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Vocational High School Graduate Wage Gap: The Role of Cognitive Skills and Firms

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Vocational High School Graduate Wage Gap: The Role of Cognitive Skills and Firms

Abstract

Comparing cohorts born between 1951 and 1994, we document and interpret changes in the wage differential among graduates from secondary education with a vocational and a general curriculum.. The wage gap initially increased and then decreased. We find that these changes cannot be attributed to simple compositional shifts in the economy, but instead relate to important changes in worker allocation to firms that are heterogeneous in wage policies: the demise of assortative matching between workers and firms that worked out favourably for vocational graduates.

JEL-Codes: J310, I260.

Keywords: returns to education, vocational wage gap.

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1 Introduction

School systems usually differentiate among vocational and general (or academic) tracks. Vocational education will prepare rather directly for specific occupations and train the students in the skills needed in these occupations. General education teaches more general, more basic abstract skills not directly related to tasks in particular occupations. Primary education is general education, tertiary education has both general and vocational components and covers specific vocational programs (such as in medical school) and general programs (liberal arts, philosophy) and all sorts of mixed programs. Secondary education covers specific vocational programs intended as qualification for direct labour market entry (auto mechanics, computer programming) and programs that prepare for advancing to tertiary education. But a substantial proportion of students enter the labour market with general secondary education as their final degree.

Debates on the relative value of vocational versus general education have a long history among educators, politicians, lobbying employers and labour leaders and opinion leaders. It's 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 focus on labour market effects in a narrow, well defined setting: wage differentials among graduates from secondary education in vocational programs and in general education who have not advanced to tertiary education. This is a relatively homogenous group, 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.

Carneiro et al. (2010) provide a comprehensive survey on the economics of vocational education literature and main results. In particular, they 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)). The role of a competitive market for apprentices is also highlighted as an important source to explain the presence of higher returns to vocational (e.g Heckman (2000)). As expected, this result does not hold universally. For example, Ryan (2002) shows that the returns to vocational education are positive but vary by qualification level in Australia. In the other scenario, in the presence of a less developed vocational system, returns are lower and a negative signal is provided to the vocational education (Woessmann (2008); Machin and Vignoles (2005)).

The relative benefits of vocational versus general education are often perceived to differ by career stage: (i) relative short-term benefits enhanced by vocational skills and (ii) relative long-term benefits enhanced by general skills. In other words, potential gains in youth by the vocational system facilitating the transition from school to work may be offset by less adaptability in the future. Empirical evidence is relatively limited. The main exceptions are the recent papers by Golsteyn and Stenberg (2017), Brunello and Rocco (2017), and Hanushek et al. (2017). In terms of earnings, Golsteyn and Stenberg (2017), show some evidence for Sweden supporting the trade-off result. For the UK, Brunello and Rocco (2017) find also evidence of

a trade-off, but only for the group with lower vocational education. In terms of employment, Hanushek et al. (2017) find evidence of the mentioned trade-off in countries with strong emphasis on apprenticeship programs.¹

Our paper contributes to this literature, comparing the wages trajectories over the life course associated with vocational and general education, for a country where the vocational system is not so well developed and most likely still in a transition period. We will describe the institutional changes that occurred in the Portuguese education system regarding the Vocational Education, distinguishing three periods: before, during and after the Carnation Revolution that started in 1974. Before the Revolution there was a traditional system with 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. We find that the change in the wage gap between vocational and general graduates coincides with these institutional changes. Changes in firm effects dominate over changes in worker effects, and in assignment of workers to firms we note a remarkable decline in assortative matching that worked out to the benefit of vocational graduates. The drastic change in the nature and role of secondary education and vocational secondary education in particular, seems connected to the change in the economic structure of Portugal. Our results point to the important role of the demand side in understanding changes in the vocational wage gap: changing patterns of worker allocation to firms that differ in the type of human capital they need and in the wage policies they apply.

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 describe our data and address selectivity issues in Section 3. In Section 4 perform detailed statistical and econometric analysis followed by interpretation of our findings. Section 5 concludes.

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 focussed 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

¹In a different context but also related, Malamud and Pop-Eleches (2010) examines the relative benefits of general education and vocational training during Romania's transition to a market economy. They analyzed an educational reform that shifted a large proportion of students from vocational training to general education. They conclude that selection was the main driver explaining the differences in labour market returns between graduates of vocational and general schools.

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 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.² Thus, human capital theory leads us to predict a wage profile with larger experience slope for the general graduate and a lower starting wage, ie 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.³ We only consider graduates who obtain no further degrees. Hence 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.⁴ Figure 1 and Table 1 provide the details.⁵

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

²The argument would be reinforced if general graduates' investment has a higher share of general rather than specific on-the-job training and by Becker (1993)'s classical argument would lead to a larger share of the cost passed on the employees.

³We have no information on repeating classes.

⁴In 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".

⁵We 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.

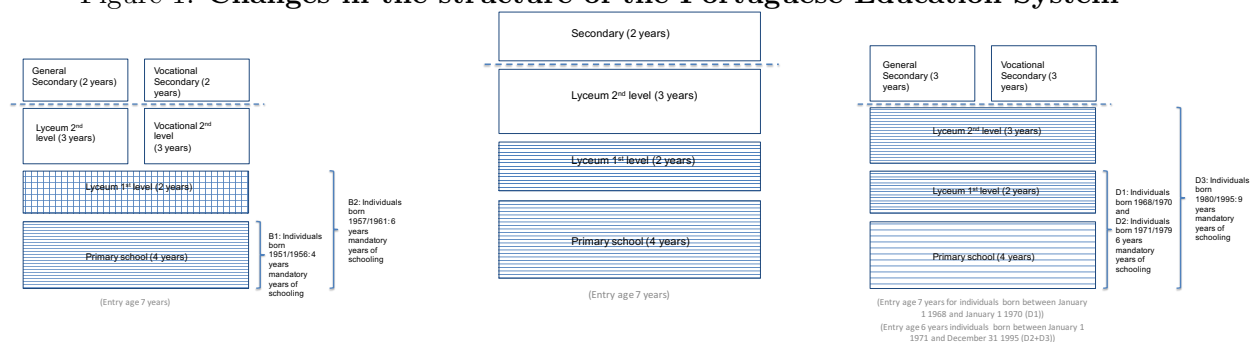
Table 1: Changes in Legislation regarding Vocational Educational System

Law/year	Description	First cohort affected	School entry age	Sec. sch. year affected by the policy	Second. school entry age	Curriculum years of sec. sch.	First possible year of entry into the labour market	First possible age of entry into the labour market	min age 1994	max age 1994	min age 2013	max age 2013	Cohort 1 (1951/1961)	Cohort 2 (1962/1967)	Cohort 3 (1968/1995)
DL 47480/67	Lower sec. reduced to 3 years Upper sec. level with 2 years	1951	7	1967	16	2	1969	18	33	43	47	62	C1A- 1951/1956 C1B- 1957/1961	C2 - 1962/1967	C3A - 1968/1970 C3C - 1980/1995
Desp. Normativo 140-A/78	Begins to start operating the unified sec. education.	1962	7	1978	16	2	1980	18	27	32	46	51			
Desp. Normativo 194-A/83	Dual certification	1968	7	1984	16	2	1986	18	24	26	43	45			
Law 46/86	System with 3 cycles of 9 years of basic school	1971	6	1986	15	3	1989	18	18	23	18	42			

Notes: 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) and (9) report respectively the first possible year and age of entry into the labour market. Finally, column (1) describes the cohort class definition that arises from the changes in the legislation and that we use in the paper.

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.

Figure 1: Changes in the structure of the Portuguese Education System



(a) Cohort class 1951-1961 (b) Cohort class 1962-1967 (c) Cohort class 1968-1995

Notes: Panel (a): Individuals born after January 1, 1951 and before December 31, 1961 (Secondary school entry year between 1967 and 1977).

Panel (b): Individuals born after January 1, 1962 and before December 31, 1967 (Secondary school entry year between 1978 and 1983).

Panel (c): Individuals born after January 1, 1968 and before December 31, 1995 (Secondary school entry year between 1984 and 2011).

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%.⁶ As several informers assured us, selection among general and vocational was not on ability but rather on family background (wealth, ambition for advancement through schooling). 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

⁶Source: "50 Anos de Estatísticas da Educação: Volume I", Figure 14 in page 9,- Gabinete de Estatística e Planeamento, Outubro de 2009.

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.

In the modern system, for birth cohorts 1968-1995, 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 formalized 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. In vocational education, there are technical craft-type courses, professional courses and specialized 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%.⁷

Thus, as Figure 1 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.

The Carnation Revolution of 1974 also affected the labour market. Just as the school system, the labour market was in some state of confusion and turmoil that lasted until the early 1980's 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, there have been changes in labour market institutions, but none aimed for differential impact on vocational and general graduates of secondary education.⁸ The composition of our student populations will have changed in terms of ability

⁷Source: "50 Anos de Estatísticas da Educação: Volume I", Figure 14 in page 9,- Gabinete de Estatística e Planeamento, Outubro de 2009.

⁸Legal minimum wages were introduced in 1974, and minimum youth wages, as a fraction of the general minimum, were gradually increased. Before the 1990's, 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

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 3.2..⁹

3 Data

3.1 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. 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 (October) 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.¹⁰ 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 government regulation, which helps to restrain measurement errors.¹¹ Civil servants are not covered by QP and we deleted the self-employed as the data on this category is too noisy. We use data from QP 1994-2013, restricted to birth year cohorts 1951-1995. Data definitions are given in Table A1 in appendix, and sample statistics in Table 2. (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.

As Table 2 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 A1 in

(2000).

⁹As 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.

¹⁰Hartog 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.

¹¹QP entails that the Ministry of Finance and labour unions have to confirm that the employers are complying with the law, especially in terms of wages and actual hours worked. The individual data are published in a public place in the premisses of the firm in order for the worker to confirm that the reported data are correct.

Table 2: Descriptive Statistics - General versus Vocational

				Hourly wage (log)	Male (%)	Age (in years)	Tenure (in years)	Firm size (log)
N								
Panel a: General versus 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: 3 Cohorts in detail								
cohort 1	1951-1961	General	766,290	0.95	0.56	46.23	13.19	2.92
		Vocational	173,604	0.91	0.63	47.46	14.24	2.93
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 3	1968-1995	General	3,594,772	0.47	0.48	30.13	4.76	2.14
		Vocational	660,342	0.42	0.53	29.47	4.64	2.13
			6,266,325					
Panel c: 6 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					

Notes: This table presents the summary statistics for individuals who have completed Upper Secondary School level in the general or the Vocational track. See Table 1 for the cohort class definition.

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.

3.2 Selectivity

We cannot take for granted that students choosing a vocational education or a general education are identical, not even if we only consider students who take no more than secondary education. The data from QP do not allow to attempt a correction for potential selectivity bias (we could not think of credible exclusion restrictions), but we can speculate a bit about selectivity in the past and consider some relevant data for the present situation.

For three recent school cohorts, we use data on students' performance in the period before entering upper secondary education. The data are from the Observatory of Student Pathways in Secondary Schools (OTES), in particular from the survey among students at the beginning of the secondary education. It is a representative survey, provided by the Ministry of Education, among students in tenth grade, i.e. the first year of our upper secondary level. We use data from all students in vocational education, but for students who have chosen general education we consider only students who have stated that they do not intend to continue education after graduating from upper secondary school. Among vocational graduates, barely anyone continues to advanced formal schooling.

