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ORIGINAL ARTICLE

Cognitive skills and the LOGSE reform in Spain: evidence from PIAAC

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Abstract We use data from the Spanish sample of the Programme for the International Assessment of Adult Competencies to analyze the effect of the LOGSE (Spanish acronym for General Law of the Education System) reform passed in 1990 on numeracy and literacy proficiency of the adult population. The LOGSE effect is identified by exploiting the variability of the rate of implementation among cohorts and regions. The results change depending on the specification of the econometric model and mainly on the type of birth year trend assumed. Nonetheless, overall results suggest that the LOGSE reform did not help to increase cognitive skills of the population despite an extension of compulsory years of education and postponement of the age of initial tracking into vocational and academic studies.

Keywords LOGSE · PIAAC · Education reform · Compulsory education · Vocational

JEL Classification I20 · J240

1 Introduction

The General Law of the Education System (LOGSE, Spanish acronym) was passed in 1990, replacing the previous General Education Law (LGE, Spanish acronym) passed

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in 1970. It introduced significant changes by increasing leaving age for compulsory schooling, from 14 to 16, and postponing tracking of students into vocational and academic schools up to age 16. There is a need for evaluation since the LOGSE could be considered the most important reform of the Spanish education system in the last 50 years, particularly for secondary education. The analysis of the impact on cognitive skills is especially relevant given the introduction of new, longer, and more comprehensive curricula that replaced the tracking system at the compulsory level.

So far, the analysis of the LOGSE focused on non-cognitive-skills outcomes. For example, Felgueroso et al. (2014) study school dropout using the labor force survey for cohorts potentially affected by the LOGSE. Their econometric model exploits the regional variation in the degree of implementation of the reform in the period 1992–2002. Interestingly, they estimate a positive effect on dropout rates for males, and negative effect for females after controlling for the availability of Lower Vocational studies in the period. Also, they find that the abolition of Lower Vocational studies increased dropout for females, although this result is not very significant. In other report, Lacasa (2006) carries out a descriptive analysis showing that the implementation of the LOGSE is correlated with a decline of some educational outcomes: the school enrollment rate at age 17; school life expectancy; percentage of population with upper secondary education; percentage of population at age 18 taking the university access exam, and; university enrollment rate at age 20. In an early work, De Miguel-Díaz et al. (2002) analyze the educational performance of students from several Spanish universities depending on the type of baccalaureate they studied, LOGSE or LGE. They found no systematic differences between these two groups in average grade in high school, university access exam marks, and performance at university.

In this paper, we use data from the Spanish sample of the Programme for the International Assessment of Adult Competencies (PIAAC) to analyze the effect of the LOGSE reform on numeracy and literacy proficiency of the adult population. PIAAC measures cognitive and workplace skills of different Spanish cohorts who studied under LOGSE and previous education laws. Applying the same methodology as in Felgueroso et al. (2014) we can estimate the relationship between the degree of exposure to LOGSE and skills. The analysis has at least two novel aspects. First, PIAAC measures skills using an internationally standardized questionnaire so that all individuals are evaluated using the same standards. This way we avoid the use of educational outcomes that are not comparable across education laws. For example, high school grades are based on criteria specific to LOGSE and LGE. The same applies to university access exam marks. In addition, the use of numeracy and literacy proficiency allows us to explore a new dimension that has implications for the labor market and differs from other outcomes previously analyzed, like school dropout or obtaining a university degree. Secondly, the plausible causal relationship between LOGSE and skills may be contaminated by cohort effects (Desjardins and Warnke 2012). For this reason, we estimate an econometric model using different functional specifications controlling for year of birth to isolate the LOGSE effect from the cohort effect. In the estimation of the cohort effect we consider not only those cohorts potentially affected by the reform but also the adults born before and after the implementation period. Notice that the analysis in Felgueroso et al. (2014) considers only those individuals that attended school during the period of implementation of the LOGSE.

The results indicate that the LOGSE reform was not successful in increasing numeracy and literacy skills of the Spanish population despite an extension of compulsory years of education and postponement of the age of initial tracking into vocational and academic studies. In fact, the relationship of the degree of exposure to LOGSE and skills tend to be negative for the majority of variants of the econometric analysis, although statistical significance is not robust to variations in the functional form of the cohort effect.

In the next section, we discuss the LOGSE reform and evidence on relevant educational reforms is reviewed. Methodological details are found in Sect. 3. In Sect. 4, the results are presented. Finally, we include a discussion and conclusion.

2 Background

Figure 1 shows the main differences between the LOGSE and LGE educational systems. Under the LGE compulsory primary education finished at age 14. After that, students could continue either vocational (FP, Spanish acronym) or academic (BUP, Spanish acronym) studies if they obtained the Primary School Qualification. Those who did not successfully finish primary education obtained a School Certificate and had access to FP only. Under LOGSE the educational system changed so that primary education finished at age 12, then Compulsory Secondary Education (ESO, Spanish acronym) continued, until students were 16 years old. After ESO, only students who obtained the qualification could continue to upper secondary school, either Baccalaureate or vocational training. Those students with no ESO qualification could study Social Guarantee Programs (PGS, Spanish acronym) for basic education before accessing the labor market.

