low; participation in secondary education only started to rise above 5% in the mid-seventies and by 1979, barely hit 10%.[8] Furthermore, selection among general and vocational was not on ability but rather on family background (wealth, ambition for

[6] We have no information on repeating classes.

[7] In line with international practice, we will refer to Primary and Lyceum 1st level as "Primary" and to the next two cycles as "Secondary"; the lower of these two cycles (Lyceum 2nd level and Vocational 2nd level in the traditional system) as "Lower Secondary" and the higher of the two (General Secondary and Vocational Secondary) as "Upper Secondary".

[8] Source: "50 Anos de Estatísticas da Educação: Volume I", Figure 14 in page 9,- Gabinete de Estatística e Planeamento, Outubro de 2009.

advancement through schooling).[9] Vocational schools were local schools, with strong ties to local industry, while general education was predominantly provided in cities, by the government but also privately and by the church. General and vocational education had the same curriculum in Portuguese and math although in vocational schools the requirements were taken somewhat more leniently. The vocational schools were mostly specialised in agricultural, commercial and crafts training.

The fuzzy period covers birth cohorts 1962–1967 and labour market entry years 1980– 1985. It was the era right after the Carnation Revolution of 1974 that ended the Salazar dictatorship. Legally, the distinction between general and vocational secondary education was abolished, on the argument that in the existing system, selection was class-based and that every child would be entitled to a general education. In practice, the old system essentially persisted, be it with much freedom for schools to organise the curriculum as they wished. Students may have made all kinds of switches between tracks that have not been properly recorded. As is typical for revolutions, this is a somewhat chaotic period. A student born in this cohort may have started in the unified system and finished in the dual system. Our classifications of general or vocational education are taken from employer registration, and hence, in this fuzzy period, just as in the other periods, we will trust their assessment. We call this period fuzzy as the formal ruling of the Ministry of Education on school curriculum is not strictly applied. Data reliability is not different from the other periods. Classification is done by the employer, checked by the union, openly published in the firm and in annual meetings employer, union and government officials discuss the data.

In the modern system, for birth cohorts 1968–1995 and labour market entry years 1986–2013, there is a return to the dual system. From birth cohort 1971 on (labour market entry year 1989), this has been legally formalised as a system with 3 years of general lower secondary education and 3 years of differentiated upper secondary education. Compared to the traditional system of 5 years of differentiated secondary education, there is now 3 years of differentiated secondary education. It now takes 12 years of schooling to graduate, but the labour market entry age is still 18, as school starts one year earlier, at age 6. This period saw the creation of fifty vocational schools, following a commitment to enlarge and diversify the provision of education (Oliveira 2015). In vocational education, there are technical craft-type courses, professional courses and specialised art courses, all aimed at entry into the world of work, and catering to the new structure of production that has evolved since the days of the traditional vocational schools. In the traditional period, secondary education was a system with tight norms for the able and the ambitious, in a world where few had extended education; in the modern period, it is an education with much larger participation, more variation in tracks and more variation in education standards. From the mid-eighties to the mid-nineties, participation in secondary education rose from some 15 to some 60%.[10]

[9]This was the general perception during that period that was also transmitted by the director from the ministry of Education (DGEEC—Directorate-General for Education and Science Statistics).

[10]Source:"50 Anos de Estatísticas da Educação: Volume I", Figure 14 in page 9,- Gabinete de Estatística e Planeamento, Outubro de 2009.

As Fig. 7 in Appendix shows, in each period, graduates had completed 6 years of basic education; initially, school started at age 7, but after 1971, it started at age 6. In the traditional system, on top of their basic education, vocational graduates had 5 years of vocational education, general graduates had 5 years of general education. In the modern system, secondary graduates had 3 years of general education and either 3 years of vocational or 3 years of general education. The middle period had formally 5 years of non-differentiated education; in practice, graduates are distinguished by employers as generally or vocationally educated, but with some fuzziness as schools could make their own decisions on the curriculum. Within our 3 basic cohort classes, we make additional distinctions for a more detailed perspective on changes over time: two sub-cohorts in the traditional period, 3 in the modern period, with a separation in 1971 to reflect the extension of schooling length and school entry at an earlier age.

3 Labour market and wage setting

The Carnation Revolution of 1974 also affected the labour market.[11] Just as the school system, the labour market was in some state of confusion and turmoil that lasted until the early 1980s and may be said to have ended in 1986, when Portugal joined the European Community. Such developments may have affected labour market entrants in particular.

If so, this should be reflected in differences between the first sub-cohort in the traditional period and later cohorts, born between 1956 and 1971. Over time, the composition of our student populations will have changed in terms of ability and parental background, as accessibility and the relative socio-economic position of schooling levels and school types have changed substantially. We cannot trace these developments over our entire sample period, but we will pay attention to this issue in Section 4.2.[12]

Collective bargaining plays a central role in the Portuguese labor market, as in several other continental European economies. Indeed, massive collective agreements, often covering an industry, are common in the economy. Firm level collective bargaining traditionally covers a low share of the workforce, less than 10%. Extension mechanisms are common, either by mandatory government regulation or on a voluntary basis, as employers automatically apply the contents of collective agreements to their non-unionised workforce.

Despite the relevance of collective bargaining, firms have always enjoyed some degree of freedom in wage setting. Cardoso and Portugal (2005) have documented that wage cushion (or wage drift, the difference between the actual wage level and the bargained wage level) promotes an alignment of wages with firm-level conditions. They show that once mandatory contract wages have been set, firm-specific

[11] This text on wage setting is largely based on Cardoso et al. (2018).

[12] As we do not know exactly when a student started school, for the purpose of cohort assignment we assumed that the school entering year corresponds to the birth year, independently of the month of birth. Thus, for each year, we assume that everyone born in one particular year started school in the same year.

arrangements stretch the returns to worker and firm attributes and shrink the returns to union power. The existence of wage cushion therefore leaves ample scope for firms to define distinct wage policies. It follows from such an institutional setting that it is of key interest to quantify the impact of the firm when estimating the returns to education.

A national minimum wage is enforced in Portugal, defined as a monthly rate for full-time work. Currently, sub-minimum wage levels apply only to physically disabled workers and trainees, after all reductions based on age were abolished in 1999. The minimum wage develops rather smoothly over time; shares of covered vocational and general educated workers at entry ages 18–25 (where impact may be strongest) increase over time but are about equal from 1994 to 2008 and differ by almost 4 percentage points in the years 2009–2013 (27.0% for general and 23.3% for vocational). Over time, there have been changes in labour market institutions, but none aimed for differential impact on vocational and general graduates of secondary education. Legal minimum wages were introduced in 1974, and minimum youth wages, as a fraction of the general minimum, were gradually increased. Before the 1990s, unemployment benefits were virtually non-existent, with unemployment assistance covering less than 10% of the jobless in 1985. The unemployment rate went up sharply after 1973, to a peak in 1986 and then tapered off. See Portugal and Cardoso (2006) and Bover and Portugal (2000) for further details.

4 Data

4.1 Sample selection and sample composition

We use data from the Portuguese Quadros de Pessoal (QP), a longitudinal dataset that covers all workers in firms with at least one employee, irrespective of age, starting in 1994 (information on schooling type is not available earlier). The data are gathered annually by the Ministry of Solidarity, Employment and Social Security, based on an inquiry that every establishment with wage-earners has to fill in under legal obligation. Currently, QP annually gathers information in a reference month for more than 300,000 firms and 3 million workers (Portugal has about 10 million inhabitants). Given the mandatory nature of the inquiry and the fact that these data cover all wage earners in the private sector, problems associated with attrition are mitigated.[13] The QP contains detailed information on the workers, including gender, age, schooling, hours worked and monthly earnings split into several components, i.e. base wage, regular payments (e.g. seniority), irregular benefits (e.g. profits and premiums) and overtime payments. The QP also provides detailed information on the firm, such as geographic location, industry and size. The data are provided by the employer under

[13] Hartog and Raposo (2017) tested a relation between starting wage and wage risk. For respondents lost from the QP panel, they added information from Social Security records, thereby reducing sample attrition to just a few percent. Using that information did not affect the estimation results for the QP data only. This suggests that sample attrition is not selective on wages or wage dispersion.