To capture the potential role of selectivity we use the effect of later vocational education among students right upon entrance of the upper secondary education on several performance measures. Our specification is:

$$Y_{it} = \alpha_1 Vocational_{it} + \alpha_2 X_i + \epsilon_i, \quad (1)$$

Here, the dependent variable, (Y_{it}) , represents several outcomes just before bifurcation in the two tracks (math and reading final grades, retention in different stages, and age of completion of Second level Lyceum) for students, at the 10th grade in academic years (2007/08, 2010/11, and 2013/14). The variable is a vector which includes individual and family characteristics: gender, household composition, mothers' education and mother's employment status. represents the usual iid error component. OLS estimates for grades and Linear Probability Model estimates for retention rates from equation 1 are presented in Table A2 in Appendix.¹²

Students choosing the general track score barely better on reading and math. The differences are about 0.05, and with scores on a 1-5 point scale, this comes down to 1/20th of a grade point. Standard deviations of the scores are about 0.5, implying gaps smaller than 10 percent of a

¹²Table A3 in Appendix presents the summary statistics of the variables used in this section.

standard deviation. In 2007/2008, the difference in math scores is not significant. Retention rates are substantially lower for general graduates, with the gap somewhat higher in the third cycle, controls have negligible effect on these gaps. As a consequence, general graduates are several months younger when graduating from the third cycle. It's essential to compare vocational students with general students that have no intention to continue: the gap in reading and math would be 10 times as large, i.e. amount to half a point, if we include students that do continue to tertiary education. As almost all vocational students are retained at least once, we have also made a comparison with general students who are retained at least once; the outcome gap in that case is similar to what we report in Table A2 in Appendix. As the difference in math and reading scores between our general and vocational scores is modest, we may speculate that the differences in graduation and retention rates may have other causes than ability differences (e.g. interests and work life ambitions).

While we can document that in recent years there is a large gap in school performance (“ability”) between vocational students and general students that go on to advanced education but only a modest gap with general students that do not continue, we can only speculate on the situation in the past. In the past, before the great expansion of participation in formal education, the effect of family background on education was much larger. With type of education only to a limited extent determined by selection on ability, many talented working class children ended up in vocational education: vocational education was not the standard fall-back option for pupils who did not make it into general education. On that account it is therefore not a priori clear that ability levels among vocational graduates were below that of general graduates. On the other hand, general education has more often been the final level of education than nowadays, and thus may have retained many high ability students that under present circumstances would have continued to university. Without proper data it is hard to draw a firm conclusion. But at the very least we can state that it is not self-evident that in the past, ability selection created a large gap between vocational and general students. Intuitively, we would be more inclined to conclude that selectivity by ability has increased over time. In that case, the selectivity we have measured above for the present situation would be an upper bound.

4 The vocational wage premium

To analyse development over time of the wage gap between the vocational and the general educated, we will use graphic and regression analysis.

4.1 Is it year, age or cohort? Unconditional Results

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, for the youngest generation we do not observe the late career stages (see the details in Table 1). In our analysis we will focus on developments that have occurred between cohorts. Focus on cohorts is natural if one is interested in the effect of changes in the school system, and in fact, as we will argue below, the action is indeed in changes among cohorts.

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 A1 in Appendix). On average, both vocational and general wages increased rapidly over the 1990's, then rose more slowly and declined markedly after 2009 (See Figure A2 in Appendix); the distance between the two follows an inverted U shape: first increasing and then decreasing.

Figure 2 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).

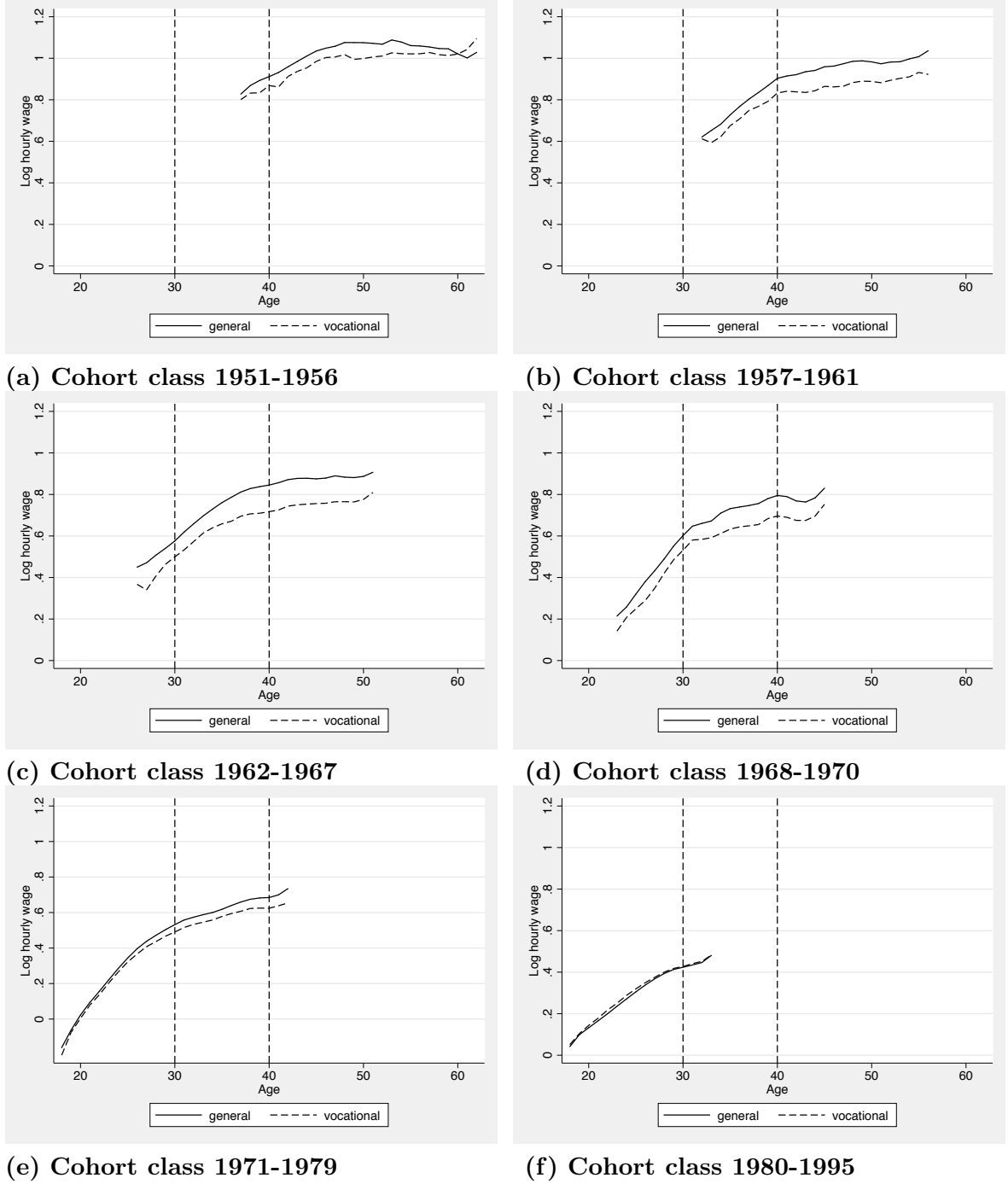
The distance between general and vocational wage profiles first increases and then decreases. In the youngest cohort class, the difference has essentially disappeared. At age 40, for the first 5 cohorts, the successive wage mark-ups for general education are 4.3, 7.1, 12.8, 9.9, and 6.0 percent, respectively (all statistically significant); at age 30, for the last 4 cohorts, the general education mark-up is 7.7 percent for cohort 1962-67, 7.1 for the cohort 1968-1970, 4.2 for cohort 1971-1979, and 0.4 for cohorts 1980-1995.¹³

Figure 3 gives the development of the gap for the specification with 3 and 6 cohort classes, respectively. The vocational wage gap is U-shaped over age within each cohort (or not at variance with it: the observation intervals are truncated), and the shift of the cohort profiles is also U-shaped over time.

We take the dynamics of the vocational wage gap as mostly a cohort effect. As noted above, year of observation, birth cohort year, and age are not independent, so we cannot fully disentangle the effects of each time dimension. But we can get an indication of what drives our results on the age profiles by birth cohort. 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 flat: 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. This, of course, is not interesting, but we can check which step has the largest impact. Controlling in this way 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 action is in the development of the vocational gap

¹³See Table OA2 in the online Appendix.

Figure 2: Log hourly wages - Vocational vs General education - By Cohort Groups



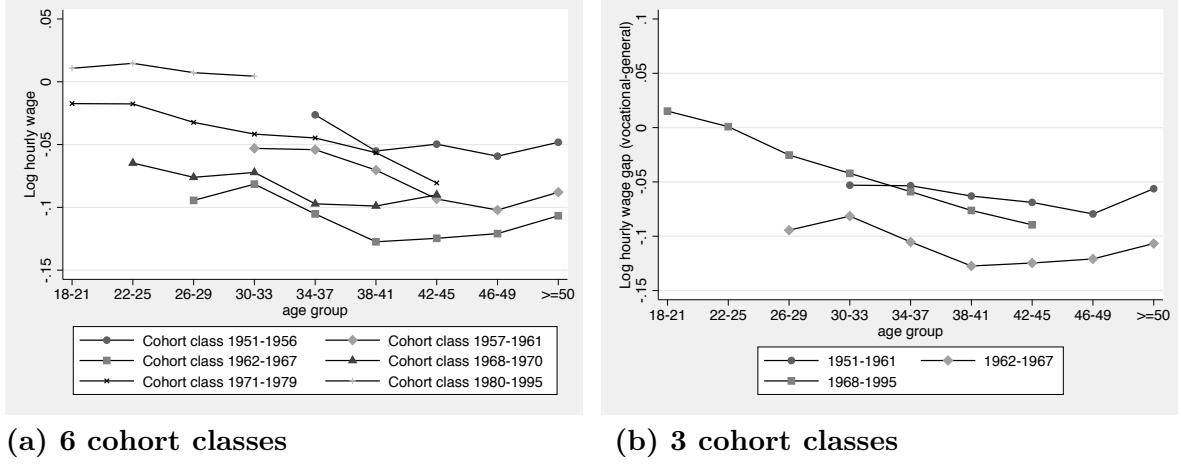
Notes: Log hourly wages in real terms for individuals with upper secondary educational level, age profiles for different birth cohorts.

among cohorts (see Figure A3 in Appendix).¹⁴

We conclude that wages are lower for vocational graduates than for general graduates. The profile of the vocational wage gap by age is asymmetrically U shaped. The gap is largest in

¹⁴The graphs are in the on-line Appendix.

Figure 3: **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. See Table 1 for cohort class definition.

mid-career, when graduates are 40 to 50 years old. Towards the end of working life the gap shrinks, but it will remain negative and larger in absolute value than at the start of the career. Between 1994 and 2013 the age profiles of the wage gap first slide down and then upwards: the gap is largest for the cohort from the fuzzy period, born 1962-1967. For the youngest cohort class, in some age classes wages are higher for vocational than for general graduates. It's primarily the development among cohorts that we seek to explain: a vocational wage gap that first increases and then decreases, almost to extinction for the youngest cohort. But we will also briefly consider the wage gap within cohort: largest in mid-career.