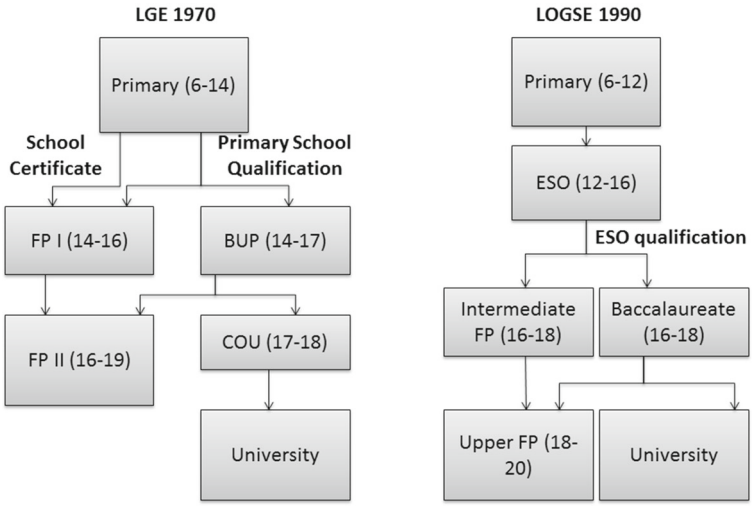

Fig. 1 Basic structure of the Spanish educational system under the LGE and the LOGSE

We can consider several aspects of the LOGSE reform that may have affected educational outcomes. First, the duration of compulsory education was extended. Additional years of schooling may affect positively those who would otherwise drop out of school before age 16, by providing more education. This effect must be even more important given that the labor market entry age is precisely 16 and no alternative to school is available for younger teenagers. Second, comprehensive education replaced tracking of students into more general education or vocational studies at age 14–16. On the one hand, the new system eliminated flexibility because less academic-oriented students were not given the chance to continue towards vocational programs. On the other hand, peer effects could have played a role. Under the LGE only high-performing students, those with Primary School Qualification, could continue academic studies. However, with the LOGSE the "bad and good peers are studying in the same classroom" at least until age 16. The overall impact of this aspect is unclear and depends on how low/high-performing students benefit from a good peer (see Hoxby 2000, for a discussion). Finally, under LOGSE, the ESO qualification is required to continue either vocational or academic programs. Therefore, those students who fail to obtain the qualification are excluded from the main tracks of the educational system. Note that under the LGE these students could attend vocational education (FP) from age 14 (see a reflection in Cabrera-Montoya 2007).

To consider the plausible impact of the LOGSE reform in Spain it is worthwhile to look at similar reforms that took place in other European countries. Therefore, we can consider those reforms that affected years of compulsory education and/or the age of initial tracking into vocational and academic studies. There is a wide evidence supporting that increasing compulsory school age have a positive effect on educational attainment. For example, Brunello et al. (2009) used information on reforms that took place over the 1949–1983 period in 12 Western European countries and estimate that the effect of one additional year of compulsory education is close to 0.3 years of schooling. A positive effect of years of compulsory education has also been estimated by other authors using data for similar sets of countries (Gathmann et al. 2015; Meyer 2017). A more recent reform implemented in the Netherlands in 2007 extended the school-leaving age from 17 to 18 and reduced dropouts—i.e. number of students with no higher secondary diploma—by 2.5% points according to Cabus and De Witte (2011). Furthermore, compulsory education laws have been used as a source of exogenous variation to estimate the causal effect of schooling on several outcomes like earnings (Angrist and Keueger 1991; Brunello et al. 2009), health (Brunello et al. 2013; Gathmann et al. 2015), political ideology (Meyer 2017), or attitudes towards immigration (d'Hombres and Nunziata 2016).

In the case of reforms that change the age of initial tracking the literature is less clear about the expected effect. Braga et al. (2013) analyzed reforms that took place in 24 European countries/regions in the twentieth century and did not find any effect of the tracking age on years of education. The same result is found by Malamud and Pop-Eleches (2010) analyzing the 1973 Romanian reform that required students to complete an additional two years of general education before choosing between vocational or academic studies. A reform that took place in Sweden in 1962 has similar characteristics to the LOGSE because changed both compulsory education and educational tracking. The reform increased the years of compulsory education, from seven

(or eight in some municipalities) to nine, and replaced tracking into academic and nonacademic studies based on academic achievement by tracking based on student's choice. Unlike LOGSE, the Swedish reform introduced more flexibility by allowing students to choose between a more academic curriculum, one general level, and one level that included vocational training. Meghir and Palme (2005) estimates that the reform increased the attained education level and years of schooling, affecting particularly those students with unskilled fathers. A more recent reform implemented in the 1990s in Sweden introduced more comprehensive content to vocational tracks in upper secondary education and extended the length of those tracks from two to three years. No effect of this reform has been estimated on educational attainment beyond the upper secondary level (Hall 2012).