Table 1 Descriptive statistics for general versus vocational

			N	Hourly wage (log)	Male (%)	Age (years)	Tenure (years)	Firm size (log)
Panel A: general vs vocational								
		General	5,314,533	0.59	0.50	33.64	6.77	2.37
		Vocational	951,792	0.54	0.54	33.61	6.95	2.39
			6,266,325					
Panel B: six cohorts in detail								
Cohort 1a	1951–1956	General	268,428	1.03	0.60	49.26	14.73	3.06
		Vocational	78,324	0.98	0.68	49.92	15.97	3.09
Cohort 1b	1957–1961	General	497,862	0.91	0.53	44.60	12.35	2.84
		Vocational	95,280	0.84	0.59	45.44	12.81	2.80
Cohort 2	1962–1967	General	953,471	0.79	0.52	39.27	9.20	2.52
		Vocational	117,846	0.69	0.52	40.10	9.12	2.48
Cohort 3a	1968–1970	General	596,902	0.66	0.49	35.22	7.24	2.28
		Vocational	78,464	0.59	0.51	35.82	7.30	2.33
Cohort 3b	1971–1979	General	1,984,013	0.49	0.48	30.92	5.01	2.14
		Vocational	336,514	0.46	0.51	31.01	5.37	2.14
Cohort 3c	1980–1995	General	1,013,857	0.30	0.46	25.61	2.81	2.00
		Vocational	245,364	0.30	0.55	25.31	2.80	1.99
			6,266,325					

This table presents the summary statistics for individuals who have completed upper secondary school level in the general or the vocational track. See Table 4 in the Appendix for the cohort class definition

government regulation, which helps to restrain measurement errors.[14] Civil servants are not covered by QP[15] and we deleted the self-employed as the data on this category is too noisy; the shares of self-employment among vocational and general graduates barely differ (see below). We use data from 1994–2013, restricted to birth year cohorts 1951–1995. Data definitions are given in Table 5 in Appendix, and sample statistics in Table 1. (Upper secondary) vocational and general education are defined as in the standard educational classification which is provided to employers with the survey instructions. In case a worker's level of education is reported differently in different years, we use the mode.

[14] QP requires that the Ministry of Finance and labour unions confirm that the employers are complying with the law, especially in terms of wages and actual hours worked. The individual data are accessible for workers to check that the reported data are correct.

[15] According to LFS, in 2011, among vocational graduates around 14% work in the public sector, while the percentage is around 26 for general HS graduates; there are no significant changes in the share of public sector workers over time. In addition, Campos and Pereira (2009) show that controlling for worker characteristics, wages are higher in the public sector than in the private sector.

As Table 1 shows, the total sample size is 6.3 million individual observations, 15% with vocational education and 85% with general education; viewed over 6 cohorts, the vocational share dropped from 23 to 16 and 11% and then increased back up to 19.5%. The total sample contains slightly more men than women. Compared to general graduates, vocational graduates are slightly older, have slightly more tenure, work on average in equally sized firms and on average have 5% lower wages (wages are defined as total real hourly wages, in logs, see Table 5 in Appendix). The share of men among the general educated consistently falls for younger cohorts, reflecting increasing labour market participation of (married) women but among vocational educated, the share increases after initial decline; the share of men in vocational education is never lower than in general education. The gap in firm sizes is never above 5%, but average firm sizes decline strongly among cohorts, which may reflect a shift of employment from manufacturing to services. The wage gap by education type is not constant but varies in a U-shape across cohorts, at 10% for the middle cohorts and ending up at 0 for the most recent cohort.

Overall distributions of wages do not differ much; the upper part of the vocational wage distribution is slightly to the left of the distribution for general wages (see Figure OA1 in online appendix in Hartog et al. 2021). On average, both vocational and general wages increased rapidly over the 1990s, then rose more slowly and declined markedly after 2009 (see Figure OA2 in online appendix in Hartog et al. 2021); the distance between the two follows an inverted U shape: first increasing and then decreasing.

4.2 Selectivity

Our focus will be on the time profile of the vocational wage gap, i.e. the difference between wages for graduates from secondary vocational and secondary general education. Our results might suffer from potential biases and we will now offer a reflection on their nature and magnitude. First, the omission of civil servants and the self-employed from our data means that our results only hold for those individuals observed as private sector employees. According to the Labour Force Survey (LFS), in 2011, among upper secondary vocational graduates, around 14% work in the public sector, while the percentage is around 26 for general graduates; there are no significant changes in the share of public sector workers over time. Campos and Pereira (2009) show that controlling for worker characteristics, wages are higher in the public sector than in the private sector. Hence, underestimation of the wage for all working graduates will be larger for general than for vocational graduates. But if the public sector pay premium would be constant, the time profile of the vocational wage gap would not be biased on this account. Also, according to LFS 2011, among vocational graduates, some 15% are self-employed, and among general graduates, the share is about 1% point lower. By cohorts, the shares among vocational graduates are 19, 14 and 12, and among general graduates, they are 18, 16, and 8. This suggests that the wage gap is only biased if general and vocational graduates have different earnings ratio for self-employment versus employment and that the time profile of the vocational wage gap is only biased if the earnings ratio is not constant over time. We have no data to check the conditions we spell out here.

Second, graduates from general secondary education may continue to tertiary education. If they complete a tertiary education, they are not in our dataset; if they try and fail, they are: our wage observations on general secondary education include benefits from incomplete tertiary education. We have no data on the magnitudes involved. The wage mark-up from an attempted but failed tertiary education is probably quite small, certainly if drop-out occurs at an early stage.[16]

Third, potentially, the most important omitted variable is ability. However, by including regressions with worker fixed effects among our specifications, we will at least control for the ability component reflected in the fixed effect and we will be able to compare between the two groups of workers. As will be shown below, in Table 3 and Fig. 4 in Section 6.2, the contribution of this component (worker fixed effect) is quite small and with modest variation over time (much less than the firm fixed effect).

We can also draw on some more direct information on selectivity on recent cohorts. For three recent school cohorts (enrolled in the 10th grade at 2007, 2010, 2013), we have regressed data on students' performance just before track selection on individual and family characteristics and a dummy for actual track choice (see Tables OA1, OA2 and OA3 in online appendix in Hartog et al. 2021). Among students choosing the general track, we only retain those who do not intend to continue to higher education (among vocational students, virtually no one advances to tertiary education). This is important, as the difference among those who do not and those who do intend to continue to higher education is substantial.[17] It is precisely the latter group that feeds the notion that general track students are better than vocational students. We find that students choosing the general track score barely better on reading and math. The differences are about 1/20th of a grade point, less than 10% of a standard deviation of grade point, and in 2007/2008, the difference in math scores is not significant. Retention rates are substantially lower for general graduates, but controls have negligible effect on these gaps. As the difference in math and reading scores between our general and vocational scores is modest, we speculate that differences in graduation and retention rates may have other causes than ability differences (e.g. interests and work life ambitions). Mother's education, whether measured in years or levels, has a significant effect on track choice: children from higher educated mothers choose the general track more often. Reading score has a positive effect on likelihood of choosing the general track, and math score has no significant effect. With math score generally considered a good indicator of general intellectual ability (or IQ), and reading scores taken as an indication of taste and talent for more scholastic engagement, this would indicate that students who choose the vocational track

[16] In Portugal, on average 20 to 25% of students in higher education drop out but the majority are students with the weakest performance at the final exam of the secondary stage (final marks of 10 and 11, the minimum marks required to complete the degree) and from more disadvantaged background families (e.g. parents with lower education levels). In fact, these characteristics are similar to the attributes of the students that did not continue to higher education level. In addition, a large share of drop-out happens earlier and not so much in the last stage of the degree. Therefore, despite the potential issues, the impact is likely to be small and does not jeopardize our main results and main conclusions.

[17] Thee may of course be a distortion to the extent that students change their mind. Students may underestimate or overestimate their ability and ambition to continue.

are not necessarily of lower ability, but have an interest in more practical, directly applicable education. But admittedly, this is a rather speculative interpretation which would require more evidence to substantiate.

To conclude on the omitted ability bias in the estimated coefficient for vocational education (the vocational wage gap), recall it will depend on the (positive) effect of ability on earnings and on the covariance between education type and ability. If the covariance between vocational education and ability is negative, as is often claimed, we would underestimate the vocational wage gap, and if the intensity of the covariance has changed over time, the omitted variable bias would also have fluctuated over time. But a modest covariance as suggested above by the difference in worker fixed effects between vocational and general graduates also matches our perception of actual practice. We have documented that in recent years, there is indeed a large gap in school performance (ability) between vocational students and general students that go on to advanced education and this may feed the common assumption of substantial ability differences. But there is only a modest gap with general students that do not continue. That surely diminishes the magnitude of the problem. In earlier days, very few children would continue to secondary education and if they did, ability was a key determinant for both general and vocational education. Many talented working class children ended up in vocational education and vocational education was not the standard fall-back option for pupils who did not make it into general education. Both general and vocational education had entry exams, and those who failed entry into general education would not simply enter vocational by default. That puts a cap on differences between ability levels in general and vocational education. As Table 3 in Section 6.2 shows, the larger contribution of the worker fixed effect points to larger potential selectivity bias and that is precisely why we included the worker fixed effect.

To sum up, there is reason to assume that we underestimate wages for general graduates because we do not observe public sector workers, that we overestimate their wages because some have some university training and that we overestimate the wage penalty for vocational graduates to the extent that vocational graduates have lower ability. But we have also given arguments that the biases may well be stable over time and do not affect the time profile of the gap.

5 The unconditional vocational wage premium

In our data, we have three measures of time: year of observation, cohort (birth year) and age of the respondent. We cannot observe actual experience, and we cannot construct it from cumulating tenures, as we are not certain about status when the individual is not observed (it may be unemployment, non-participation, self-employment or work for the government). We will not be able to identify the separate effects of all three time variables as they are not independent (cohort plus age is year of observation). We should also note that our window of observation is limited, and this has truncation effects. For the oldest generation, we do not observe the early career stages, and for the youngest generation, we do not observe the late career stages (see the details in Table 4 in Appendix).