4.2 First conditional results

We start from the specification :

$$\text{Logwage}_{ift} = \eta_1 \text{Vocational}_i + \eta_2 \text{male}_i + \beta_1 \text{age}_{it} + \beta_2 \text{age}_{it}^2 + \beta_3 \text{tenure}_{it} + \beta_4 \text{tenure}_{it}^2 + \gamma \log \text{firm size}_{ft} + \phi_t + \theta_f + \epsilon_{ift}, \quad (2)$$

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 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 represents 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 of the vocational wage gap in equation 2 are presented in Table 3.¹⁵

¹⁵Tables A4, A5, and A6 in Appendix provide the coefficient estimates of the other covariates in equation 2, respectively for the whole sample, six, and three cohort classes.

Table 3: Vocational wage gap

VARIABLES	(1)	(2)	(3)	(4)	(5)
Panel a - Whole Sample					
VocationalHS	-0.0550*** (0.000627)	-0.0583*** (0.000627)	-0.0588*** (0.000524)	-0.0174*** (0.000497)	0.0119*** (0.000450)
Panel b - Six Cohort Classes					
cohort 1a * VocationalHS	-0.0463*** (0.00211)	-0.0572*** (0.00207)	-0.0868*** (0.00191)	-0.0454*** (0.00180)	0.0154*** (0.00144)
cohort 1b * VocationalHS	-0.0736*** (0.00184)	-0.0886*** (0.00180)	-0.100*** (0.00166)	-0.0571*** (0.00157)	0.00385*** (0.00127)
cohort 2 * VocationalHS	-0.0986*** (0.00161)	-0.115*** (0.00157)	-0.107*** (0.00145)	-0.0576*** (0.00137)	0.0126*** (0.00114)
cohort 3a * VocationalHS	-0.0731*** (0.00198)	-0.0877*** (0.00193)	-0.0909*** (0.00178)	-0.0420*** (0.00168)	0.0174*** (0.00138)
cohort 3b * VocationalHS	-0.0325*** (0.000970)	-0.0407*** (0.000950)	-0.0524*** (0.000875)	-0.0115*** (0.000828)	0.0139*** (0.000705)
cohort 3c * VocationalHS	0.00270** (0.00117)	0.00174 (0.00115)	-0.0126*** (0.00106)	0.0269*** (0.000999)	0.00642*** (0.000831)
Panel c - Three Cohort Classes					
cohort 1 * VocationalHS	-0.0494*** (0.00141)	-0.0581*** (0.00139)	-0.0915*** (0.00125)	-0.0509*** (0.00118)	0.00967*** (0.000974)
cohort 2 * VocationalHS	-0.0986*** (0.00164)	-0.110*** (0.00162)	-0.107*** (0.00145)	-0.0577*** (0.00137)	0.0123*** (0.00113)
cohort 3 * VocationalHS	-0.0498*** (0.000710)	-0.0588*** (0.000702)	-0.0426*** (0.000631)	-0.00141** (0.000598)	0.0119*** (0.000526)

Notes:

The table reports the vocational wage gap defined in equation (2). 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 and c we provide the results by 6 and 3 cohort classes, respectively. Robust standard errors in parentheses

* Significant at 10%; ** significant at 5%; *** significant at 1%.

The crude wage gap is some 6% negative and not sensitive to including year effects, age, tenure and gender.¹⁶ Bringing in firm characteristics has substantial effect. Adding log firm size reduces the gap to almost -2%, adding firm fixed effects turns it into a gap of +1.2%. Figure 4 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.

To understand what may be behind these results, we turn to the composition of the labour force by occupation and industry.¹⁷ 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. In Table A7 in Appendix, we present the shift in occupational distributions between the traditional and the modern cohort. 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 vocational graduates in career opportunities.¹⁸ The results in the lower panel of the table, exposing 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.

In Table A8 in Appendix, we estimate the vocational wage gap within occupations, by cohort, in 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). Two results are striking: the magnitudes of the vocational wage gap have declined dramatically, and differences among occupations have decreased immensely. In the oldest cohort, Skilled Agricultural workers had a vocational premium of 14%,¹⁹ Managers had a penalty of 6%, a difference of 20 percentage points, while in the youngest cohort, the range declined to just over 5 percentage points (from -2.9 to +2.4%). Both within and between occupations, the vocational wage gap has drastically diminished.

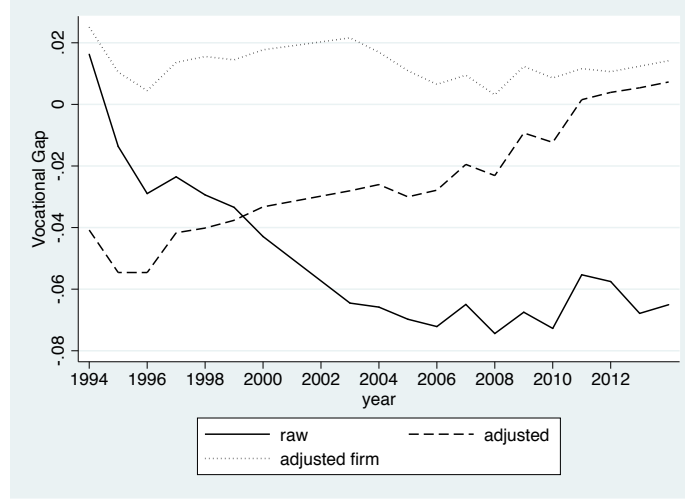
¹⁶Adding controls for industry, region or working part-time has no effect on the main results.

¹⁷Table OA1 in the online Appendix provides detailed description of each occupation according to the International Standard Classification of Occupations (ISCO).

¹⁸Ideally, 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.

¹⁹Skilled Agricultural workers have a very small share in our sample (rounded to 0 in Table A7 in Appendix). Ignoring this occupation, the range would be 14.9 among the oldest cohort.

Figure 4: 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:

$$\text{Logwage}_{ift} = \eta_{1t} \text{VocationalHD} + \psi X_{ift} + \epsilon_{ift}$$

The straight 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.

4.3 Understanding the dynamics in the cohort effect

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 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.²⁰ The exercise undertaken can be interpreted very intuitively bringing to light 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 4, column (4) 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.

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 base line specification 3, without the firm fixed effect:

²⁰Consider 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.

$$\text{Logwage}_{ift} = \eta_1 \text{Vocational}_i + \eta_2 \text{male}_i + \beta_1 \text{age}_{it} + \beta_2 \text{age}_{it}^2 + \beta_3 \text{tenure}_{it} + \beta_4 \text{tenure}_{it}^2 + \gamma \log \text{firm size}_{ft} + \phi_t + \epsilon_{ift}, \quad (3)$$

where the error term includes 3 components:

$$\epsilon_{ift} = \alpha_i + \theta_f + \mu_{ift}, \quad (4)$$

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.

Table 4: Gelbach Decomposition of the Vocational Wage Gap

		base (1)	full (2)	base-full (3)=(2)-(1)	Firm fixed effect (4)	Worker fixed effect (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
Panel c - Three Cohort Classes						
cohort 1	1951-1961	-0.051	0	-0.051	-0.033	-0.018
cohort 2	1962-1967	-0.058	0	-0.058	-0.039	-0.019
cohort 3	1968-1995	-0.001	0	-0.001	-0.004	0.002

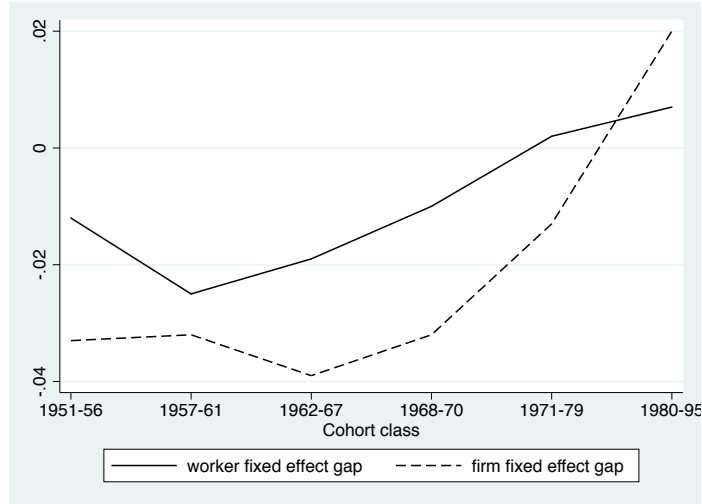
Notes: The conditional decomposition of the return to education is based on Gelbach (2016). Column (1) reports the coefficient of the benchmark result on returns to vocational education. Column (2) reports the coefficient of the full specification after including worker and firm fixed effects, which 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 and c we provide the results by 6 and 3 cohort classes, respectively.

By ignoring the worker and firm fixed effects in equation (3), 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:

$$\text{Logwage}_{ift} = \beta_1 \text{age}_{it} + \beta_2 \text{age}_{it}^2 + \beta_3 \text{tenure}_{it} + \beta_4 \text{tenure}_{it}^2 + \gamma \log \text{firm size}_{ft} + \alpha_i + \phi_t + \theta_f + \mu_{ift}, \quad (5)$$

With the Gelbach decomposition, we decompose the difference between the conditional wage premium estimated in equation (3) and the zero premium in equation (5) 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 per cent. In particular, we find, for the whole sample, that only 0.4 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 Figure 5 and Table 4 (Panel B and C) 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.

Figure 5: **Worker and Firm Fixed Effect - Vocational Gap - by cohort class**



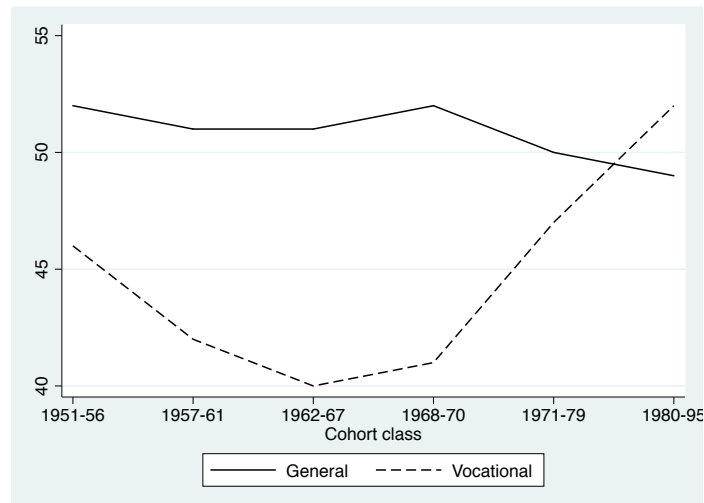
Notes: This figure reports the vocational gap for the worker fixed effect and the firm fixed effect by the six cohort class. The worker and firm fixed effects are estimated in equation (2).

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.

Dynamics of economic development manifest themselves in general most 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 equation 5. We have then 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. 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.