3 Methodology

The empirical strategy in this paper is to exploit the regional variation in the implementation of the new educational system during the transition period in which the LOGSE progressively replaced the old LGE system. This transition period affected those students born in the 1976–1983 period that potentially could study either under LOGSE or under LGE. The degree of implementation of the LOGSE, during the transition period, varied among the 19 Spanish Autonomous Communities/Cities. To exploit variation in the level of exposure to the reform we compute a proxy variable for the probability that an individual studied LOGSE according to birth year and region. If the LOGSE had an impact on cognitive skills, we should find a relationship between this variable and PIAAC scores. This strategy follows closely the methodological approach in Felgueroso et al. (2014).

3.1 Calculation of LOGSE implementation variable

We use data files "The education figures in Spain" (in Spanish, *Las cifras de la educación en España*) from the Ministry of Education to compute the explanatory variable.[1] In those documents, we have information about the percentage of students who studied LOGSE over the total number enrolled for each academic year and region. We can differentiate between those students that studied different educational levels in LOGSE: ESO first stage, ESO 1st and 2nd year; ESO second stage, ESO 3rd and 4th year; and Baccalaureate (1st and 2nd year). An important aspect is that students could have entered the new LOGSE schools at any of these stages. Therefore, we compute the next implementation variables:

(a) *ESO1* The "probability" that a student studied ESO first stage;
(b) *ESO2* The "probability" that a student studied ESO second stage, and;
(c) *BACH_LOGSE* The "probability" that a student studied the LOGSE Baccalaureate.

[1] This statistical information can be accessed in the website of the Ministry of Education, Culture and Sport in the following link: http://www.mecd.gob.es/servicios-al-ciudadano-mecd/estadisticas/educacion/indicadores-publicaciones-sintesis/cifras-educacion-espana.html.

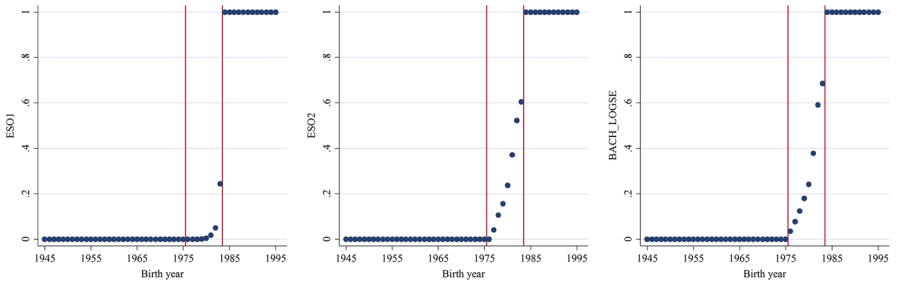

Fig. 2 Variables of implementation of the LOGSE by year of birth

We calculate the *ESO1* variable as the proportion of students at ESO 2nd year according to year of birth. For example, those born in 1983 could have studied ESO 2nd year (or analogous level under the LGE) at age 13 in the 1996–1997 academic year. Therefore, we assign to this cohort the proportion of students in ESO 2nd year in that specific academic year. For *ESO2,* we use the proportion of students in ESO 4th year. Finally, *BACH_LOGSE* is the proportion of students studying the LOGSE Baccalaureate 2nd year. According to year of birth, we can consider three groups of individuals:

(I) PRE-LOGSE. Those born between 1945 and 1975. They all studied under the LGE or previous law.
(II) TRANSITION. Those born between 1976 and 1983 studied LOGSE or LGE with some probability.
(III) POST-LOGSE. Those born between 1984 and 1995 studied only under the LOGSE.

Figure 2 shows the average value of the implementation variables by birth year. The red vertical lines in these graphs delimit the three periods considered. The degree of implementation of LOGSE increases for the TRANSITION period. However, there is more variability in the case of the ESO2 and BACH_LOGSE than in the case of ESO1.

3.2 Econometric model

To estimate the effect of the variables of implementation of the LOGSE we estimate the next equation,

$$S_{iry} = \alpha + \beta LOGSE_{ry} + T\,(y) + \gamma R_r + \eta X_{iry} + u_{iry}, \tag{1}$$

where S_{iry} is skills of an individual i born in year y and living in region r at the time of the PIAAC exam. The skills depend on the probability of being affected by the reform, $LOGSE_{ry}$, that varies among regions and birth years. The cohort effect is captured by the birth year trend $T\,(y)$. The model also controls for a vector of regional dummies R_r and individual characteristics X_{iry}.