While we cannot fully disentangle the effects of each time dimension, we can get an indication of the main driver. Using 9 age classes and 3 cohort classes, both for general and vocational education, we can graph the wage gap for vocational education by combined age-cohort class, by taking the differences in class means for vocational and general. If we would regress wages on dummies for age and birth cohort, subtract from each wage the estimated effect of age and birth cohort (effectively subtracting the mean of the combined class), and then calculate the vocational premium from the residuals in each class, the resulting cohort profiles would be identically at: if we control for the average effect of age and birth year, the average profile in age and birth year has in fact been eliminated. In this process, we can check which step has the largest impact. Controlling for year effects does not make any difference, controlling for birth years has some effect, but if we control for cohort classes separately by type of education, the age profiles of the gap for our three cohorts coincide. This tells us that the intertemporal action is in the development of the vocational gap among cohorts (see Figure OA3 in online appendix in Hartog et al. 2021) and that we have to analyse the wage gap separately within and among cohorts.

Figure 1 gives age profiles by cohort class for the age intervals that we can observe for each of the cohorts (for old cohorts we have no observations on early ages, for young cohorts we observe no advanced ages). The distance between general and vocational wage profiles first increases and then decreases. In the youngest cohort class, the difference has essentially disappeared. At age 40, for the first 5 cohorts, the successive wage mark-ups for general education are 4.3, 7.1, 12.8, 9.9 and 6.0%, respectively (all statistically significant); at age 30, for the last 4 cohorts, the general education mark-up is 7.7% for cohort 1962–1967, 7.1 for the cohort 1968–1970, 4.2 for cohort 1971–1979 and 0.4 for cohorts 1980–1995.[18]

Figure 2 depicts the development of the wage gap by cohort. The vocational wage gap tends to be U-shaped over age within each cohort but only the downturns from early to later career stages are statistically significant, as can be read off from comparing confidence intervals around the age dummies. The shift between the cohort profiles is more convincingly U-shaped: first downwards, then upwards.

Crossing wage profiles, from positive to negative, as predicted by the human capital hypothesis, is not the common result. Only for the youngest cohort, observed up to their mid-thirties, is the vocational wage higher than the general wage and may be on its way to a lower level at advanced ages. The tendency for the upturn towards late career is not statistically significant in any of the cohort profiles, but neither do we observe that especially in late career, vocational graduates loose out on general graduates, as they would be less equipped to cope with changes in the labour market. Thus, the human capital prediction does not come out with strong support. So far, we have not observed crossing wage profiles and we do not observe an increasing lag of vocational wages in late career.

The absence of general graduates increasingly outperforming vocational graduates might be explained from higher depreciation on their human capital, but that is hard to substantiate empirically. It might also be more selective withdrawal from

[18] See Table OA4 in the online appendix in Hartog et al. (2021).

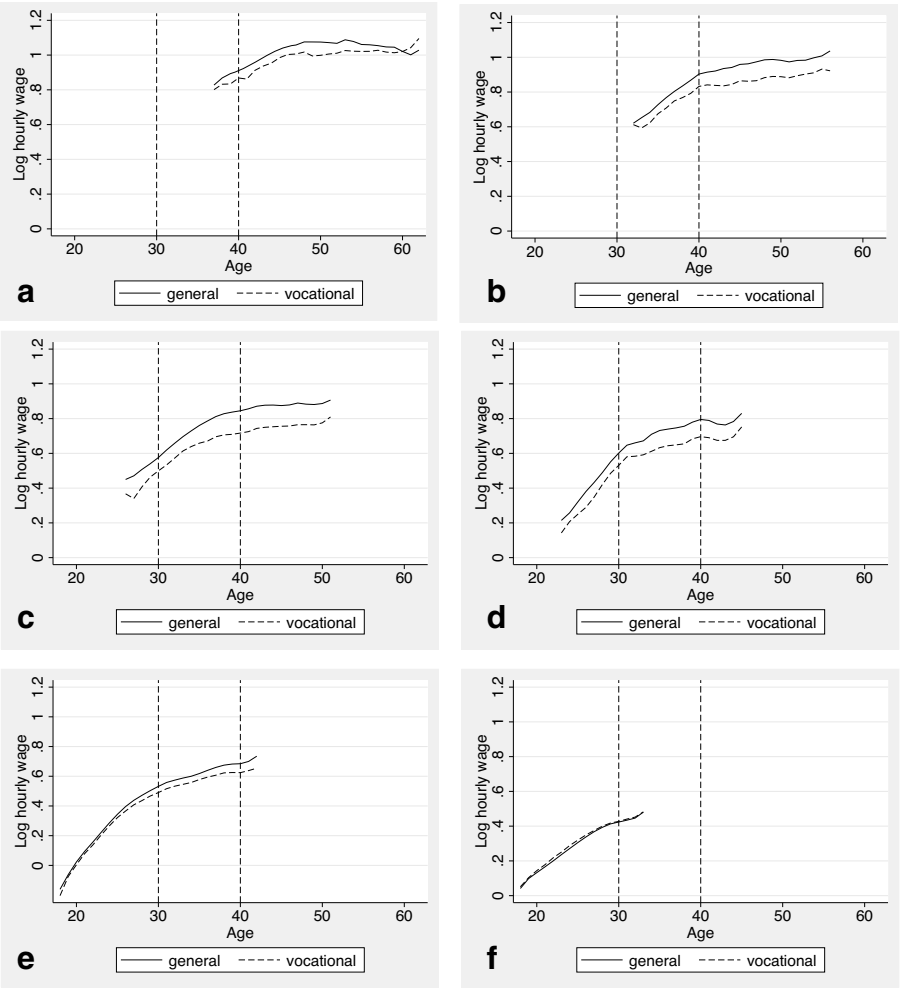

Fig. 1 Log hourly wages—vocational vs general education—by cohort groups. Notes: Log hourly wages in real terms for individuals with upper secondary educational level, age profiles for different birth cohorts. **a** Cohort class 1951-1956 **b** Cohort class 1957-1961 **c** Cohort class 1962-1967 **d** Cohort class 1968-1970 **e** Cohort class 1971-1979 **f** Cohort class 1980-1995

the labour market of low-wage vocational graduates, leaving increasing shares of the higher paid among the working population. This would indeed be support for the common argument that vocational graduates are less equipped to deal with labour market dynamics. To check this hypothesis, we have estimated separation probabilities, that is, the probability to leave our sample, in function of age, tenure etc. (see Tables OA5, OA6 and OA7 in the online appendix in Hartog et al. 2021). The QP data allow a limited glance at labour market turnover, as they reveal if an individual observed in year t is observed or not in year $t + 1$. If not, the individual may have

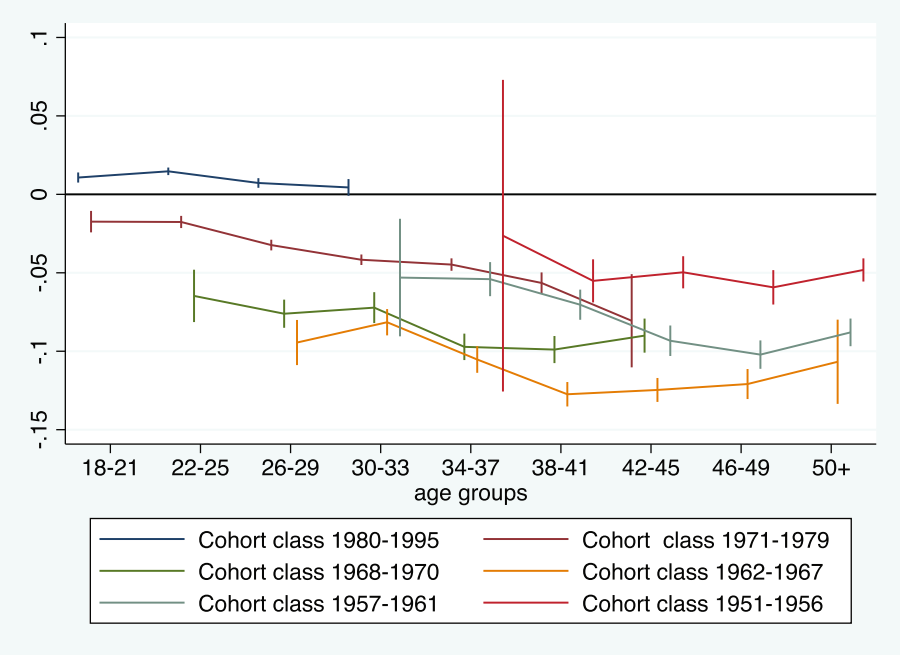

Fig. 2 Log hourly wage gap (vocational—general)—by cohort class and age group. Notes: Log hourly wage gap between vocational and general education for individuals with upper secondary school by age groups and by cohort classes. The figure includes the 95% confidence interval for each point estimate. See Table 4 in the Appendix for cohort class definition

lost her/his job (through voluntary or involuntary separation), have changed to some kind of temporary work (under "recibos verdes"), moved to the civil service or have retired. We cannot differentiate among destinations and have to lump all these moves together, under the name of "exit". We have run linear probability models (LPM) to test if there are differences among the exit probabilities for general and vocational education. The vocational educated have lower exit probabilities, and exit probabilities are reduced for higher wage. The effect of the wage rate differs among general and vocational educated, but the difference is modest relative to the wage effect itself. The variation in controls only has noticeable effect on these results once we add the firm level variables, in particular the firm fixed effects. With all controls included, exit probabilities barely differ among cohorts, and the effects of the wage are also very similar in magnitude. The conclusions on cohort-specific wage effects are barely sensitive to the inclusion of controls.