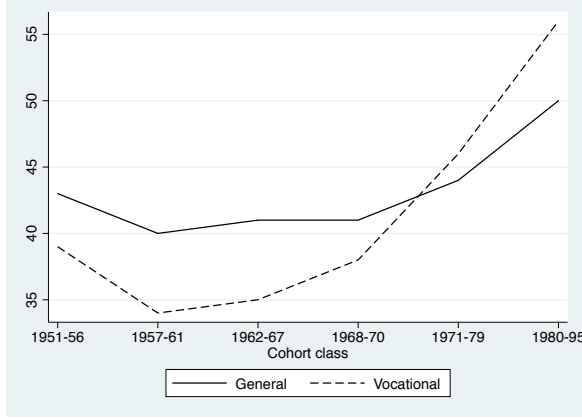
Matrices of assignment shares, separately for vocational and general graduates, are given in the Table A9 in Appendix. Developments are visualised in Figure 6 and Figure 7. Figure 6 shows that the share of general graduates in high paying firms is quite stable across cohorts, while the share for vocational graduates exhibits a marked U-shape: a decline for cohorts of the mid-sixties and more than recovery for the later cohorts. Figures 7c and 7d 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. The off-diagonal assignments in Figures 7a and 7b also show how vocational graduates improved their position relative to general graduates. High ability general graduates ended up more often in low paying firms, while there was not much change for vocational graduates, low ability vocational graduates were much more successful in obtaining jobs in high paying firms. In all these developments, the U-shape pattern that we observed for the vocational wage gap is visible in the dynamics of the assignment structure. The suggestion is emerging that initially, vocational education lost ground, but later, it was successful in preparing graduates for the new economic structure, replacing manufacturing by services.

Figure 6: Percentage of workers in General and Vocational in high paying firms - by cohort class

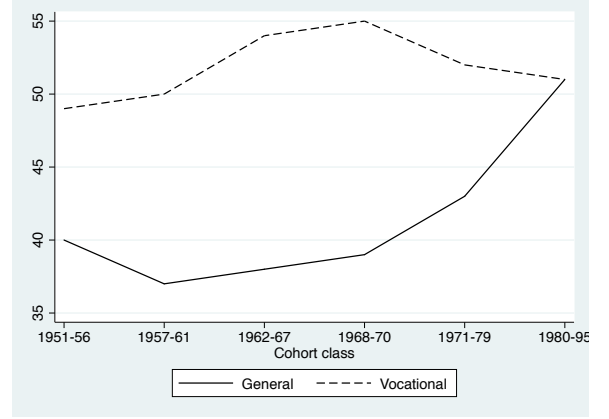


Notes: This figure reports the share of workers in high paying firms by the six cohort class. High paying firms: firms above median firms fixed effects. In other words, firm fixed effects above percentile 50.

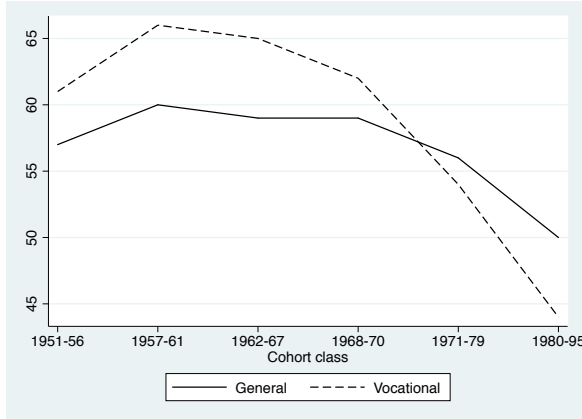
Figure 7: Percentage in General and Vocational of low/high ability workers in low/high paying firms - by cohort class



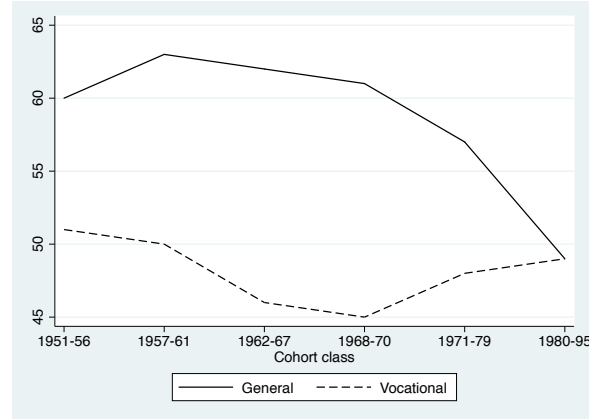
(a) Low ability worker, high wage firm



(b) High ability worker, low wage firm



(c) Low ability worker, low wage firm



(d) High ability worker, high wage firm

Notes: This figures report the share of low/high workers in low/high paying firms by the six cohort class.

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.

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

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

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 demise of assortative matching must be seen as a complex process throughout the economy, not as a simple shift from one sector to another. 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 A10, A11, A12 and A13 in Appendix). In the oldest cohort, the LL assignment (low ability worker, low pay firm), the composition by industry does not differ much among vocational and general graduates, while in the youngest of the six cohorts, Commerce and Transport is more important for general than for vocational. For the HH assignment (high ability worker, high pay firm), in the oldest cohort Finance and Services dominates strongly for general, while Manufacturing dominates for vocational. In the youngest cohort, the differences in industry share among general and vocational are smaller, with Commerce and Transport dominating for both. By regions, the most important change is the reduced concentration in the Lisbon area. The reduction was strongest for vocational, with about equal shares for general and vocation among the LL and the HH matches for the oldest cohort and lower shares for vocational for the youngest cohort. The incidence of matching types differed barely by firm size. LL assignments became more concentrated in large firms, HH assignments became less concentrated in large firms. By occupation, both for general and vocational graduates, in the oldest cohort LL matches mostly belonged to Clerical support workers, while among HH matches most workers were Technicians and associate professionals. Among the youngest cohort, LL matches were mostly Services and sales workers, while among the HH matches they were mostly Clerical support workers.

As noted, the changes in these decompositions are not easily summarised in some simple trends. The LL match for general graduates became more concentrated in Commerce and in Service workers, for vocational graduates concentration among Clerical workers was replaced by concentration among Service workers, and work in Commerce and Transport. The HH match remained concentrated in large firms, for general graduates dominance of Finance was replaced by dominance of Commerce, and concentration in work as technicians was replaced by work as Clerical workers; for vocational graduates Manufacturing lost its dominance and work as Technician retained highest frequency, but at smaller distance. These are shifts that do not evoke an easily recognisable simple pattern.

The absence of simple compositional changes also emerged from other analyses we have applied. What did emerge is that workers with secondary education have less frequently been assigned to high (secondary education) wage firms. In particular after 1970, this drop was substantially larger for General than for Vocational graduates. We do not find all these patterns within decompositions such as by industry, region, firm size and occupation.

Strong assortative matching (diagonal cell above 50 percent) is never observed within occupations, never observed for LL within industry, region or firm size, and only infrequently for HH: it occurs in Finance for General, regionally only in Lisbon, both for General and Vocational, by firm size only for Large, General and Vocational.

Within industries, the changes in matching (HH and LL) are quite modest within Manufacturing and Construction (only HH drops substantially for General towards 1967 within Manufacturing). Within Commerce, there is a remarkable increase in HH for both General and Vocational (with the former slightly stronger), while within Finance, there is a remarkable decrease in HH for General.

By region, we observe as more or less substantial movements an increase in LL for Vocational in North and a decline in Lisbon, and also an increase in HH for North and a decline in Lisbon for vocational, and a decline for HH General in Lisbon.

By firm size, it is hard to discover any regularity: no monotonicity, no U shapes. At most we can say that changes are largest after 1979; but the last cohort is also the longest in years covered.

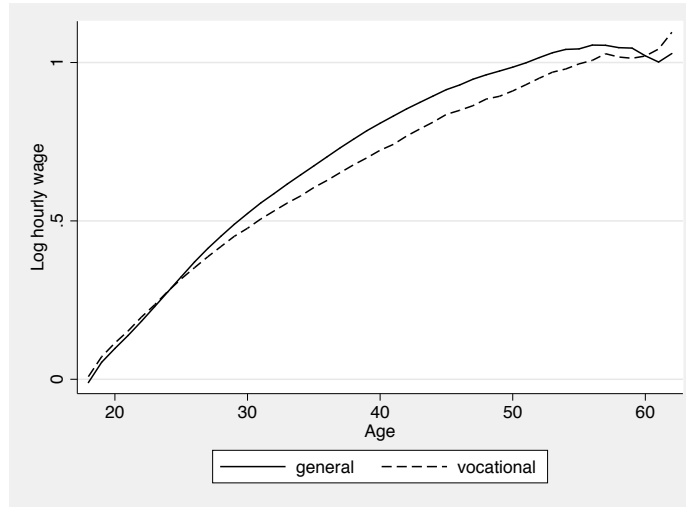
Within occupations there is not much of a common pattern of development. Most diagonal cell entries are quite low; only Technicians, Clerical Workers and Service Workers reach into substantial levels (above 30 say). Most action is in the HH frequencies; for LL stability dominates, apart from decline for Technicians and increase for Service Workers. The incidence of HH drops, and sometimes sharply, for Managers, Professionals and Technicians, and increased for Services, Plant and Craft Workers. The changes for General are mostly larger than for Vocational.

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, as the demise of assortative matching that benefit vocational graduates, or, stated conversely, 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 and matching with low wage firms increases, while the pattern for vocational graduates is relatively stable. But the aggregate result is not the outcome of homogenous processes within or across segments of the economy: the aggregate outcome results from complex underlying developments.

4.4 Why is the wage gap U-shaped over working life?

Figure 8 shows a gap between vocational and general wages that first increases and then decreases: the general wage overtakes the vocational wage around age 25, towards the end of working life the vocational wage catches up again. The profiles of Figure 2 show similar profiles by cohort. The widening of the gap in mid-career is visible in each of the graphs, overtaking by the vocational wage is only clearly visible for the oldest cohort. Faster wage growth for general educated, and overtaking, is in line with the human capital hypothesis that general education has to be complemented more by on-the-job training than the readily applicable vocational education: higher investment cost and higher pay-off explain the steeper profile for general graduates. The relative decline of the wage for general graduates at the end of working life might be explained from higher depreciation on their human capital, but that is hard to substantiate empirically. It might also be more selective withdraw from the labour market of

Figure 8: **Log hourly wages - Vocational vs General education - By age**



Notes: Log hourly wages in real terms for individuals with upper secondary educational level

vocational graduates, leaving increasing shares of the higher paid among the working population. This would relate to the common argument that vocational graduates are less equipped to deal with labour market dynamics. There is indeed some support for this hypothesis. We have estimated separation probabilities, that is the probability to leave our sample, in function of age, tenure etc. We can, unfortunately, not distinguish destinations: workers may leave the labour force, go work for the government or become self-employed. We find indeed that a higher wage reduces the exit rate, that this effect is slightly increasing for younger cohorts, and that among the oldest cohort the effect is stronger for vocational graduates.

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 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 will consider exit behaviour for the same sample as used above for analysis of wage differences, to check if we should worry about selective exit patterns that may bias our wage results.

We have run Linear Probability Models (LPM) to test if there are differences among the exit probabilities for general and vocational education. The 5 columns in Table 5 are similar to the 5 columns in Table 3. The first column is a LPM regression with vocational dummy only, the second adds year dummies, the third adds age (and square), tenure (and square) and gender, the fourth adds log firm size, the fifth adds firm fixed effects turns. Age and tenure have significant negative, non-linear effect, men have lower exit probability than women.²¹

²¹In the online appendix, Table OA3 we provide the results for the Probit Specification. In general, the marginal effects are very similar to the LPM specification results.