An important task of this model is to estimate an effect of LOGSE after controlling for cohort effects. For this reason, we estimate the econometric model for up to 10 different specifications of the cohort effect $T\,(y)$ depending on the number of trend periods (one, two, or three) and the type of trend (linear, quadratic, and polynomial

Table 1 Specifications of the effect of birth year

Type of trend	Number of trends considered			
	Three periods 1945–1975 1976–1983 1984–1995	Two periods 1945–1975 1976–1995	Two periods 1945–1983 1984–1995	One period 1945–1995
Linear	(1)	(3)	(5)	(7)
Quadratic	(2)	(4)	(6)	(8)
Polynomial D.3				(9)
Polynomial D.4				(10)

of 3rd and 4th degree) as shown in Table 1. For models (1) and (2) three different periods are considered—PRE-LOGSE, TRANSITION, and POST-LOGSE—; and linear and quadratic trends are estimated respectively. For models (3) and (4) we estimate two different trends—PRE-LOGSE, on one hand, and TRANSITION jointly with POST-LOGSE, on other hand. In the case of models (5) and (6) also two trends are estimated—with PRE-LOGSE and TRANSITION grouped together. Finally, models (7) to (10) consider several types of specification for a single trend: linear, quadratic, and polynomial of 3rd and 4th degree, respectively.

4 Results

4.1 Descriptive analysis

Figure 3 shows the graphs of the average PIAAC score by year of birth, for numeracy and literacy respectively. The two graphs have an inverted-U pattern, consistent with the literature on cognitive skills (Desjardins and Warnke 2012). Nonetheless, Fig. 3 shows an interesting shape that is worth studying. The TRANSITION period coincides with changes in the birth year trend. Specifically, the PIAAC scores increases with birth

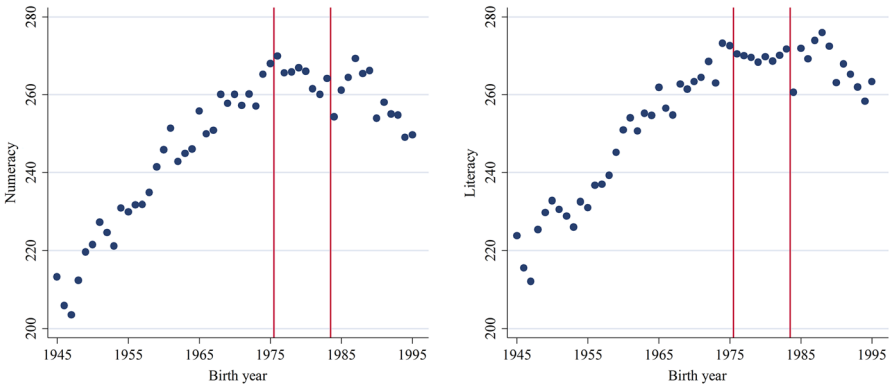

Fig. 3 Scores in numeracy and literacy by year of birth

year during the PRE-LOGSE period, a downward trend is found for the TRANSITION period, and then an upward trend is found again, at least for the years 1984–1989. As a result, the curves for both numeracy and literacy have a double peak shape with two maximum values: one around 1975; and other around 1988. The econometric analysis will reveal to what extent this changes in trend are related to the implementation of the LOGSE.

Figure 4 shows family/individual characteristics of the sample by birth year. In panel (a) we see the percentage of individuals with at least one parent with middle (secondary) or high (college) education. This variable shows no change in trend for the TRANSITION group and therefore it is a poor candidate for explaining the decline of skills for that period (Lacasa 2006). The same applies to self-reported health, which have a continuous positive slope for the three cohort groups considered (see panel b). In addition, the proportion of individuals who are currently studying is always higher for younger cohorts (see panel f). However, there is a trend shift in the percentage of employed individuals (panel c), the percentage of white-collar occupations (panel d) and the percentage of people with college degree (panel e). All these variables seem to decrease during the TRANSITION period contrasting with the upward trend in the PRE-LOGSE period. Finally, we consider the percentage of individuals having a secondary or university degree directly related to Mathematics and Sciences (panel g) or Arts and Humanities (panel h). There is no clear pattern for these characteristics in the considered periods.

4.2 Econometric results

In the analysis, we only consider native individuals because immigrant adults probably did not attend school in Spain. In Table 2 we see the results of the estimation of model (1) (see Table 1 above) for numeracy and literacy. The ESO2 variable captures the effect of LOGSE once we control for a linear trend, different for the three periods considered, and family/individual characteristics. The coefficient is interpreted as the impact of an increase from 0 to 1 in the probability of studying under LOGSE. Therefore, it could be interpreted as the difference between a LOGSE student and LGE student. The estimated effect of the LOGSE is negative and significant at 1% level, and very similar for numeracy and literacy, around − 18 points of PIAAC scores. The birth year variable is included in differences with respect to 1984 and divided by 10; hence, it captures the effect of belonging to a 10-year younger cohort. Birth year is interacted with other binary variables that indicate the specific period to estimate the three different trends. The results indicate a significant positive trend for the first two periods PRE-LOGSE and TRANSITION. The trend is not significant for the POST-LOGSE period.