The wage sensitivity of the separation probability varies a bit by quartile of the wage distribution but within cohorts, general and vocational graduates have no differential sensitivity by wage distribution quartile. We conclude that exit probabilities are sensitive to wage rates, and in that sense, there may be selection effects in wage

rates that we observe, but the difference in wage effects among general and vocational graduates appears quite modest, suggesting that differential selectivity may not be substantial. Restricting the wage regressions to workers who have been observed in each year of our sample supports this conclusion: for workers who never left the sample, we find the same basic patterns in the wage structure (See Table OA8 in online appendix in Hartog et al. 2021).

The absence of an increase in the wage gap towards the end of the working life seems a true wage phenomenon, not due to selectivity in the exits. This is at variance with the hypothesis that graduates from general education are better prepared for future dynamics of the labour market. The data for the youngest cohort are exceptional as they show the vocational wage to be higher than the general wage for the four age intervals up to age 33. The negative slope after age 25 does not rule our that the general wage will overtake the vocational wage. Only more recent data can be the judge here. As noted in the introduction, Oliveira (2015) found an overtaking around age 25, but reported no catching up towards the end of working life. Her data cover a different time interval (individuals born between 1974 and 1990) and she does not allow for cohort effects. Figure 2 indicates that if we would combine the two youngest cohorts, we would also find general wages overtaking vocational wages.

Brunello and Rocco (2017b) analyse data for Great Britain from two different datasets, each covering a cohort from a singular month of birth (in 1958 and in 1970). Their results show for "lower vocational education" (which is comparable to our vocational education at secondary level) an earnings advantage up to about age 30, that then turns into an increasing negative gap that is erased above age 50. Thus, they find support for the takeover that we do not find, but the wage gaps are U-shaped over the lifecycle.

6 Changing gaps between cohorts

6.1 Possible explanations

We will now seek to understand the change in the wage gap among cohorts. A common perception is that with increased participation in tertiary education, it has become more difficult for secondary school graduates to reach the higher job levels, such as top level management, and this may have worked out differently for general and vocational graduates. However, this is not what we see. We have analysed the shift in occupational distributions between the traditional and the modern cohort.[19] The conclusion is quite clear: the dynamics of the occupational distribution are highly similar for general and vocational graduates. The shares for top-level occupations (Management and Professional) are even equal for general and vocational within each time interval. The results do not suggest a differential change among general and

[19] See Table OA9 in online appendix in Hartog et al. (2021). Table OA10 in the online appendix in Hartog et al. (2021) provides detailed description of each occupation according to the International Standard Classification of Occupations (ISCO).

vocational graduates in career opportunities.[20] The data for changes in the industry distribution between cohorts points to the same conclusion: changes in the production structure of the economy, by occupation and industry have affected general and vocational graduates in roughly the same proportions.

An obvious candidate to explain the shifts in cohort profiles would be shifts in the volumes of supply and demand of vocational and general graduates.[21] As observed in our data, the average total number of graduates by year of birth rose monotonocally from some 58 thousand in the first cohort to 257 thousand in cohort 3b and then plunged to 78 thousand. The developments are similar for vocational and general graduates, but not for the shares: the ratio of vocational over general in our 6 cohorts was .29, .19, .13, .13, .17 and .24. As the relative vocational wage is lowest when the relative educational share is also low, this does not point to a supply effect. The profiles of unemployment by age show an upward trend across cohorts for both vocational and general graduates, but only differ markedly for cohorts 2 and 3a: graduates born between 1962 and 1970, entering the labour market between 1980 and 1988. In these cohorts, vocational graduates have lower unemployment rate at young ages and dramatically higher rates when older than their late 30s. The exceptional profiles for the unemployment ratio are fully located in the vocational unemployment rates, as general graduates' unemployment is not unusual. Low relative unemployment for the young and high for the older suggests structural change: it is not the entrants in the labour market that are hit but the experienced workers (see Figure OA5 in online appendix in Hartog et al. 2021). Cohorts born between 1962 and 1970 are the last cohorts educated in the old school system, graduates from the fuzzy revolutionary school system and the earliest cohort in the new system: apparently, they became obsolete and were replaced by new, young graduates.

6.2 The role of worker-firm matching

For a deeper analysis of the shifts in the wage gap between cohorts, we start from the specification:

$$\begin{aligned} Logwage_{ift} = {} & \eta_1 VocationalHS_i + \eta_2 male_i + \beta_1 age_{it} + \beta_2 age_{it}^2 \\ & + \beta_3 tenure_{it} + \beta_4 tenure_{it}^2 + \gamma logfirmsize_{ft} + \phi_t + \theta_f + \epsilon_{ift}. \quad (1) \end{aligned}$$

Here, the dependent variable, $Logwage_{ift}$, represents the log of the total hourly wage for workers i, working in firm f at year t(from 1994 to 2013). Our coefficient of

[20] Ideally, we would make this comparison for identical experience (or age), but this is not feasible with our data. With the oldest cohort, we have no observations below age 33 (born in 1961, observed in 1994), with the youngest cohort we have no observations above age 45 (born in 1968, observed in 2013). To get as close as possible to overlap, we have compared the distributions for the 4 earliest years for the oldest cohort with the 4 latest years for the youngest cohort. The conclusion remains the same. As the frequencies change only slowly over time, the exact selection of years is not essential for the conclusion.

[21] A referee suggested that the fuzzy period is characterised by measurement error in type of education and that this can explain the widening wage gap between the traditional and the fuzzy period. But the most likely error would be erroneously labelling vocational as general, leading to lower recorded general wage and hence a recorded decline in the wage gap.

interest, the vocational wage gap, is represented by η_1, while η_2 stands for the gender gap. $\beta = \{\beta_1, \beta_2, \beta_3, \beta_4\}$ is a vector of the coefficients associated with individual time-variant characteristics; respectively, age, age squared, tenure, tenure squared and γ represent the firm time-variant characteristics (log of firm size). θ_f represents the firm fixed effects (unobservable and observable time invariant attributes of the firm). ϕ_t represents the year specific effects. OLS estimates[22] of the vocational wage gap in Eq. 1 are presented in Table 2.[23]

The crude wage gap across all cohorts is some 6% negative and not sensitive to including year effects, age, tenure and gender.[24] Bringing in firm characteristics has substantial effect. Adding log firm size reduces the gap to almost −2%, meaning that vocational graduates more likely work in small firms.[25] There is no obvious explanation for this effect. It may be that within larger firms the better scope for allocating skills to job requirements works to the advantage of vocational graduates, collective bargaining may benefit vocational graduates in the larger firms or it may be that the curriculum of vocational schools caters more to needs of large firms. Adding firm fixed effects turns the wage gap to a positive 1.2%. This suggests an important role for the assignment of workers to firms, which we will analyse in greater detail below.[26] Figure 3 also shows the dominant role of firm characteristics. Controlling for individual characteristics, the trend in the vocational wage premium is reversed, adding firm characteristics eliminates the trend.

As stated before, age patterns are generally difficult to identify separately from cohort or calendar period effects. Following Dohmen et al. (2017) we replace year fixed effects with observable time-variant variables (GDP growth and unemployment rate for the High School graduates) for the specific underlying factors that may change vocational education choices and outcomes across periods. In this setup, we obtain very similar results in terms of the vocational wage premium among the different specifications of the regression equation despite some changes in the age coefficient (see Table OA13 in online appendix in Hartog et al. 2021).

[22] In addition to OLS, we have also estimated the model applying Instrumental Variables: a) with standard instruments in the returns to schooling literature, like quarter of births (Angrist and Krueger 1991), changes in compulsory schooling laws (Angrist and Krueger 1991; Acemoglu and Angrist 2001; Oreopoulos 2006); b) interpreting our 6 cohorts as schooling law changes; c) historical schooling rates by municipality (Portugal is divided in 18 districts and then subdivided in 308 municipalities) when the worker was 10 years old, 5 years before they were entering secondary school; d) combinations of the three. The instruments end up not having sufficient power ending up with estimates between 7 to 75 times bigger than OLS and gaps of 30 to 350%. Dai and Martins (2020) focus on heterogeneity in the vocational premium in China. OLS estimates point to 20% higher wages for vocational versus academic secondary education in urban areas, but IV estimates (with variations in school type quotas as instrument) of quantile regressions show that only vocational graduates in the middle quantiles enjoy a statistically signficant premium, of some 30%.

[23] Tables OA11 and OA12 in online appendix in Hartog et al. (2021) provide the coefficient estimates of the other covariates in Eq. 1, respectively for the whole sample, and six cohort classes.

[24] Adding controls for industry, region or working part-time has no effect on the main results.