Table 5: Job Separation Probability - specification with logwages

	(1)	(2)	(3)	(4)	(5)
Panel A					
VocationalHS	-0.0134*** (0.00201)	-0.0116*** (0.00208)	-0.0106*** (0.00165)	-0.0125*** (0.00152)	-0.00821*** (0.00158)
VocationalHS*Logwage	0.00955** (0.00410)	0.00894** (0.00414)	0.00881** (0.00351)	0.00712** (0.00300)	0.00388** (0.00165)
Logwage	-0.0929*** (0.00365)	-0.0926*** (0.00370)	-0.0580*** (0.00349)	-0.0491*** (0.00259)	-0.0245*** (0.00187)
Observations	5,565,672	5,565,672	5,565,672	5,565,672	5,565,672
R-squared	0.017	0.019	0.031	0.032	0.128
Panel B - By cohort					
VocationalHS	-0.0330*** (0.00447)	-0.0374*** (0.00448)	-0.0129*** (0.00457)	-0.0118*** (0.00429)	-0.00602 (0.00510)
cohort 1b*VocationalHS	-0.00967** (0.00445)	-0.00840* (0.00443)	-0.00705 (0.00439)	-0.00832* (0.00437)	-0.0122*** (0.00456)
cohort 2*VocationalHS	0.00490 (0.00506)	0.00641 (0.00507)	0.00330 (0.00483)	0.00133 (0.00469)	-0.00311 (0.00504)
cohort 3a*VocationalHS	0.0153*** (0.00498)	0.0160*** (0.00500)	0.00533 (0.00493)	0.00259 (0.00485)	-0.00308 (0.00517)
cohort 3b*VocationalHS	0.0297*** (0.00470)	0.0331*** (0.00469)	0.0111** (0.00458)	0.00784* (0.00447)	0.00630 (0.00510)
cohort 3c*VocationalHS	0.0254*** (0.00484)	0.0409*** (0.00486)	-0.00522 (0.00513)	-0.00868* (0.00469)	-0.00877 (0.00549)
Logwage	-0.0773*** (0.00325)	-0.0803*** (0.00306)	-0.0421*** (0.00361)	-0.0324*** (0.00319)	9.37e-05 (0.00244)
VocationalHS*Logwage	0.0207*** (0.00528)	0.0248*** (0.00501)	0.00700 (0.00493)	0.00400 (0.00439)	0.00216 (0.00392)
cohort 1b*Logwage	-0.0190*** (0.00202)	-0.0178*** (0.00199)	-0.0123*** (0.00197)	-0.0129*** (0.00191)	-0.0158*** (0.00159)
cohort 2*Logwage	-0.0224*** (0.00303)	-0.0205*** (0.00309)	-0.0160*** (0.00267)	-0.0170*** (0.00264)	-0.0241*** (0.00229)
cohort 3a*Logwage	-0.0236*** (0.00315)	-0.0205*** (0.00330)	-0.0208*** (0.00302)	-0.0214*** (0.00305)	-0.0288*** (0.00262)
cohort 3b*Logwage	-0.0124*** (0.00338)	-0.00478 (0.00330)	-0.0185*** (0.00342)	-0.0194*** (0.00361)	-0.0298*** (0.00330)
cohort 3c*Logwage	0.0127** (0.00566)	0.0312*** (0.00511)	-0.0172*** (0.00453)	-0.0168*** (0.00467)	-0.0381*** (0.00465)
cohort 1b*VocationalHS*Logwage	0.00963** (0.00446)	0.00917** (0.00442)	0.00884** (0.00428)	0.00929** (0.00416)	0.00815** (0.00402)
cohort 2*VocationalHS*Logwage	0.00593 (0.00548)	0.00567 (0.00547)	0.00569 (0.00516)	0.00556 (0.00486)	0.00342 (0.00470)
cohort 3a*VocationalHS*Logwage	-0.00313 (0.00611)	-0.00223 (0.00613)	0.00523 (0.00588)	0.00529 (0.00560)	0.00439 (0.00519)
cohort 3b*VocationalHS*Logwage	-0.0290*** (0.00582)	-0.0307*** (0.00571)	-0.00984* (0.00533)	-0.00859* (0.00510)	-0.00921* (0.00483)
cohort 3c*VocationalHS*Logwage	-0.0301*** (0.00747)	-0.0486*** (0.00703)	0.000661 (0.00634)	0.00229 (0.00603)	0.00586 (0.00549)
Observations	5,565,672	5,565,672	5,565,672	5,565,672	5,565,672
R-squared	0.017	0.020	0.032	0.032	0.128

Notes:

The table reports marginal effects of the likelihood of job separation for an individual with a vocational versus an individual in the general track in Panel A, and the same effect by cohort in Panel B. In both cases it is analysed the heterogeneity by log wages. Column (1) do not include more controls, column (2) includes the year effects, and the specification in Column (3) includes age and tenure in quadratic form and the gender. Column (4) adds to the previous specification log size of the firm and column (5) includes also the firm fixed effects. Robust standard errors in parentheses

* Significant at 10%; ** significant at 5%; *** significant at 1%.

The vocational educated have lower exit probabilities, and exit probabilities are reduced for higher wage (Table 5). 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. In panel B of Table 5, with all controls included (column 5), exit probabilities barely differ among cohorts, and the effects of the wage are also very similar in magnitude. The wage effect is only significantly different from that in cohort 1a for cohorts 1b and 3b, and in those cohorts the magnitude of the difference is substantial relative to the wage effect for the general graduates. 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 (Table A14 in Appendix).²² 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 in Table 3 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 (Table A15 in appendix).

5 Conclusion

In our data from Quadros Pessoal covering the years 1994-2013, graduates from vocational secondary education have about 5% lower wage rates than graduates with general secondary education as their highest degree. 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. We explain this development from the demise of assortative matching that works out more favourably for vocational graduates than for general graduates. In particular, 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. We could not trace these developments to easily identifiable patterns across or within decompositions such as industry, firm size, region or occupation. 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 premium declined within

²²In the online Appendix, Table OA4 provides the same evidence of no differential sensitivity by wage distribution quartile by cohort.

each occupation.

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 per cent of total curriculum.²³ 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 per cent of the total duration of courses²⁴. 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.

In Duarte (2014) there is a clear reference to the significant difference between the technical and the general system in terms of curriculum and subjects. In particular, the book emphasizes the low weight given by the technical curriculum to cognitive skills.²⁵

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.

²³Using information from *Circular L. 25, de 6 de Julho de 1972 and Circular Série A, N 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/>)

²⁴Using 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 n. 139/2012*

²⁵“...the technical system was characterized by a strong practical component and a very short general component.” (Duarte (2014))

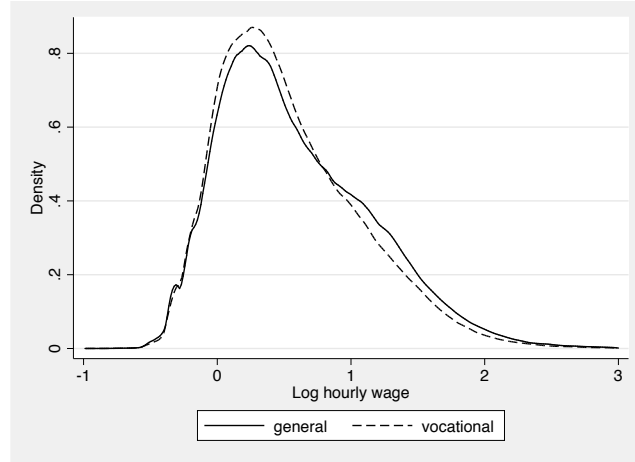
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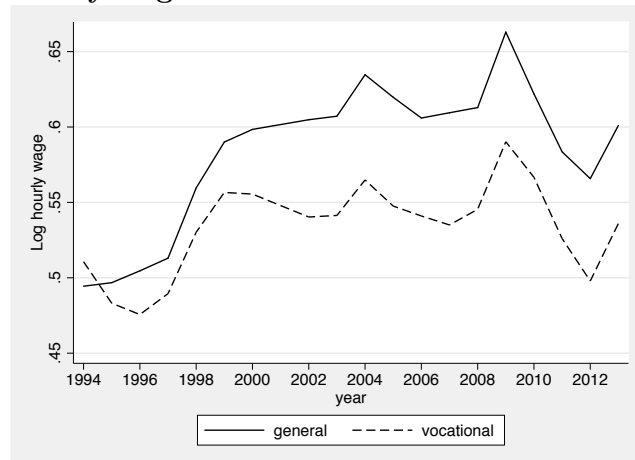
Appendix

Figure A1: **Log hourly wages - Vocational vs General education**



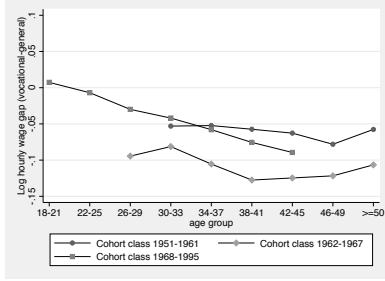
Notes: Unconditional empirical distributions of log hourly wages in real terms for individuals with upper secondary educational level.

Figure A2: **Log hourly wages - Vocational vs General education - By year**

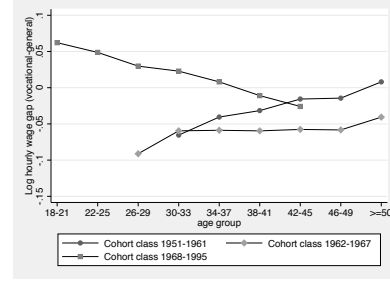


Notes: Log hourly wages in real terms for individuals with upper secondary educational level

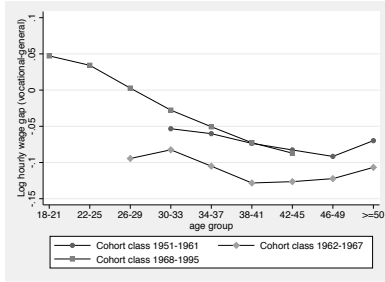
Figure A3: Log hourly wage gap (Vocational - General) - Decomposition by cohort, age and year effect



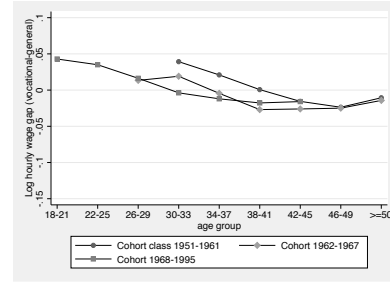
(a) no year effect



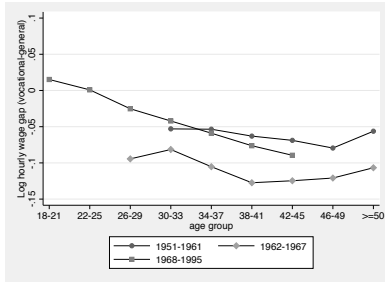
(b) no year effect interacted with vocational



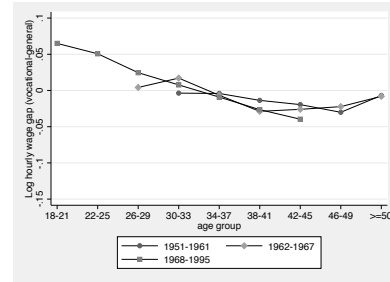
(c) no born year effect



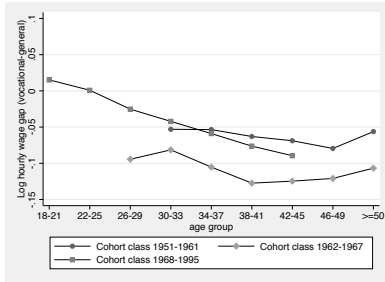
(d) no born year effect interacted with vocational