With respect to other individual characteristics, males obtain significantly higher scores than females for the two types of skills assessed. The result for numeracy is consistent with other studies that find gender differences in favor of males in mathematics. However, the result for literacy contrasts with the *Programme for International Student Assessment* (PISA) which shows that 15-years old girls obtain better results in reading (see Stoet and Geary 2013, for an international comparison; and the Spanish report for PISA 2015 on gender differences for literacy, Instituto Nacional de Evaluación Educativa 2016). Nonetheless, gender differences in literacy are not significant for young

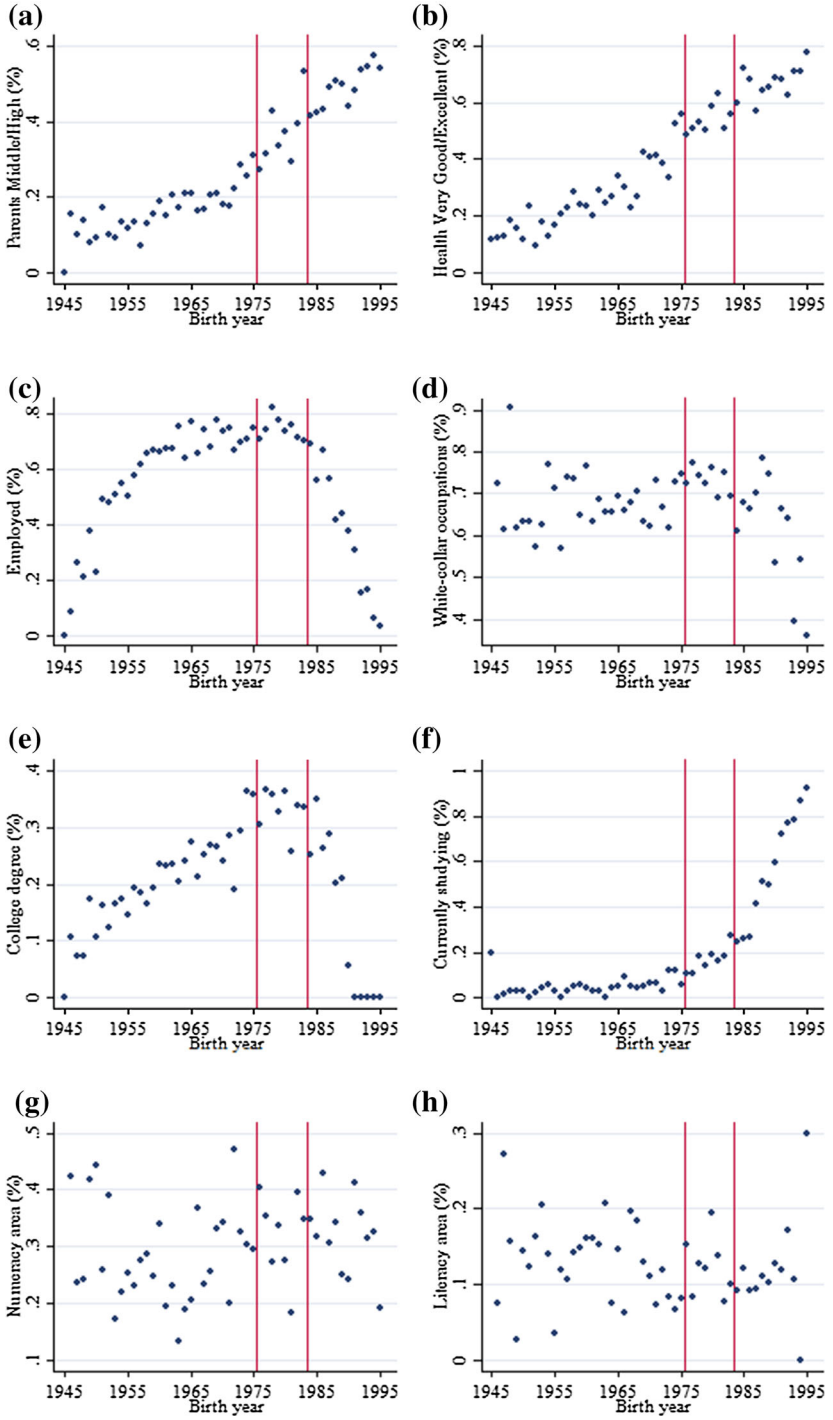

Fig. 4 Characteristics of the individuals by year of birth

cohorts (see the Spanish PIAAC report, Chapter 3 of Volume I, Instituto Nacional de Evaluación Educativa 2013). For parental education, we include individuals who have a father and mother with primary education or less (low) in the constant and compare them with those who have at least one parent with secondary education (middle) and those who have at least one parent with tertiary education (high). The effect of having parents with high or middle education is positive for both competences. The impact of health on skills is complex because those individuals who have very good health get better results than those with excellent health (reference group). This implies that health has some negative effect. One possible explanation for this result is the existence of selection bias, e.g. those who have excellent health also have different unobservable characteristics. Nonetheless, those with fair or poor health obtain a lower score, which can be interpreted as a positive relationship between health and cognitive abilities. As for employment status, individuals who are employed obtain a significantly higher score than inactive individuals in the case of numeracy. Also, those who have white collar occupations, both skilled and semi-skilled workers, have significantly higher scores compared to unqualified blue-collar workers for both studied competences.

The variables that have more influence on PIAAC scores are those related to formal education. For example, those adults with college degree have around 55 points more than individuals with primary education or no education. The model also includes some variables which indicate whether the individual has completed studies related to Mathematics and Sciences (numeracy area) or related to Arts and Humanities (literacy area). The constant includes the rest of studies that are not included in any of the two disciplines assessed. These variables are interacted with the education levels to estimate a different effect for those with 2nd Stage Secondary education, on the one hand, and those with university education, on the other hand. Interestingly, those who studied a degree related to numeracy obtain significantly higher scores in both numeracy and literacy. However, those with literacy-related studies are not different to those with unspecialized studies. Finally, we include a variable that shows whether the adult is still studying for an official qualification; this variable has a positive effect on PIAAC scores for both competences.