[25] Our results are essentially unchanged when we measure firm size by sales rather than workforce.

[26] Controlling for fixed effects after firm size has already been controlled for affects estimated cohort wage gaps, controlling for firm size when fixed affects have been controlled for leaves all regression coefficients unaffected. Thus, firm size can pick up some of the effects that can also be caught by the fixed effects, but once we include fixed effects, our results are not sensitive to including firm size or not.

Table 2 Vocational wage gap

	(1)	(2)	(3)	(4)	(5)
Panel A—whole sample					
VocationalHS	−0.0550***	−0.0583***	−0.0588***	−0.0174***	0.0119***
	(0.0006)	(0.0006)	(0.0005)	(0.0005)	(0.0005)
Panel B—six cohort classes					
Cohort 1a * VocationalHS	−0.0463***	−0.0572***	−0.0868***	−0.0454***	0.0154***
	(0.0021)	(0.0021)	(0.00191)	(0.0018)	(0.0014)
Cohort 1b * VocationalHS	−0.0736***	−0.0886***	−0.100***	−0.0571***	0.0039***
	(0.0018)	(0.0018)	(0.0017)	(0.0016)	(0.0013)
Cohort 2 * VocationalHS	−0.0986***	−0.115***	−0.107***	−0.0576***	0.0126***
	(0.0016)	(0.0016)	(0.0015)	(0.0014)	(0.0011)
Cohort 3a * VocationalHS	−0.0731***	−0.0877***	−0.0909***	−0.0420***	0.0174***
	(0.0020)	(0.0019)	(0.0018)	(0.0017)	(0.0014)
Cohort 3b * VocationalHS	−0.0325***	−0.0407***	−0.0524***	−0.0115***	0.0139***
	(0.0010)	(0.0010)	(0.0009)	(0.0008)	(0.0007)
Cohort 3c * VocationalHS	0.0027**	0.0017	−0.0126***	0.0269***	0.0064***
	(0.0012)	(0.0012)	(0.0011)	(0.0010)	(0.0008)

The table reports the vocational wage gap defined in Eq. 1. Column (1) reports the unconditional results, column (2) includes the year effects, and the specification in Column (3) includes individual characteristics: gender, and age and tenure in quadratic form. Column (4) adds to the previous specification the log size of the firm and column (5) specification includes also the firm fixed effects. Panel A provides results for the whole sample, while in panel B we provide the results by 6 cohort classes

Robust standard errors in parentheses. * Significant at 10%; ** significant at 5%; *** significant at 1%

Composition effects play no dominant role in an explanation of wage gap change. We have tested our basic findings on the wage profiles with difference-in-difference specifications: differences in the wage gaps by age interval within and between cohorts. The tests confirm the (weak) U shapes by age within cohorts and among cohorts over time, and the fading away of the gap when firm fixed effects are allowed for (see Figure OA4 in online appendix in Hartog et al. 2021).

We estimate the vocational wage gap within nine occupations, by cohort, i.e. from unconditional to a regression with fixed effect for occupation, controlling for age, tenure, gender, firm size, year dummies and firm fixed effect (occupation interacted with a vocational dummy) (see Table OA14 in the online appendix in Hartog et al. 2021). Crude wage gaps across the occupations have converged, mostly as the wage penalty has strongly declined for Managers (from −0.16 for cohort 1951–1961 to −0.03 for cohort 1968–1995) and the wage premium for Craft Workers and Plant Operators also strongly declined (from 0.18 and 0.16 to 0.04 and 0.01). But just as in Table 2, when we use all our controls the wage gap almost disappes, with the biggest jump when we enter firm characteristics.

As the change in the vocational wage premium cannot be explained from sectoral composition effects and the firm fixed effect appears to play an important role, we

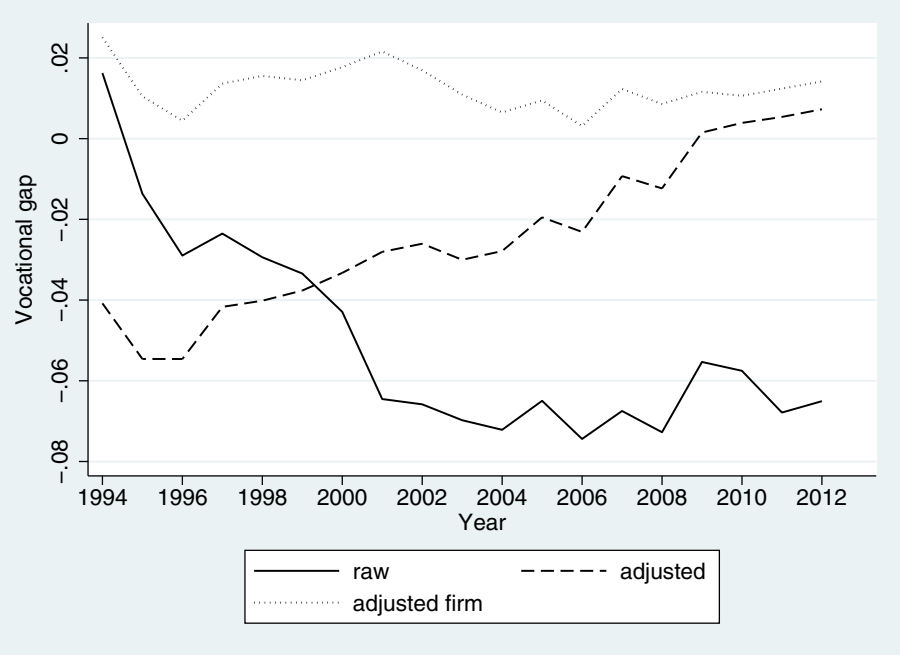

Fig. 3 Vocational wage gap. Notes: This figure reports the vocational wage gap by year (η_{1t}) from regressions with different sets of explanatory variables according to the following specification: $Logwage_{ift} = \eta_{1t} Vocational HS_i + \psi X_{ift} + \epsilon_{ift}$. The solid black line (raw) reports the unconditional results; the dashed line (adjusted) includes individual characteristics (gender, and age and tenure in quadratic form) and the log size of the firm; the dotted line (adjusted firm) specification includes also the firm fixed effects

decided to look closer at the role of unobservables, not only as firm fixed effects but also as worker fixed effects. For this purpose, we use the Gelbach (2016) decomposition, to quantify how much of the vocational wage gap operates through a firm channel, as opposed to a worker individual channel.[27] The exercise can be interpreted very intuitively as highlighting differences in firm wage effects across vocational and general education tracks. In other words, it quantifies the relevance of worker sorting across firms in shaping the vocational wage gap. In Table 3, column (1) gives the wage premium conditional on the observables in our data. We will now check to what extent this estimated premium can be replaced by worker fixed effects and firm fixed effects.

[27] Consider a full regression equation $Y = b_1 X_1 + b_2 X_2 + \varepsilon$ where we omit X_2 from the estimation, and the estimate of b_1 is subject to the omitted variable bias determined by the product of b_2 and the regression coefficient of X_2 on X_1. The Gelbach decomposition measures the part of the biased estimation of b_1 in the "baseline regression" (when X_2 has been excluded) that can be "explained" by the omitted variable bias. By construction, the full difference between b_1 estimated in the full specification and in the baseline specification is explained. The value of the method is to measure the contribution of each of the variables in X_2 if X_2 is a vector.

Table 3 Gelbach decomposition of the vocational wage gap

		Base	Full	Base-full	Firm fixed effect	Worker fixed effect
		(1)	(2)	(3)=(2)-(1)	(4)	(5)
Panel A—whole sample						
VocationalHS		−0.017	0	−0.017	−0.013	−0.004
Panel B—six cohort classes						
Cohort 1a	1951–1956	−0.045	0	−0.045	−0.033	−0.012
Cohort 1b	1957–1961	−0.057	0	−0.057	−0.032	−0.025
Cohort 2	1962–1967	−0.058	0	−0.058	−0.039	−0.019
Cohort 3a	1968–1970	−0.042	0	−0.042	−0.032	−0.010
Cohort 3b	1971–1979	−0.011	0	−0.011	−0.013	0.002
Cohort 3c	1980–1995	0.027	0	0.027	0.020	0.007

The conditional decomposition of the return to education is based on Gelbach (2016). Column (1) reports the coefficient of the benchmark result on returns to vocational education (column (4) in Table 2). Column (2) reports the coefficient of the full specification after including worker and firm fixed effects, which is zero by construction. The results of the decomposition are reported in columns (4) and (5). Adding up the results of columns (4) and (5) we obtain the benchmark coefficient in column (1)

Panel A provides results for the whole sample, while in panel B we provide the results by six cohort classes

By nature of the Gelbach decomposition, the two effects will exhaust the full gap between including and excluding these variables, i.e between full and baseline specification. We start with the baseline specification without the firm fixed effect:

$$Logwage_{ift} = \eta_1 VocationalHS_i + \eta_2 male_i + \beta_1 age_{it} + \beta_2 age_{it}^2 + \beta_3 tenure_{it} + \beta_4 tenure_{it}^2 + \gamma logfirmsize_{ft} + \phi_t + \epsilon_{ift}, \quad (2)$$

where the error term includes 3 components:

$$\epsilon_{ift} = \alpha_i + \theta_f + \mu_{ift}, \quad (3)$$

where α_i stands for worker fixed effects (the unobservable and observable time invariant attributes of the worker), θ_f for the firm fixed effects (unobservable and observable time invariant characteristics of the firm) and μ_{ift} represents the idiosyncratic error term.