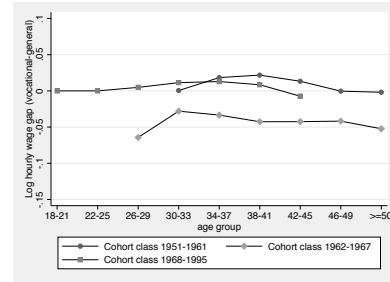
(e) no cohort class effect



(f) no cohort class effect interacted with vocational



(g) no age group effect



(h) no age group effect interacted with vocational

Notes: This figure reports the decomposition of the log wage vocational gap by cohort, age and year effect. Panel (a) represents the log wage after removing the year effects, i.e., the residual of the log wage regression on year dummies. For this residual, we calculate the average vocational gap for each age group and cohort classes. Panel (b) represents the log wage after removing the specific vocational/general year effects, i.e., the residual of the log wage regression on year dummies interacted with the vocational variable. Panel (c) represents the log wage after removing the birth year effects, i.e., the residual of the log wage regression on birth year dummies. Panel (d) represents the log wage after removing the specific vocational/general birth year effects, i.e., the residual of the log wage regression on birth year dummies interacted with the vocational variable. Panel (e) represents the log wage after removing the cohort class effects, i.e., the residual of the log wage regression on cohort class dummies. Panel (f) represents the log wage after removing the specific vocational/general cohort class effects, i.e., the residual of the log wage regression on cohort class dummies interacted with the vocational variable. Panel (g) represents the log wage after removing the age group class effects, i.e., the residual of the log wage regression on age group class dummies. Panel (h) represents the log wage after removing the specific vocational/general age group class effects, i.e., the residual of the log wage regression on age group class dummies interacted with the vocational variable.

Table A1: Key Variables - Definition

Explanatory variable	Description
Outcome Variables	
<i>Logwage_{ift}</i>	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).
<i>Job Separation Probability</i>	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	
<i>Male_i</i>	Dichotomous variable indicating whether the individual is a male.
<i>Age_{it}</i>	Reports the person's age in years.
<i>Tenure_{it}</i>	Reports the number of months an employee has worked for his firm.
<i>Logfirmsize_{ft}</i>	Reports the log of the number of individuals in the firm.
Education Variables	
<i>VocationalHS_i</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 A2: Selection - Students reporting no intention to proceed to higher education

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Reading	Math	Retention	Retention 1st cycle	Retention 2nd cycle	Retention 3rd cycle	Age at 3rd cycle graduation
2007/2008							
Panel A1 - Specification without controls							
Vocational	-0.0503*** (0.0131)	-0.00398 (0.0218)	0.228*** (0.0133)	0.0831*** (0.00880)	0.0524*** (0.00689)	0.148*** (0.0126)	0.406*** (0.0257)
Observations	7,825	7,796	8,032	8,058	8,058	8,058	7,799
R-squared	0.002	0.000	0.041	0.011	0.005	0.017	0.033
Panel B1 - Specification with controls							
Vocational	-0.0475*** (0.0135)	-0.00103 (0.0222)	0.229*** (0.0136)	0.0729*** (0.00864)	0.0520*** (0.00719)	0.155*** (0.0130)	0.405*** (0.0266)
Observations	7,126	7,102	7,291	7,312	7,312	7,312	7,095
R-squared	0.021	0.011	0.051	0.033	0.007	0.023	0.042
2010/2011							
Panel A2 - Specification without controls							
Vocational	-0.0547*** (0.0121)	-0.0564*** (0.0197)	0.183*** (0.0134)	0.0952*** (0.00905)	0.0483*** (0.00692)	0.0916*** (0.0113)	0.312*** (0.0248)
Observations	8,257	8,225	8,579	8,582	8,582	8,582	8,414
R-squared	0.003	0.001	0.027	0.012	0.005	0.008	0.023
Panel B2 - Specification with controls							
Vocational	-0.0561*** (0.0126)	-0.0545*** (0.0209)	0.179*** (0.0139)	0.0866*** (0.00900)	0.0469*** (0.00693)	0.0917*** (0.0118)	0.291*** (0.0256)
Observations	7,495	7,466	7,735	7,738	7,738	7,738	7,591
R-squared	0.026	0.010	0.043	0.033	0.012	0.020	0.042
2013/2014							
Panel A3 - Specification without controls							
Vocational	-0.0413*** (0.0134)	-0.0537** (0.0208)	0.218*** (0.0128)	0.0850*** (0.00742)	0.0327*** (0.00480)	0.146*** (0.0111)	0.313*** (0.0229)
Observations	9,484	9,458	9,824	9,826	9,826	9,826	9,558
R-squared	0.001	0.001	0.036	0.011	0.004	0.019	0.023
Panel B3 - Specification with controls							
Vocational	-0.0400*** (0.0136)	-0.0398* (0.0218)	0.212*** (0.0130)	0.0733*** (0.00751)	0.0284*** (0.00491)	0.144*** (0.0113)	0.283*** (0.0222)
Observations	8,621	8,592	8,886	8,887	8,887	8,887	8,663
R-squared	0.016	0.016	0.048	0.027	0.010	0.027	0.035

Notes: This table reports the estimated coefficient for the vocational dummy in equation (1), for students at the 10th grade in the indicated academic years. The data are from the Ministry of Education, Observatory of Student Pathways in Secondary Schools (OTES). For students in vocational education we use data from all students, for students in general education only students who have stated that they do not intend to continue education after graduating from upper secondary school. Controls in B panels relate to individual and family characteristics: Gender, household composition, mother's education, and mother's employment status. See Table A3 for the detailed summary statistics.

Robust standard errors in parentheses.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table A3: Summary Statistics - Selection - Students reporting no intention to proceed to higher education

	Reading	Math	Retention	Retention 1st cycle	Retention 2nd Cycle	Retention 3rd Cycle	Age at 3rd cycle graduation
2007/2008							
Total							
mean	3.068	2.689	0.617	0.144	0.105	0.410	15.338
st.dev	0.461	0.680	0.486	0.351	0.307	0.492	0.979
General							
mean	3.106	2.692	0.446	0.082	0.066	0.299	15.034
st.dev	0.473	0.704	0.486	0.274	0.249	0.458	0.865
Vocational							
mean	3.055	2.688	0.674	0.165	0.119	0.447	15.440
st.dev	0.457	0.671	0.486	0.371	0.323	0.497	0.994
2010/2011							
Total							
mean	3.057	2.805	0.551	0.181	0.101	0.287	15.171
st.dev	0.484	0.700	0.497	0.385	0.301	0.452	0.932
General							
mean	3.096	2.845	0.419	0.112	0.066	0.221	14.946
st.dev	0.505	0.716	0.494	0.315	0.248	0.415	0.830
Vocational							
mean	3.041	2.788	0.602	0.207	0.114	0.313	15.258
st.dev	0.475	0.693	0.489	0.405	0.318	0.464	0.954
2013/2014							
Total							
mean	3.037	2.705	0.527	0.147	0.052	0.309	15.103
st.dev	0.479	0.700	0.499	0.354	0.222	0.462	0.896
General							
mean	3.068	2.745	0.364	0.084	0.027	0.200	14.869
st.dev	0.499	0.722	0.481	0.277	0.163	0.400	0.800
Vocational							
mean	3.027	2.691	0.582	0.169	0.060	0.346	15.182
st.dev	0.471	0.692	0.493	0.374	0.238	0.476	0.912

Notes: This table reports the mean and the standard deviation regarding different outcomes for students at the 10th grade in the academic years of 2007/2008, 2010/2011, and 2013/2014 in the vocational track and in the general education. In column (1) and (2) it is evaluated the final grades of each student in the 3rd cycle (before entering upper secondary education) for Reading and Math, respectively. In column (3) we use an indicator reporting whether the student was retained at least once before 10th grade. In Columns (4) to (6) we use an indicator of retention for the 1st, 2nd and 3rd cycle, respectively. Finally, column (7) report the results for the age at which the student have completed the 3rd cycle. The data are from the Observatory of Student Pathways in Secondary Schools (OTES), in particular the survey to students at the beginning of the secondary education in Portugal. It is a representative survey, provided by the Ministry of Education, among students in tenth grade, i.e. the first year of our upper secondary level. We use data from all students in vocational education, but for students who have chosen general education we consider only students who have stated that they do not intend to continue education after graduating from upper secondary school.

Robust standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1

Table A4: Log of the total hourly wage regression - Whole Sample

VARIABLES	(1)	(2)	(3)	(4)	(5)
VocationalHS	-0.0550*** (0.000627)	-0.0583*** (0.000627)	-0.0588*** (0.000524)	-0.0174*** (0.000497)	0.0119*** (0.000450)
Age			0.0358*** (8.92e-05)	0.0367*** (8.42e-05)	0.0240*** (6.82e-05)
Age Squared			-0.000514*** (2.40e-06)	-0.000483*** (2.27e-06)	-0.000262*** (1.81e-06)
Tenure			0.0303*** (8.28e-05)	0.0232*** (7.86e-05)	0.0214*** (6.63e-05)
Tenure Squared			-0.000334*** (3.21e-06)	-0.000317*** (3.03e-06)	-0.000352*** (2.44e-06)
Male			0.276*** (0.000376)	0.245*** (0.000357)	0.170*** (0.000315)
Logfirmsize				0.0683*** (7.81e-05)	0.00489*** (0.000421)
Constant	0.594*** (0.000244)	0.503*** (0.00146)	-0.103*** (0.00136)	-0.402*** (0.00133)	0.0150*** (0.00219)
Observations	6,266,325	6,266,325	6,266,325	6,266,325	6,266,325
R-squared	0.001	0.006	0.307	0.382	0.680

Notes:

The table reports the vocational wage gap defined in equation (2) for the whole sample. 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. Robust standard errors in parentheses

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table A5: Log of the total hourly wage regression - six cohort classes