Table 3 includes variations of the analysis presented in Table 2. Ten different specifications of the birth year trend are included as outlined in Table 1. Each of these models have been estimated using the three implementation variables (ESO1, ESO2 and BACH_LOGSE), and for both numeracy and literacy. Therefore, a total of 60 estimations ($10 \times 3 \times 2$) has been considered. The LOGSE effect is negative for 59 estimations; 37 of these are significant (p value < 0.1). The effect is positive and not significant for only one of the estimations. Thus, there are differences in effect size and statistical significance among the specifications considered. For example, if we consider the linear trends (models 1, 3, 5 and 7) we estimate a stronger and more significant effect than for the quadratic (2, 4, 6 and 8) or polynomial (9 and 10) models. The type of variable considered to identify the LOGSE effect also seems to influence, although to a less extent, the results: the estimated effect is systematically lower for ESO1 than for ESO2 and BACH_LOGSE. Also for some models, the significance is lower in the case of ESO1 (see models 6, 8 and 9). Finally, the significance of the estimated effect is more robust in the case of literacy, since this holds for quadratic models 2 and 4.

5 Discussion and conclusion

The results about the LOGSE effect on PIAAC scores change depending on the specification considered and mainly on the type of birth year trend assumed. Consequently, the study of variations of the econometric analysis is justified. The statistical significance of the LOGSE effect is not robust to different specifications although the

Table 2 Estimation of the LOGSE effect on numeracy and literacy

Variables	Numeracy	Literacy	Variables	Numeracy	Literacy
ESO2	− 18.7***	− 18.3***	*Occupation* (Cons: Unskilled blue-collar)		
	(2.9)	(3.5)	Semi-skilled blue-collar	3.6	0.8
Trends				(2.7)	(2.8)
Birth year × PRE.	8.6***	9.3***	Semi-skilled white-collar	8.4***	6.3**
	(1.2)	(1.2)		(2.6)	(2.6)
Birth year × TRAN.	14.6***	19.7***	Skilled white-collar	12.1***	9.7***
	(4.8)	(4.3)		(2.8)	(2.8)
Birth year × POST.	5.6	2.7	Has not worked in 5 years	4.6	4.5
	(4.1)	(4.2)		(3.3)	(3.2)
			Educational level (Cons: Primary or none)		
Male	12.3***	5.9***	Sec. 1st stage	23.9***	20.2***
	(1.5)	(1.4)		(2.4)	(2.3)
Parental education (Cons: E. low)			Sec. 2nd stage	37.7***	34.1***
				(2.5)	(2.5)
E. middle	2.0	3.2**	Tertiary	55.8***	53.4***
	(1.5)	(1.5)		(2.6)	(2.7)
E. high	9.8***	8.9***			
	(2.3)	(1.9)	*Area of studies* (Cons: Unspecialized)		
Health (Cons: excellent)			Area-num × Tertiary	16.1***	10.3***
Very good	3.7*	4.9**		(2.8)	(2.7)
	(2.1)	(1.9)	Area-num ×Sec. 2nd E	12.5***	7.8***
Good	1.4	1.1		(2.5)	(2.4)
	(2.0)	(1.8)	Area-lit × Tertiary	− 3.3	4.2
Fair	− 4.4*	− 5.1**		(3.9)	(3.7)
	(2.5)	(2.2)	Area-lit ×Sec. 2nd E.	4.8	5.6
Bad	− 16.1***	− 20.2***		(3.9)	(3.7)
	(4.3)	(4.0)			