By ignoring the worker and firm fixed effects in Eq. 2, this equation suffers from omitted variable bias. Then, we add the worker and firm fixed effects in order to obtain the full model. In this full model, we cannot estimate the vocational gap, nor the gender gap, given the presence of the worker fixed effects:

$$Logwage_{ift} = \beta_1 age_{it} + \beta_2 age_{it}^2 + \beta_3 tenure_{it} + \beta_4 tenure_{it}^2 + \gamma logfirmsize_{ft} + \alpha_i + \phi_t + \theta_f + \mu_{ift}. \quad (4)$$

With the Gelbach decomposition, we decompose the difference between the conditional wage premium estimated in Eq. 2 and the zero premium in Eq. 4 into contributions of a worker fixed effect and a firm fixed effect. By far, the largest contribution to the explanation is the firm fixed effect (column (4)), contributing with more than 60%. The relatively modest contribution of the individual fixed effect is in line with often modest effects of increased scrutiny of unobserved differences among individuals.[28] In particular, we find, for the whole sample, that only 0.4 points out of the 1.7 overall vocational gap are immune to the allocation of individuals into firms. In other words, this decomposition shows that the conditional vocational wage gap would fall by 1.3 percentage points if workers of different educational tracks were randomly distributed across firms.

As Fig. 4 and Table 3 (panel B) show, both worker fixed effect (WFE) and firm fixed effect (FFE) contribute towards closing the wage gap. The change over time in the FFE is the larger of the two, the WFE has a somewhat more outspoken U shaped pattern.[29]

By construction, WFE and FFE are constant over the interval of observation. If these effects are to play a role in understanding the change in wage differentials, there must be a change in allocation of workers to firms. We observe workers during the interval 1994–2014, reaching back to workers born in 1951 and entering the labour market in 1979. Over the past half century, education and the sectoral composition of the Portuguese economy have changed dramatically. Such dynamics manifest themselves quite markedly in changes in allocation, often even within fairly stable relative wages. To get an understanding of this process, we have used the worker and firm fixed effects estimated in Eq. 4. We have defined low-/high-ability workers by their worker fixed effect below or above the median worker fixed effect and low-/high-paying firms by their firm fixed effect below or above the median firm fixed effect.

[28] Hanushek et al. (2017) study the differential effect of vocational versus general education on employment across the lifecycle in 18 countries. They conclude "that individuals with higher literacy scores and more favorable family backgrounds (as measured by mother's education) are indeed more likely to select into general types of education. Importantly, however, this selection does not significantly vary with age. Thus,to the extent that this pattern is informative for the variation in selection on unobservables across cohorts, there is little indication that cohort-specific selection into education types is a major concern for our analysis." (o.c., p 64). Brunello and Rocco (2017a) use the inverse probability weighted regression adjusted (IPWRA) method to estimate average treatment effects on the effect of vocational educational on skills and competences, using the PIAAC survey as in Hanushek et al. (2015). The method guarantees that potential treatments are as good as randomly assigned to individual, under the strong assumption that the individual traits that have determined the choice of initial education are adequately captured by observed pre-determined variables. The qualitative effects on estimated returns to vocational education are negligible. Brunello and Rocco (2017b) report that differences in employment between vocational and general education estimated with AIPW are always similar to those estimated with OLS; AIPW is a GMM to deal with treatment effects in non-random trials (o.c., footnote 26). Golsteyn and Stenberg (2017) studying earnings differentials between general and vocational education in Sweden, note (p 192): "The added measures of skills and personality traits, observed ex post, cannot explain the short-term differences and can only partly explain the long-term differences".

[29] We also applied the Gelbach decomposition to the unconditional vocational wage premium, to check if controlling for individual characteristics makes any difference. It does not, the conclusions are not affected.

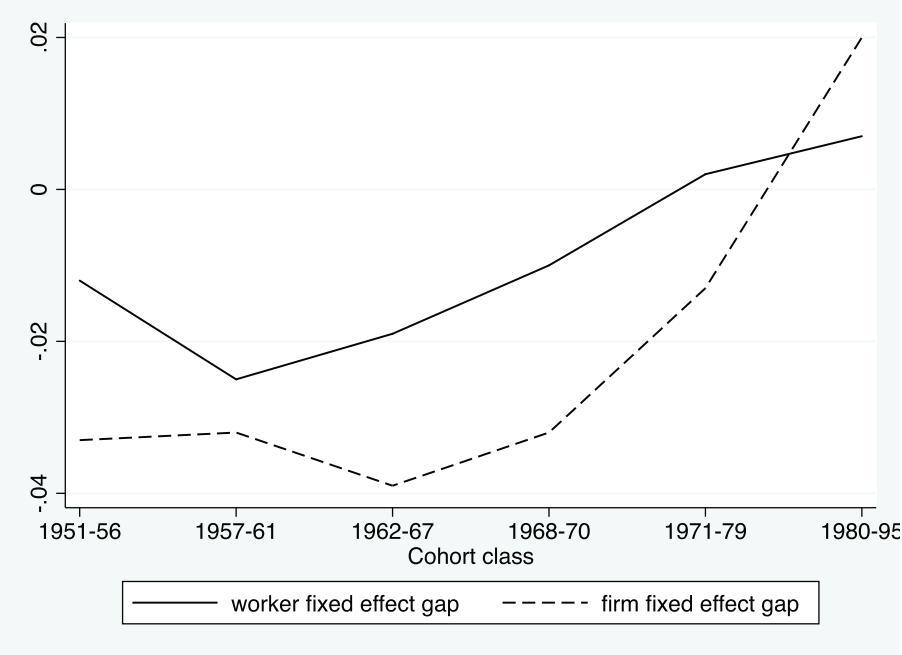

Fig. 4 Worker and firm fixed effect—vocational gap—by cohort class. Notes: This figure reports the vocational gap for the worker fixed effect and the firm fixed effect by the six cohort class. The worker and firm fixed effects are estimated in Eq. 4

Our key finding from studying this process is a decline in assortative matching among workers and firms in a way that benefitted vocational educated workers.

Matrices of assignment shares, separately for vocational and general graduates, are given in the Table 6 in appendix. Developments are visualised in Figs. 5 and 6. Figure 5 shows that the share of general graduates in high paying firms is quite stable across cohorts, while the share for vocational graduates exhibits a marked U-shape: a decline for cohorts of the mid-sixties and more than recovery for the later cohorts. The matrices in the online appendix in Hartog et al. (2021) show the demise of assortative matching: the incidence of low-low declines strongly, after initial increase, the incidence of high-high declines for general graduates and recovers after a decline for vocational graduates. Patterns clearly differ between low ability workers and high ability workers. Among low ability workers, developments are similar for general and vocational, but more pronounced for vocational: an increase in high wage firms, a decline in low wage firms. Among high-ability workers, developments differ: almost stable for vocational, increase in low wage firms, decrease in high wage firms for general. Figure 6 summarises the developments. Both trends are beneficial for vocational: stronger upward among low ability, stable rather than downward among the high ability. In all these developments, the U-shape pattern that we observed for the vocational wage gap is also visible in the dynamics of the assignment structure. The suggestion is emerging that initially, vocational education lost ground, but later, it was

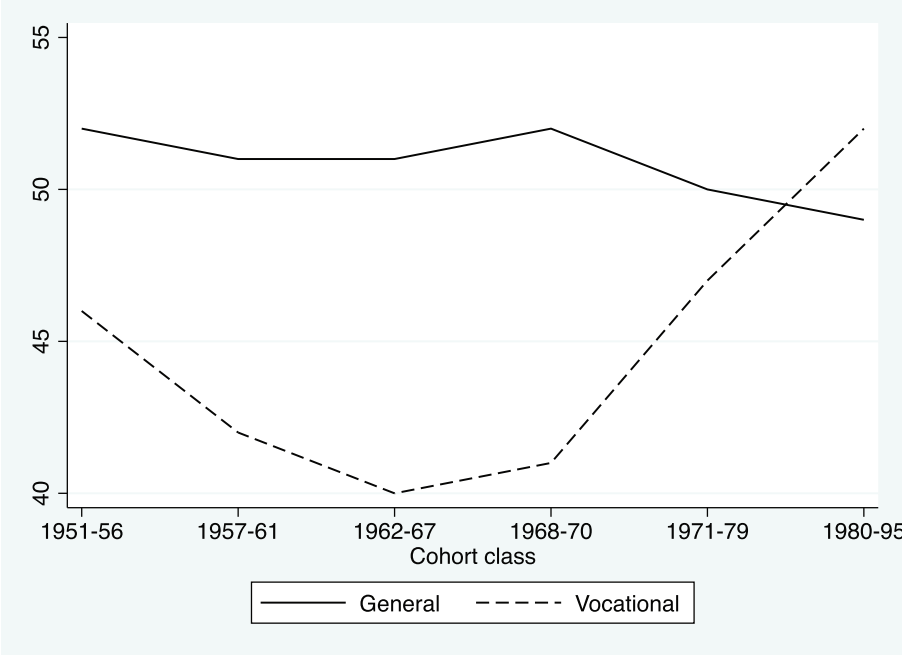

Fig. 5 Percentage of workers in general and vocational in high-paying firms—by cohort class. Notes: This figure reports the share of workers in high paying firms by the six cohort class. High paying firms: firms above median firms fixed effects. In other words, firm fixed effects above percentile 50

successful in preparing graduates for the new economic structure, where manufacture was replaced by services.