VARIABLES	(1)	(2)	(3)	(4)	(5)
cohort 1b	-0.118*** (0.00125)	-0.128*** (0.00122)	-0.0549*** (0.00124)	-0.0234*** (0.00117)	-0.0185*** (0.000917)
cohort 2	-0.244*** (0.00114)	-0.258*** (0.00111)	-0.0801*** (0.00146)	-0.0275*** (0.00138)	-0.0315*** (0.00109)
cohort 3a	-0.369*** (0.00121)	-0.390*** (0.00118)	-0.108*** (0.00176)	-0.0443*** (0.00166)	-0.0469*** (0.00132)
cohort 3b	-0.537*** (0.00107)	-0.594*** (0.00105)	-0.155*** (0.00206)	-0.0768*** (0.00195)	-0.0676*** (0.00155)
cohort 3c	-0.735*** (0.00113)	-0.854*** (0.00113)	-0.165*** (0.00269)	-0.0863*** (0.00254)	-0.0703*** (0.00201)
cohort 1a*Vocational HS	-0.0463*** (0.00211)	-0.0572*** (0.00207)	-0.0868*** (0.00191)	-0.0454*** (0.00180)	0.0154*** (0.00144)
cohort 1b*Vocational HS	-0.0736*** (0.00184)	-0.0886*** (0.00180)	-0.100*** (0.00166)	-0.0571*** (0.00157)	0.00385*** (0.00127)
cohort 2*Vocational HS	-0.0986*** (0.00161)	-0.115*** (0.00157)	-0.107*** (0.00145)	-0.0576*** (0.00137)	0.0126*** (0.00114)
cohort 3a*Vocational HS	-0.0731*** (0.00198)	-0.0877*** (0.00193)	-0.0909*** (0.00178)	-0.0420*** (0.00168)	0.0174*** (0.00138)
cohort 3b*Vocational HS	-0.0325*** (0.000970)	-0.0407*** (0.000950)	-0.0524*** (0.000875)	-0.0115*** (0.000828)	0.0139*** (0.000705)
cohort 3c*Vocational HS	0.00270** (0.00117)	0.00174 (0.00115)	-0.0126*** (0.00106)	0.0269*** (0.000999)	0.00642*** (0.000831)
Age			0.0347*** (0.000119)	0.0355*** (0.000112)	0.0230*** (8.95e-05)
Age Squared			-0.000606*** (2.74e-06)	-0.000513*** (2.59e-06)	-0.000298*** (2.07e-06)
Tenure			0.0301*** (8.28e-05)	0.0230*** (7.87e-05)	0.0213*** (6.64e-05)
Tenure Squared			-0.000329*** (3.22e-06)	-0.000311*** (3.04e-06)	-0.000348*** (2.44e-06)
Male			0.275*** (0.000376)	0.245*** (0.000357)	0.170*** (0.000315)
Logfirmsize				0.0681*** (7.82e-05)	0.00341*** (0.000422)
Constant	1.031*** (0.00100)	0.791*** (0.00161)	0.0144*** (0.00236)	-0.342*** (0.00227)	0.0747*** (0.00267)
Observations	6,266,325	6,266,325	6,266,325	6,266,325	6,266,325
R-squared	0.148	0.184	0.308	0.383	0.680

Notes:

The table reports the vocational wage gap defined in equation (2) by the six cohort classes definition. 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. Robust standard errors in parentheses

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table A6: Log of the total hourly wage regression - three cohort classes

VARIABLES	(1)	(2)	(3)	(4)	(5)
cohort 2	-0.167*** (0.000813)	-0.172*** (0.000804)	-0.0233*** (0.000843)	0.000409 (0.000796)	-0.00886*** (0.000635)
cohort 3	-0.488*** (0.000667)	-0.531*** (0.000670)	-0.0675*** (0.00104)	-0.0296*** (0.000981)	-0.0282*** (0.000791)
cohort 1*VocationalHS	-0.0494*** (0.00141)	-0.0581*** (0.00139)	-0.0915*** (0.00125)	-0.0509*** (0.00118)	0.00967*** (0.000974)
cohort 2*VocationalHS	-0.0986*** (0.00164)	-0.110*** (0.00162)	-0.107*** (0.00145)	-0.0577*** (0.00137)	0.0123*** (0.00113)
cohort 3*VocationalHS	-0.0498*** (0.000710)	-0.0588*** (0.000702)	-0.0426*** (0.000631)	-0.00141** (0.000598)	0.0119*** (0.000526)
Age			0.0354*** (9.15e-05)	0.0362*** (8.64e-05)	0.0237*** (6.98e-05)
Age Squared			-0.000563*** (2.62e-06)	-0.000494*** (2.48e-06)	-0.000283*** (1.97e-06)
Tenure			0.0301*** (8.28e-05)	0.0230*** (7.86e-05)	0.0213*** (6.64e-05)
Tenure Squared			-0.000329*** (3.22e-06)	-0.000312*** (3.04e-06)	-0.000349*** (2.44e-06)
Male			0.275*** (0.000376)	0.245*** (0.000357)	0.170*** (0.000315)
Logfirmsize				0.0682*** (7.82e-05)	0.00400*** (0.000422)
Constant	0.954*** (0.000606)	0.750*** (0.00144)	-0.0552*** (0.00155)	-0.381*** (0.00151)	0.0397*** (0.00230)
Observations	6,266,325	6,266,325	6,266,325	6,266,325	6,266,325
R-squared	0.116	0.136	0.308	0.383	0.680

Notes:

The table reports the vocational wage gap defined in equation 2 by the three cohort classes definition. 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.

Robust standard errors in parentheses

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table A7: Frequency distributions of workers by occupation and industry

	Cohort 1951-1961		Cohort 1968-1995	
	1994-1997		2010-2013	
	General	Vocational	General	Vocational
Occupation				
Managers	6-7	6-7	2	2
Professionals	3-4	3-4	2-3	3
Technicians	29-30	30-33	14-15	16-18
Clerical support	41-45	29-34	27-28	23-25
Service and sales	6-7	5-7	30	23-25
Skilled agriculture	0	0	0	0
Craft workers	4-5	9-10	6	10
Plant and machine operators	3-5	5-9	8-9	10-11
Elementary occupations	2-5	3-6	9	8-10
Industry				
Manufacturing	23-25	37-39	15-17	22-24
Construction	4	5	3-4	5-6
Commerce-Transport	35	31-32	42-44	37
Finance-Services	36-37	25-27	37-38	33-34

Note: This table reports the range of percentages of workers by occupation and industry by general and vocational education. The first two columns present results for the cohort class 1951-1961 over the years 1994-1997. The last two columns report the percentages for the cohort class 1968-1995 over the years 2010-2013.

Table A8: Log of the total hourly wage regression by Occupation and by Cohort

	(1)	(2)	(3)	(4)	(5)
Panel A - Regression cohort 1951-1961					
0 Not Classified × Vocational	-0.00938 (0.267)	-0.00938 (0.265)	-0.0648 (0.243)	-0.0524 (0.224)	-0.0396 (0.152)
1. Managers × Vocational	-0.162*** (0.00531)	-0.171*** (0.00527)	-0.186*** (0.00482)	-0.128*** (0.00444)	-0.0620*** (0.00405)
2. Professionals × Vocational	-0.182*** (0.00699)	-0.185*** (0.00694)	-0.190*** (0.00635)	-0.0842*** (0.00586)	0.000215 (0.00470)
3. Technicians and Associate Professionals × Vocational	-0.0915*** (0.00266)	-0.0954*** (0.00264)	-0.131*** (0.00242)	-0.0696*** (0.00224)	-0.0264*** (0.00184)
4. Clerical Support Workers × Vocational	-0.0795*** (0.00274)	-0.0869*** (0.00272)	-0.0958*** (0.00249)	-0.0172*** (0.00231)	0.0104*** (0.00201)
5. Services and Sales Workers × Vocational	0.0281*** (0.00503)	0.0220*** (0.00499)	-0.0200*** (0.00457)	0.0150*** (0.00421)	0.0540*** (0.00403)
6. Skilled Agric., forestry and fishery workers × Vocational	0.155*** (0.0461)	0.149*** (0.0457)	0.149*** (0.0418)	0.136*** (0.0386)	0.138*** (0.0340)
7. Craft and Related Trade Workers × Vocational	0.178*** (0.00525)	0.172*** (0.00520)	0.0774*** (0.00477)	0.0784*** (0.00439)	0.0655*** (0.00372)
8. Plant and Machine Operators and Assemblers × Vocational	0.156*** (0.00641)	0.157*** (0.00636)	0.0777*** (0.00582)	0.0958*** (0.00537)	0.0878*** (0.00431)
9. Elementary Occupations × Vocational	0.0211*** (0.00663)	0.0216*** (0.00657)	-0.0376*** (0.00601)	-0.0194*** (0.00555)	0.0225*** (0.00461)
Observations	933,732	933,732	933,732	933,732	933,732
R-squared	0.207	0.219	0.347	0.445	0.758
Panel B - Regression cohort 1962-1967					
0 Not Classified × Vocational	1.094 (0.763)	1.094 (0.749)	1.111 (0.693)	1.024 (0.637)	0.407 (0.438)
1. Managers × Vocational	-0.147*** (0.00693)	-0.159*** (0.00681)	-0.160*** (0.00631)	-0.113*** (0.00579)	-0.00782 (0.00552)
2. Professionals × Vocational	-0.130*** (0.00807)	-0.135*** (0.00792)	-0.110*** (0.00734)	-0.0401*** (0.00674)	0.0292*** (0.00544)
3. Technicians and Associate Professionals × Vocational	-0.140*** (0.00325)	-0.146*** (0.00319)	-0.124*** (0.00296)	-0.0487*** (0.00272)	0.00872*** (0.00236)
4. Clerical Support Workers × Vocational	-0.108*** (0.00303)	-0.123*** (0.00298)	-0.105*** (0.00276)	-0.0270*** (0.00254)	0.0113*** (0.00236)
5. Services and Sales Workers × Vocational	-0.0475*** (0.00455)	-0.0557*** (0.00447)	-0.0577*** (0.00414)	-0.0264*** (0.00380)	0.0525*** (0.00361)
6. Skilled Agric., forestry and fishery workers × Vocational	0.0620 (0.0462)	0.0425 (0.0454)	0.0650 (0.0420)	0.0488 (0.0386)	-0.0525 (0.0328)
7. Craft and Related Trade workers × Vocational	0.0210*** (0.00598)	0.00613 (0.00588)	0.000104 (0.00544)	0.0308*** (0.00500)	0.0380*** (0.00450)
8. Plant and Machine Operators and Assemblers × Vocational	-0.0304*** (0.00721)	-0.0409*** (0.00708)	-0.0484*** (0.00656)	-0.00158 (0.00602)	0.0243*** (0.00514)
9. Elementary Occupation × Vocational	-0.0165** (0.00689)	-0.0321*** (0.00677)	-0.0496*** (0.00627)	-0.0182*** (0.00576)	0.0219*** (0.00489)
Observations	1,064,573	1,064,573	1,064,573	1,064,573	1,064,573
R-squared	0.188	0.217	0.329	0.434	0.752
Panel C - Regression cohort 1968-1995					
1. Managers × Vocational	-0.0297*** (0.00421)	-0.0418*** (0.00415)	-0.0543*** (0.00378)	-0.0364*** (0.00353)	-0.0116*** (0.00310)
2. Professionals × Vocational	-0.139*** (0.00350)	-0.145*** (0.00345)	-0.115*** (0.00314)	-0.0621*** (0.00293)	-0.0297*** (0.00239)
3. Technicians and Associate Professional × Vocational	-0.128*** (0.00140)	-0.139*** (0.00138)	-0.106*** (0.00126)	-0.0666*** (0.00118)	-0.0298*** (0.000995)
4. Clerical Support workers × Vocational	-0.0981*** (0.00111)	-0.109*** (0.00109)	-0.0810*** (0.000993)	-0.0300*** (0.000931)	0.00447*** (0.000823)
5. Services and Sales Workers × Vocational	-0.0309*** (0.00135)	-0.0374*** (0.00133)	-0.0259*** (0.00121)	0.0100*** (0.00114)	0.0153*** (0.000988)
6. Skilled Agric., forestry and fishery workers × Vocational	-0.0481*** (0.0172)	-0.0537*** (0.0170)	-0.0334** (0.0155)	-0.0240* (0.0145)	-0.0192 (0.0124)
7. Craft and Related Trade Workers × Vocational	0.0400*** (0.00195)	0.0248*** (0.00192)	0.0298*** (0.00175)	0.0394*** (0.00164)	0.0247*** (0.00141)
8. Plant and Machine Operators and Assemblers × Vocational	-0.0138*** (0.00223)	-0.0249*** (0.00220)	0.00360* (0.00200)	0.0224*** (0.00187)	0.0172*** (0.00154)
9. Elementary Occupation × Vocational	-0.0258*** (0.00221)	-0.0390*** (0.00218)	-0.0189*** (0.00199)	0.00516*** (0.00186)	0.0125*** (0.00152)
Observations	4,239,940	4,239,940	4,239,940	4,239,940	4,239,940
R-squared	0.138	0.163	0.307	0.394	0.684

Notes: This table reports the vocational wage gap within occupations and by cohort class. In panel (A) the table displays the results for the cohort class 1951-1961, in panel (B) for the cohort class 1962-1967, and in Panel (c) the results for cohort class 1968-1995. 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.