Table 2 continued

Variables	Numeracy	Literacy	Variables	Numeracy	Literacy
			Currently studying	12.3***	14.5***
Employment status (Cons: inactive)				(2.6)	(2.2)
Employed	5.0**	0.6	*Cons.*	215.4	237.4
	(2.0)	(2.2)		(4.5)	(5.1)
Unemployed	−2.4	−3.3	Observations	4,967	4,967
	(2.5)	(2.4)	R2 (%)	46.7	45.6

Model (1): 3 linear trends
*, **, and *** mean that the coefficient is significant at 10, 5, and 1%, respectively
Standard errors are shown in brackets and have been calculated following the methodology of the PIAAC study, using 10 plausible values for each competence and 80 replications
The estimations control for a series of binary variables representing each region

econometric analysis shows a negative effect in most variants of the analysis. Therefore, the results suggest that the LOGSE reform did not help to increase cognitive skills of the population despite an extension of compulsory years of education and postponement of the age of initial tracking into vocational and academic studies. The results contrast with wide evidence that shows a positive effect of years of compulsory education (Brunello et al. 2009; Gathmann et al. 2015; Meyer 2017), but is in line with other studies that find no effect of the age of initial tracking (Braga et al. 2013; Malamud and Pop-Eleches 2010). The conclusions of the present analysis are also consistent with Felgueroso et al. (2014) in that "overall, the average of effect of the LOGSE seems to be at least not positive". Even in the case of females, they find a non-positive effect of LOGSE when considering the detrimental effect of the abolition of Lower Vocational studies.

Three further aspects of the analysis should be considered that could affect the interpretation of the results. First, the implementation variables are based on the specific grade (at each stage ESO1, ESO2, or Baccalaureate) an individual "should" have studied according to birth year. However, a significant percentage of students in Spain are enrolled in a grade different to the one they "should" due to the practice of grade retention (González-Betancor and López-Puig 2016; García-Pérez et al. 2014). Those individuals in the TRANSITION period had a higher likelihood to be enrolled in the new LOGSE system if they had been retained. This implies that the implementation variables may be downward biased estimations of the probability of studying under LOGSE. In this sense, the variables ESO2 and BACH_LOGSE could be better approximations than ESO1 given that they entail higher probabilities of studying under LOGSE for any individual within the TRANSITION group.

Second, the estimated LOGSE effect should be interpreted as the impact of the reform for those individuals in the TRANSITION period during which the implementation variables change, i.e. similar to the interpretation of estimations by Regression Discontinuity Design around the cutoff point (Lee and Lemieuxa 2010). In this sense, it is important to remark that the education reform could have brought adjustment

Table 3 Estimation of the LOGSE effect on numeracy and literacy, according to variables of implementation and specification of the trend

	Trends									
	Three periods 1945–1975 1976–1983 1984–1995		Two periods 1945–1975 1976–1995		Two periods 1945–1983 1984–1995		One period 1945–1995			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Numeray										
ESO1	−14.2***	−5.5	−14.6***	−1.8	−12.3***	−4.0	−12.8***	−2.7	−4.2	−1.6
ESO2	−18.7***	−8.1	−18.9***	−6.2	−17.0***	−7.9*	−17.4***	−8.6**	−9.3***	−6.5
BACH_LOGSE	−18.1***	−7.0	−18.4***	−5.5	−16.8***	−7.3	−17.4***	−8.5**	−9.0**	−6.0
Literacy										
ESO1	−14.8***	−11.2*	−15.6***	−5.7	−11.3***	−4.0	−12.7***	−3.1	−3.3	0.8
ESO2	−18.3***	−13.4**	−18.7***	−11.4*	−15.4***	−7.6	−16.6***	−7.7**	−7.8**	−0.6
BACH_LOGSE	−17.7***	−12.1*	−18.2***	−10.5*	−15.3***	−7.3	−16.7***	−7.8*	−7.8**	−0.3

*, ** and *** mean that the coefficient is significant at 10, 5 or 1%, respectively

Standard errors have been omitted but have been calculated following the methodology of the PIAAC study, using 10 plausible values for each competence and 80 replications. The estimations control for the same covariables included in Table 2

costs in the short term that may have disappeared in the long term. Unlike for other neighbouring countries (Portugal and Italy) the Spanish reform was a comprehensive restructuring of the education system (Meijer 1991). For example, teachers had to face challenges like: (a) a more heterogeneous student population in the same classroom; (b) new curricula to be implemented; (c) new approaches to teaching like "adaptation to student diversity" or evaluation of "attitudes and skills" rather than educational attainment (Cabrera-Montoya 2007).