We have also checked the dynamics of assortative matching across subgroups: 4 industrial sectors, 5 regions and 3 size classes of the firm and 9 occupational categories of the worker (Tables OA15, OA16, OA17, and OA18 in online appendix in Hartog et al. 2021). The changes in the nature of matching that we observe at the aggregate level are not identically visible in decompositions of subgroups, implying that the change in allocation across low-wage and high-wage firms that benefitted vocational graduates must be seen as a complex process throughout the economy, not as a simple shift from one sector to another.

To sum up, our conclusion has two components. At the aggregate level, the change in the vocational wage gap between cohorts can be related to changes in the structure of matching between low-/high-ability workers and low-/high-wage firms that hurt general graduates. For low-ability workers, the dynamics are similar for vocational and general graduates, among high-ability workers, general graduates matching with low wage firms increases, matching with high-wage firms decreases, while the pattern for vocational graduates is relatively stable. But the rather clean aggregate result is not the outcome of homogenous processes within or across segments of the economy: the aggregate outcome results from complex underlying developments.

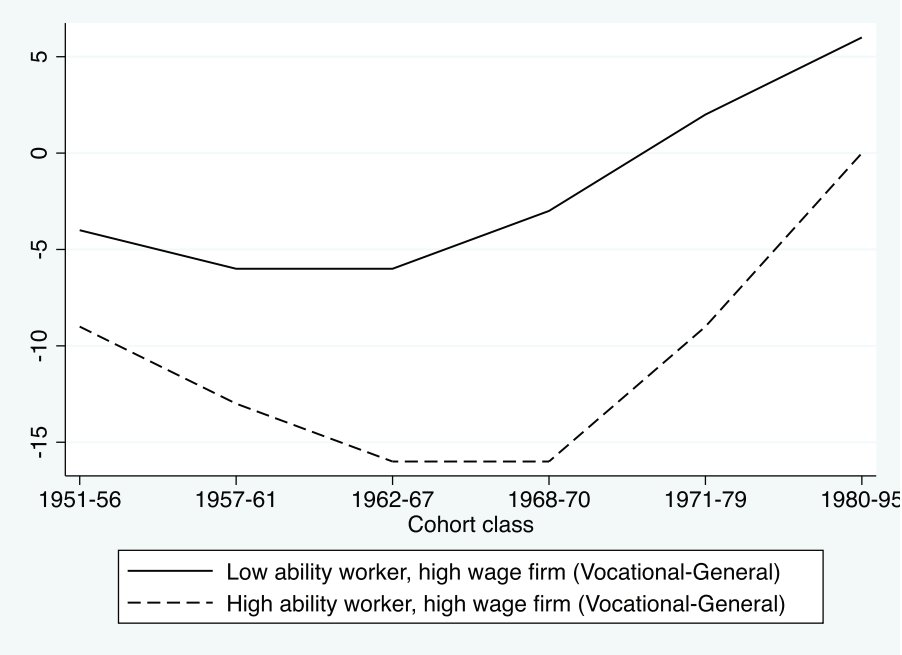

Fig. 6 Gap in the share of low-/high-ability workers in high-paying firms between general and vocational workers—by cohort class. Notes: This figures report the vocational gap in the share of low/high workers in high-paying firms by the six cohort classes. Low-ability workers: individuals below median worker fixed effects. In other words, worker fixed effects below percentile 50. High-wage workers: individuals above median worker fixed effects. In other words, worker fixed effects above percentile 50. High-paying firms: firms above median firm fixed effects. In other words, firm fixed effects above percentile 50

7 Interpretation and conclusion

We set out to measure and interpret the wage differential among graduates from vocational and general secondary education in Portugal. As the labour force contains workers who have been educated in different institutional settings, distinction by birth cohorts is imperative. The data do not allow us to observe a complete lifecycle of wages for all cohorts. Only for the youngest cohort, observed until age 33, vocational wages are higher than general wages. For the other five cohorts that we distinguish, vocational wages are always below general wages. The segments that we do observe all point to a weakly U-shaped wage gap between vocational and general education (the downturn is statistically significant, the upturn is not). These results are at variance with the human capital prediction that initially, vocational wages will be higher than general wages, while with advancing labour market experience, general wages will come to surpass vocational wages. We should reiterate that this conclusion is necessarily based on incomplete observation of cohort profiles: we do not know what happens in the non-observed age intervals. Convergence of the wages towards the end of working life might be due to selective exits from the labour force (more low-wage

vocational graduates exiting than low-wage general graduates), but the data that we have available do not support this.

The distinction by cohorts uncovered that the vocational wage gap over time followed a U-shaped pattern. Over the years 1994–2013, graduates from vocational secondary education on average have about 5% lower wage rates than graduates with general secondary education. When we split the sample by cohorts matching the institutional history of secondary education, as the traditional system before the Carnation Revolution of 1974, the fuzzy situation during that Revolution and the modern system thereafter, we find crude, unconditional wage gaps of 4, 10 and 5%.

Careful statistical and econometric analyses confirm this U-shaped pattern in the wage disadvantage for vocational secondary education: it first increases and then decreases, almost to extinction for the youngest cohort. The change in the vocational wage penalty cannot be attributed to a simple shift in the industrial or occupational composition of the economy. These shifts affected vocational and general graduates in much the same way, and the vocational wage penalty declined within each occupation. We relate the development to the change in worker-firm matching that in the end works out more favourably for vocational graduates than for general graduates. In particular, in the later cohorts low ability vocational graduates were more successful in finding employment at higher wage firms than low ability general graduates. Or, framed conversely, low ability general graduates lost their advantage over low ability vocational graduates in high wage firms.

The results indicate that vocational education, at the secondary level, initially lost ground relative to general education, but later more than made up for that loss. There may be a relationship with two changes in the educational system that have made general and vocational education more similar. First, in the traditional system, the differentiation between general and vocational education covered 5 school years, in the modern system it covered only 3 years. Second, the curriculum of vocational education has changed. In the traditional system the share of the general component (Portuguese, Math, Physics and Foreign Language) ranges between 35 and 45% of total curriculum.[30] Duarte (2014) points to the significant difference between the technical and the general system in terms of curriculum and subjects. In particular, she emphasizes the low weight given by the technical curriculum to cognitive skills.[31] Compared to the traditional system, the modern system of vocational education has moved towards more weight for the general component. Currently, in the vocational program, practical training in a real work environment occupies around 15–20% of the total duration of courses.[32] Whereas in the traditional system, vocational education was mainly catering to blue-collar jobs, in the modern system vocational education caters to both blue and white collar jobs.

[30] Using information from *Circular L. 25, de 6 de Julho de 1972 and Circular Série A, Nº 13/73, de 16 de Agosto* available online in the *Agência Nacional para a Qualificação e o Ensino Profissional* (National Agency for Qualification and Professional Education) website (http://www.anqep.gov.pt/)

[31] "...the technical system was characterised by a strong practical component and a very short general component." (Duarte 2014)

[32] Using information available online in the *Agência Nacional para a Qualificação e o Ensino Profissional* (National Agency for Qualification and Professional Education) website (http://www.anqep.gov.pt/) and information from *Decreto-Lei nº. 139/2012*

The shift towards a larger component of general education can be interpreted as an increased emphasis on developing cognitive skills rather than manual and other skills. An increase in the relative return to cognitive skill has been established for several labour markets, due to changes in technology (Murnane and Levy 1995; Fouarge et al. 2017). As the Portuguese labour market may well be subject to the same changes in technology and wage structure, our results would fit in with this interpretation: increased weight for a skill that has increased in relative price. It would be an interesting topic for further research to look beyond the matching in terms of fixed effects and uncover the link between changes in the curricula and in allocation to firms by characteristics like innovations in technology, output and distribution.

In our analysis, we pointed to structural change in the labour market that hurt experienced vocational graduates rather than entering graduates. A coherent interpretation might thus be that the traditional vocational education lost relevance for the labour market when the economy was restructured after the 1980s, and that the reorganisation of vocational education, increasing the weight of building cognitive skills and preparing for new jobs in the service sector of the economy improved the relative position of vocational graduates in the high wage firms.[33] That would make the overhaul of vocational education at the secondary level a successful policy intervention. Apparently, vocational education has managed to respond adequately to the modernisation of the Portuguese economy that has taken place. Indeed, as our results indicate, reforms of the late 1980s catered properly to the demands of a new economic structure.[34] This interpretation of our results supports Portuguese literature, as noted by Oliveira (2015) (page 7): "In the literature, the creation of vocational schools is seen as the renaissance of vocational education in Portugal. Moreover, these schools played an essential role in launching job oriented streams as credible avenues for the completion of upper secondary education". It underlines a general conclusion that the value of vocational education depends on the extent to which that education matches the demand in the labour market, and that a changing structure of production also requires a change in the structure of vocational education. This is almost trivial, but certainly not without relevance. General education, by its very nature, has little direct connection to the labour market: it teaches broad skills, analytical, cognitive, social. Vocational skills are meant to be directly useful in the labour market. Hence, their relative value should be assessed by considering how well they match actual job requirements. The value of vocational education can therefore never be fully assessed by only considering timing and length of the vocational component.