See Table A2 in the Appendix for the detailed description of the occupations according to the International Standard Classification of Occupations (ISCO).

Table A9: 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
Panel a								
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
Panel b								
cohort 1	1951-1961	Low worker	61	39	66	34	4	
		High worker	39	61	49	51		-10
cohort 2	1962-1967	Low worker	59	41	65	35	6	
		High worker	38	62	54	46		-15
cohort 3	1968-1995	Low worker	56	44	53	47	-3	
		High worker	43	57	52	48		-9

Notes:

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 firms fixed effects. In other words, firm fixed effects below percentile 50.

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

Table A10: Percentage of workers in General and Vocational by low paying firms and high paying firms - By Industry

	Low paying firm		High paying firm	
	General	Vocational	General	Vocational
Cohort 1a - 1951-1956				
Industry	24	30	17	40
Construction	6	8	3	3
Commerce and transports	42	34	26	22
Finance and services	29	27	54	34
cohort 1b 1957-1961				
Industry	25	27	17	34
Construction	6	6	3	4
Commerce and transports	38	37	31	30
Finance and services	32	30	49	32
cohort 2 1962-1967				
Industry	23	23	17	23
Construction	5	6	3	5
Commerce and transports	39	39	36	37
Finance and services	32	32	44	34
cohort 3a 1968-1970				
Industry	21	23	18	23
Construction	5	7	4	6
Commerce and transports	41	38	37	36
Finance and services	33	31	42	35
cohort 3b 1971-1979				
Industry	18	21	20	24
Construction	5	7	5	7
Commerce and transports	44	39	41	37
Finance and services	34	33	35	32
cohort 3c 1980-1995				
Industry	15	20	19	27
Construction	4	7	5	8
Commerce and transports	47	38	46	37
Finance and services	35	34	29	29

Notes:

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

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

Table A11: Percentage of workers in General and Vocational by low paying firms and high paying firms - By Region

	Low paying firm		High paying firm	
	General	Vocational	General	Vocational
Cohort 1a - 1951-1956				
North	25	28	19	15
Centrum	10	12	3	6
Lisbon	56	50	72	69
Alentejo	6	7	3	5
Algarve	3	2	2	4
cohort 1b 1957-1961				
North	29	30	19	16
Centrum	13	14	4	7
Lisbon	48	46	70	67
Alentejo	7	7	4	5
Algarve	3	2	2	5
cohort 2 1962-1967				
North	30	32	19	18
Centrum	13	13	5	8
Lisbon	47	46	69	64
Alentejo	7	7	4	6
Algarve	3	3	3	4
cohort 3a 1968-1970				
North	30	32	18	21
Centrum	14	15	6	10
Lisbon	46	44	69	58
Alentejo	7	7	4	7
Algarve	3	3	3	4
cohort 3b 1971-1979				
North	30	33	19	24
Centrum	13	16	8	12
Lisbon	46	41	64	53
Alentejo	7	7	5	7
Algarve	4	3	4	3
cohort 3c 1980-1995				
North	32	38	24	31
Centrum	12	17	10	13
Lisbon	47	35	55	43
Alentejo	6	6	7	8
Algarve	3	4	4	5

Notes:

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

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

Table A12: Percentage of workers in General and Vocational by low paying firms and high paying firms - By Firm Size

	Low paying firm		High paying firm	
	General	Vocational	General	Vocational
Cohort 1a - 1951-1956				
Small	29	31	11	14
Medium	27	30	16	18
Large	44	39	73	68
cohort 1b 1957-1961				
Small	32	34	12	18
Medium	30	33	18	22
Large	38	33	70	60
cohort 2 1962-1967				
Small	34	38	15	26
Medium	28	30	20	28
Large	37	31	64	47
cohort 3a 1968-1970				
Small	37	39	18	29
Medium	27	30	21	27
Large	37	31	61	45
cohort 3b 1971-1979				
Small	37	41	21	30
Medium	24	27	24	28
Large	39	32	55	42
cohort 3c 1980-1995				
Small	32	39	23	26
Medium	22	26	25	28
Large	46	35	51	45

Notes:

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

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

Table A13: Percentage of workers in General and Vocational by low paying firms and high paying firms - By Occupation

	Low paying firm		High paying firm	
	General	Vocational	General	Vocational
Cohort 1a - 1951-1956				
Managers	10	10	7	7
Professionals	4	5	6	4
Technicians and Associate Professionals	24	28	37	41
Clerical Support Workers	32	24	40	28
Services and Sales Workers	12	10	3	3
Skilled Agricultural, Forestry and Fishery Workers	0	0	0	0
Craft and Related Trades Workers	7	11	3	9
Plant and Machine Operators and Assemblers	5	5	3	6
Elementary Occupations	7	7	2	3
cohort 1b 1957-1961				
Managers	7	9	5	6
Professionals	3	4	5	5
Technicians and Associate Professionals	23	23	35	36
Clerical Support Workers	34	28	42	31
Services and Sales Workers	16	15	3	4
Skilled Agricultural, Forestry and Fishery Workers	0	0	0	0
Craft and Related Trades Workers	6	10	3	8
Plant and Machine Operators and Assemblers	5	5	3	8
Elementary Occupations	7	7	2	3
cohort 2 1962-1967				
Managers	5	7	4	5
Professionals	3	3	5	6
Technicians and Associate Professionals	20	22	33	33
Clerical Support Workers	35	28	42	32
Services and Sales Workers	18	19	6	7
Skilled Agricultural, Forestry and Fishery Workers	0	0	0	0
Craft and Related Trades Workers	6	9	4	7
Plant and Machine Operators and Assemblers	4	5	5	6
Elementary Occupations	7	8	3	3
cohort 3a 1968-1970				
Managers	4	5	3	4
Professionals	3	3	4	5
Technicians and Associate Professionals	18	20	28	31
Clerical Support Workers	36	31	44	34
Services and Sales Workers	21	18	7	8
Skilled Agricultural, Forestry and Fishery Workers	0	0	0	0
Craft and Related Trades Workers	7	10	4	8
Plant and Machine Operators and Assemblers	4	5	6	7
Elementary Occupations	8	8	3	4
cohort 3b 1971-1979				
Managers	3	3	2	2
Professionals	2	3	4	4
Technicians and Associate Professionals	13	16	23	26
Clerical Support Workers	31	31	40	35
Services and Sales Workers	29	23	13	10
Skilled Agricultural, Forestry and Fishery Workers	0	0	0	0
Craft and Related Trades Workers	7	10	6	9
Plant and Machine Operators and Assemblers	5	5	8	8
Elementary Occupations	10	8	6	5
cohort 3c 1980-1995				
Managers	1	1	1	1
Professionals	1	2	2	3
Technicians and Associate Professionals	8	13	13	19
Clerical Support Workers	24	24	28	26
Services and Sales Workers	41	32	28	18
Skilled Agricultural, Forestry and Fishery Workers	0	0	0	0
Craft and Related Trades Workers	8	11	9	14
Plant and Machine Operators and Assemblers	6	7	10	12
Elementary Occupations	11	10	9	8

Notes:

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

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

Table A14: Job Separation Probability - specification with logwages by quartiles

	(1)	(2)	(3)	(4)	(5)
VocationalHS	-0.0132*** (0.00172)	-0.0112*** (0.00179)	-0.0107*** (0.00165)	-0.0120*** (0.00157)	-0.00877*** (0.00172)
Second Quartile (Log Wages)*VocationalHS	-0.0139*** (0.00266)	-0.00147 (0.00239)	0.000136 (0.00206)	-0.00106 (0.00197)	0.000783 (0.00187)
Third Quartile (Log Wages)*VocationalHS	-0.00985*** (0.00305)	0.00326 (0.00325)	0.00501* (0.00303)	0.00348 (0.00270)	0.00372 (0.00232)
Fourth Quartile (Log Wages)*VocationalHS	0.00862 (0.00660)	0.0208*** (0.00682)	0.0190*** (0.00568)	0.0159*** (0.00470)	0.00902*** (0.00246)
Second Quartile (Log Wages)	-0.0543*** (0.00196)	-0.0523*** (0.00193)	-0.0355*** (0.00182)	-0.0301*** (0.00153)	-0.0285*** (0.00165)
Third Quartile (Log Wages)	-0.0977*** (0.00253)	-0.0972*** (0.00268)	-0.0658*** (0.00275)	-0.0582*** (0.00211)	-0.0480*** (0.00181)
Fourth Quartile (Log Wages)	-0.150*** (0.00601)	-0.150*** (0.00612)	-0.0965*** (0.00571)	-0.0835*** (0.00381)	-0.0541*** (0.00220)
Observations	5,565,672	5,565,672	5,565,672	5,565,672	5,565,672
R-squared	0.018	0.021	0.032	0.033	0.129

Notes:

The table reports marginal effects of the likelihood of job separation for an individual with a vocational versus an individual in the general track in Panel A by log wages quartiles. Column (1) do not include more controls, column (2) includes the year effects, and the specification in Column (3) includes age and tenure in quadratic form and the gender. Column (4) adds to the previous specification log size of the firm and column (5) includes also the firm fixed effects. Robust standard errors in parentheses

* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table A15: Vocational Wage gap - Only workers always in the sample

VARIABLES	(1)	(2)	(3)	(4)	(5)
VocationalHS	-0.112*** (0.00111)	-0.104*** (0.00111)	-0.0725*** (0.000885)	-0.0129*** (0.000827)	0.00608*** (0.000795)
Age			0.0364*** (0.000157)	0.0374*** (0.000146)	0.0249*** (0.000122)
Age ²			-0.000510*** (4.23e-06)	-0.000487*** (3.92e-06)	-0.000255*** (3.21e-06)
Tenure			0.0332*** (0.000150)	0.0228*** (0.000140)	0.0192*** (0.000120)
Tenure ²			-0.000347*** (5.49e-06)	-0.000290*** (5.10e-06)	-0.000308*** (4.11e-06)
Male			0.260*** (0.000650)	0.231*** (0.000605)	0.151*** (0.000543)
Log firm size				0.0729*** (0.000126)	0.00214*** (0.000765)
Constant	0.676*** (0.000445)	0.727*** (0.00290)	0.00989*** (0.00256)	-0.360*** (0.00246)	0.111*** (0.00430)
Observations	2,052,553	2,052,553	2,052,553	2,052,553	2,052,553
R-squared	0.005	0.016	0.379	0.465	0.744

Note: The table reports the vocational wage gap using only permanent workers. 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. Robust standard errors in parentheses

* Significant at 10%; ** significant at 5%; *** significant at 1%.