Finally, since part of the LOGSE effect is identified by the variability in the rate of implementation between regions it is important that these differences are exogenous. In other words, if those regions with higher (lower) scores are those that have implemented the reform more (less) quickly, then our results could be biased to some extent (see a discussion in Felgueroso et al. 2014). To test for this hypothesis, we estimate the effect of the regional rate of implementation of the LOGSE at the middle of the process on different outcomes of the cohorts born in the period 1971–1975, just before the TRANSITION period. About 50% of adults born in 1982 attended a LOGSE school (see ESO2 variable in Fig. 2), however the rate of implementation varied across regions (from less than 10% to more than 80%). Notice, that this rate of implementation should not have any effect on cohorts born in 1971–1975 unless it is not exogenous. We do not find any significant effect on any outcome considered: numeracy, literacy, parental education, health, employment status, occupation, education level, and if currently studying.

References

Angrist JD, Keueger AB (1991) Does compulsory school attendance affect schooling and earnings? Q J Econ 106(4):979–1014

Braga M, Checchi D, Meschi E (2013) Educational policies in a long-run perspective. Econ Policy 28(73):45–100

Brunello G, Fort M, Weber G (2009) Changes in compulsory schooling, education and the distribution of wages in Europe. Econ J 119(536):516–539

Brunello G, Fabbri D, Fort M (2013) The causal effect of education on body mass: evidence from Europe. J Labor Econ 31(1):195–223

Cabrera-Montoya B (2007) Políticas educativas en clave histórica: la LOGSE de 1990 frente a la LGE de 1970. Témpora: Revista de historia y sociología de la educación 10:147–181

Cabus SJ, De Witte K (2011) Does school time matter?—on the impact of compulsory education age on school dropout. Econ Educ Rev 30(6):1384–1398

De Miguel-Díaz M, Apocada Urquijo P, Arias Blanco JM, Escudero Escorza T, Rodriguez Espinar S, Vidal García JY (2002) Evaluación del rendimiento en la enseñanza superior. Comparación de resultados entre alumnos procedentes de la LOGSE y del COU. Revista de Investigación Educativa 20(2):357–383

Desjardins R, Warnke AJ (2012) Ageing and skills: a review and analysis of skill gain and skill loss over the lifespan and over time (No. 72). OECD Education Working Papers

d'Hombres B, Nunziata L (2016) Wish you were here? Quasi-experimental evidence on the effect of education on self-reported attitude toward immigrants. Eur Econ Rev 90:201–224

Felgueroso F, Gutiérrez-Domènech M, Jiménez-Martín S (2014) Dropout trends and educational reforms: the role of the LOGSE in Spain. IZA J Labor Policy 3(1):1–24
García-Pérez JI, Hidalgo-Hidalgo M, Robles-Zurita JA (2014) Does grade retention affect students' achievement? Some evidence from Spain. Appl Econ 46(12):1373–1392
Gathmann C, Jürges H, Reinhold S (2015) Compulsory schooling reforms, education and mortality in twentieth century Europe. Soc Sci Med 127:74–82
González-Betancor SM, López-Puig AJ (2016) Grade retention in primary education is associated with quarter of birth and socioeconomic status. PLoS ONE 11(11):e0166431
Hall C (2012) The effects of reducing tracking in upper secondary school evidence from a large-scale pilot scheme. J Hum Resour 47(1):237–269
Hoxby C (2000) Peer effects in the classroom: learning from gender and race variation, NBER Working Paper 7867
Instituto Nacional de Evaluación Educativa (2013) PIAAC. Programa Internacional para la Evaluación de las Competencias de la población adulta, 2013. Análisis secundario, vol II. Madrid: Autor
Instituto Nacional de Evaluación Educativa (2016) PISA 2015: Programa para la Evaluación Internacional de los Alumnos. En Instituto Nacional de Evaluación Educativa (eds) Informe español. Madrid: Autor
Lacasa JM (2006) El efecto LOGSE y otros cuentos. Instituto FORMA de Investigación Educativa
Lee DS, Lemieuxa T (2010) Regression discontinuity designs in economics. J Econ Lit 48(2):281–355
Malamud O, Pop-Eleches C (2010) General education versus vocational training: evidence from an economy in transition. Rev Econ Stat 92(1):43–60
Meghir C, Palme M (2005) Educational reform, ability, and family background. Am Econ Rev 95(1):414–424
Meijer K (1991) Reforms in vocational education and training in Italy, Spain and Portugal: similar objectives, different strategies. Eur J Educ 26(1):13–27
Meyer AG (2017) The impact of education on political ideology: evidence from European compulsory education reforms. Econ Educ Rev 56:9–23
Stoet G, Geary DC (2013) Sex differences in mathematics and reading achievement are inversely related: within- and across-nation assessment of 10 years of PISA data. PLoS ONE 8(3):e57988. https://doi.org/10.1371/journal.pone.0057988

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