Appendix

[33] In figure OA6 in online appendix in Hartog et al. (2021) we plot wage gap, vocational share of graduates and unemployment. The graph clearly illustrates our argument that developments are not driven by the supply side.

[34] Oliveira (2015) notes in her description of educational reforms the creation of 50 vocational schools and a new curriculum track structure as noted in our description above.

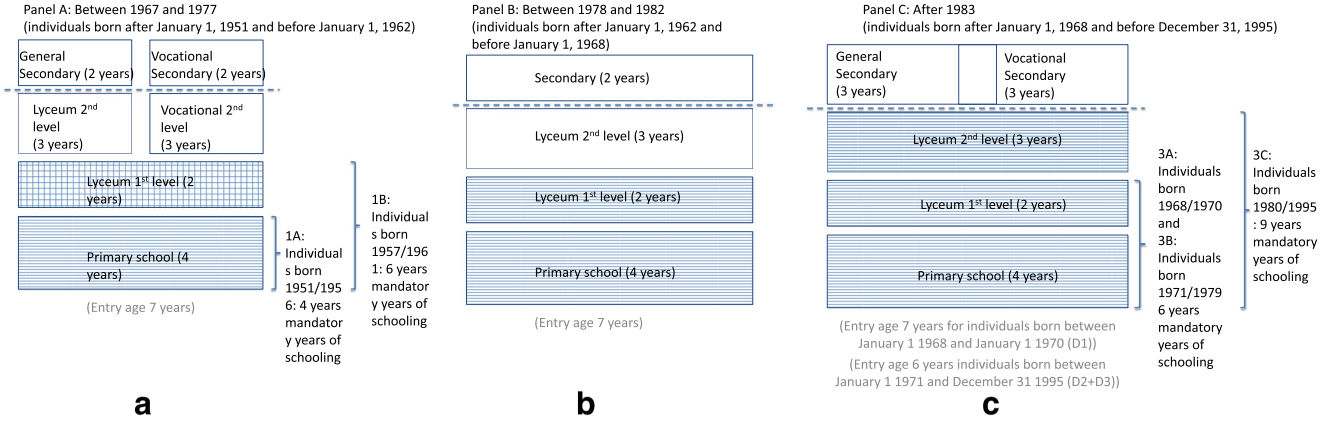

Fig. 7 Changes in the structure of the Portuguese education system. Notes: **a** Individuals born after January 1, 1951, and before December 31, 1961 (Secondary school entry year between 1967 and 1977). **b** Individuals born after January 1, 1962, and before December 31, 1967 (Secondary school entry year between 1978 and 1983). **c** Individuals born after January 1, 1968, and before December 31, 1995 (Secondary school entry year between 1984 and 2011)

Table 4 Changes in legislation regarding vocational educational system

Law/year	Description	First cohort affected	School entry age	Sec. sch. entry year affected by the policy	Sec. school entry age	Years sec. sch.	First year labour market	Min age 1994	Max age 1994	Min age 2013	Max age 2013		
DL 47480/67	Lower sec. with 3 years Upper sec. with 2 years	1951	7	1967	16	2	1969	33	43	47	62	Cohort 1 (1951/1961)	Cohort 1A (1951/1956) Cohort 1B (1957/1961)
Desp. Normativo 140-A/78	Begin of the unified sec. education	1962	7	1978	16	2	1980	27	32	46	51	Cohort 2 (1962/1967)	Cohort 2 (1962/1967)
Desp. Normativo 194-A/83	Dual certification	1968	7	1984	16	2	1986	24	26	43	45	Cohort 3 (1968/1995)	Cohort 3A (1968/1970)
Law 46/86	System with 3 cycles of 9 years of basic school	1971	6	1986	15	3	1989	18	23	18	42		Cohort 3B (1971/1979) Cohort 3C (1980/1995)

This table reports the changes in legislation regarding the Vocational Educational System and the cohorts affected by each change. Column (1) reports the Law and year it was implemented, column (2) describes briefly the change in the legislation, and column (3) the born year of the first cohort affected by the law. Columns (4) and (5) report the primary and secondary school entry age, respectively. Column (6) states the first possible year affected by the law and column (7) the curriculum years of the upper secondary school. Column (8) reports the first possible year of entry into the labour market. This means that all individuals entry potentially at age 18. Columns (9) to (12) display the minimum and maximum age of the individuals in 1994 and 2013 respectively. Finally, columns (13) and (14) describe the cohort class definition that arises from the changes in the legislation (See also Fig. 7 in Appendix)

In the cohort class definition, school entering year corresponds to the birth year. For example, in 1962 we assume that everyone born in 1962 went to school in the same academic year, viz 1969

We benefitted greatly from information provided by Luísa Canto e Castro Loura, General Director from DGEEC and Joaquim Santos and Nuno Cunha from DGEEC (Direção -Geral de Estatísticas da Educação e Ciência), and Fernando Jorge Teixeira—first director of the Massama high-school

Table 5 Key variables—definition

Outcome variables	
$Logwage_{ift}$	Reports the real hourly wages in log terms. The hourly wage is measured in euros and it is the ratio between total regular and non-regular payroll (base wage, regular payments, non-regular benefits, and overtime payments) in the reference month and total hours of work (normal and overtime). It was deflated using the Consumer Price Index (with base-year 1986).
Job separation probability	Reports the probability for a worker to separate between t and t + 1. A worker is considered to be separated from the firm if he changes employer or leaves the firm.
Explanatory variables	
$Male_i$	Dichotomous variable indicating whether the individual is a male.
Age_{it}	Reports the person's age in years.
$Tenure_{it}$	Reports the number of months an employee has worked for his firm.
$Logfirmsize_{ft}$	Reports the log of the number of individuals in the firm.
Education variables	
$VocationalHS_i$	Dichotomous variable indicating whether the individual highest completed degree is the upper secondary level in the Vocational education track. The employer reports the education of the worker following the instructions according to the Portuguese official classification of education.

Table 6 Percentage of workers in general and vocational by low-/high-ability workers and low-/high-paying firms conditional on worker ability

			General		Vocational		Diff (V-G)	
			Low firm	High firm	Low firm	High firm	Low firm	High firm
Cohort 1a	1951–1956	Low worker	57	43	61	39	4	
		High worker	40	60	49	51		−9
Cohort 1b	1957–1961	Low worker	60	40	66	34	6	
		High worker	37	63	50	50		−13
Cohort 2	1962–1967	Low worker	59	41	65	35	6	
		High worker	38	62	54	46		−15
Cohort 3a	1968–1970	Low worker	59	41	62	38	4	
		High worker	39	61	55	45		−16
Cohort 3b	1971–1979	Low worker	56	44	54	46	−2	
		High worker	43	57	52	48		−9
Cohort 3c	1980–1995	Low worker	50	50	44	56	−6	
		High worker	51	49	51	49		0

Low-ability workers: individuals below median worker fixed effects. In other words, worker fixed effects below percentile 50

High-ability workers: individuals above median worker fixed effects. In other words, worker fixed effects above percentile 50

Low-paying firms: firms below median firm fixed effects. In other words, firm fixed effects below percentile 50

High-paying firms: firms above median firm fixed effects. In other words, firm fixed effects above percentile 50

Acknowledgements We are grateful for the comments from five anonymous referees and the editor, Klaus F. Zimmermann, which have led to substantial improvements of the paper. We are also grateful for helpful comments and suggestions from Isabel Horta Correia, Luísa Canto e Castro Loura, Pedro Portugal, Pedro Telhado Pereira and Jorge Correia da Cunha. We have also benefited from comments made by participants at the IZA/SOLE Transatlantic Meeting of Labor Economists, EALE conference, China meeting of the Econometric Society, CVER conference, Portuguese Ministry of Education workshop and Bank of Portugal seminar. We are grateful to the Portuguese Ministry of Employment for access to the data and thank Lucena Vieira for outstanding data and computational assistance. The data used in this paper (Quadros de Pessoal—QP) builds on anonymised micro datasets that can be obtained by filling an accreditation form according to the protocol established by Statistics Portugal (INE). Request for getting access can be emailed to: info@ine.pt. The authors are willing to assist in this process (Pedro Raposo; pedro.raposo@ucp.pt). The data request forms are available in the website of INE. The usual disclaimer applies. An old working paper version of the article circulated under the title "Vocational high school graduate wage gap: the role of cognitive skills and firms".

Funding Joop Hartog would like to acknowledge the financial support of the Spanish Ministry of Education (grant number ECO2010-20829).

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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