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Factors that influence the financial literacy of young Spanish consumers

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Abstract

This study examines the development of mathematical and financial literacy skills amongst 471 students in Spain. Most studies on this topic have looked at either one or the other skill but they have not examined the relationship between the two. The use of simultaneous equations has enabled us to do so. The aim of the paper is to disentangle the factors determining the financial skills of young consumers in Spain. To do this, the PISA Financial Literacy Assessment conducted by the OECD in 2012 is used. Our paper's main contribution lies in the methodological way to deal with the empirical challenges overshadowing our study. Particularly, our methodological strategy is defined by the application of a multi-level model of simultaneous equations (MSiEM). This method allows us to take into account the simultaneous determination of math and financial skills at school and the nested structure of the database. This MSiEM permits the identification of the determinants of financial skills, differentiating between the influences operating at school level from those at student level. A first conclusion is that the development of financial abilities of young consumers is mediated by their mathematical skills. A second conclusion, in accordance with those of other international studies, is the importance of the family on the financial literacy of 15-year-old Spanish students. The family, a first-order determinant in reading, science and math scores, is also a key variable in the development of financial skills. Finally, school type (public vs. private) does not display any effect on either the financial or math performance of Spanish young people.

KEYWORDS

financial literacy, mathematical performance, multi-level model of simultaneous equations, simultaneity bias

1 | INTRODUCTION

Over the past 10 years, there has been considerable international interest in the measurement and analysis of the economic and financial knowledge of the consumers, especially among young people. This fact may be explained by a variety of factors. On the one hand, the baby boom generation is drawing nearer to retirement age, leading to rising concern regarding the savings levels of the elderly population, given the increasing limitations affecting the public social security system. Consequently, many studies have aimed to disentangle the determinants of domestic savings in the long term, with financial culture being one of the main factors of interest in this literature (Lusardi & Mitchell, 2014; Van Rooij, Lusardi, & Alessie, 2012). On the other hand, the last economic crisis has demonstrated the

inability of many consumers to make optimal financial investments. Some evidence of this reality is the acquisition of complex financial products, such as preferred stocks, by groups of consumers with an inappropriate investor profile, as well as the excessive debt levels of many low-income households (Bover, Casado, & Costa, 2014). The increasing complexity of financial assets currently offered by the capital markets requires small investors to be financially qualified in order to make well-informed decisions that maximize their economic well-being. Indeed, some authors have stated that such a lack of financial skills is one of the primary causes of the last economic crisis (Gerardi, Goette, & Meier, 2010; President's Advisory Committee on Financial Literacy [PACFL], 2008). Finally, the financial culture of the consumers influences not only its personal well-being but is also a source of positive externalities for society as a whole, as discussed by Gnan, Silgoner, and Weber (2007) and Lusardi and Mitchell (2011), among others. Awareness of this situation on the part of public authorities is another factor underlying recent concern over the assessment and improvement of the financial literacy of the young population. Proof of this concern is the publication of the Financial Literacy Assessment conducted by the OECD in 2012 (OECD, 2014) among 15-year-old students. This wave of PISA (Program for the International Students Assessment) constitutes the first large-scale international assessment of financial literacy on young population around the world.

Most studies about economic-financial competency have focused on the role of the financial skills of the population in stimulating diverse economic outcomes. Some have attempted to evaluate the distribution of economic knowledge based on ethnicity (Crossan, Feslier, & Hurnard, 2011), gender (Moscarola & Migheli, 2017), educational level or employment status (Fornero & Monticone, 2011). Other research has focused on the influence of financial education on the probabilities of having a pension plan (Fornero & Monticone, 2011; Klaper & Panos, 2011), on expectations formation (Bateman et al., 2012), on savings levels (Behrman, Mitchell, Soo, & Bravo, 2010[1]), on participation in the stock market (Van Rooij, Lusardi, & Alessie, 2011), on the risk of defaulting on bank loans (Gerardi et al. 2010; Grinstein-Weiss, Spader, Yeo, Key, & Freeza, 2012), on consumers financial capability (Xiao & O'Neill, 2016), on the risk of assuming over indebtedness (Lusardi & Tufano, 2015) or on the potential of financial literacy to prevent social exclusion (Robson, 2012).[2] Finally, some papers explore how financial education changes investment, financing and consumers behaviour, finding strong effects from financial literacy training (Carlin & Robinson, 2012; Xiao, Ahn, Serido, & Shim, 2014[3]). In this literature, financial knowledge is regarded as a form of human capital, that is, as another input in the economic process.

By contrast, a less prolific line of research into financial literacy has focused on the internal processes through which consumers develop economic and financial skills. Such studies aim to identify the factors involved in the promotion of financial performance, in order for them to serve as the basis for successful public policies aimed at improving such skills (see Lusardi, Mitchell, & Curto, 2010; Erner, Goedde-Menke, & Oberste, 2016; Riitsalu & Pöder, 2016). In these studies, financial skills are described as the output of a complex production process in which several influences participate (individual attitudes, aptitudes for learning, the family context, social networks, schools, etc.).

Our study provides new evidence on this last topic from the Spanish experience. Its aim is to inquire into the complexity of factors influencing financial abilities (Riitsalu & Pöder, 2016) with the purpose to broaden the knowledge about the determinants of financial literacy among the young.

Our paper´s contribution lies in the methodological way that it follows to deal with the empirical challenges overshadowing our study. Particularly, our methodological strategy is defined by the application of a multi-level model of simultaneous equations (MSiEM). This method will allow us to take into account the simultaneous determination of math and financial skills at school and the nested structure of the PISA database.

In particular, our work focuses on the PISA 2012 data corresponding to Spain, one of the 13 countries participating in the first International Financial Literacy Assessment. Specifically, the PISA 2012 Financial Literacy Assessment (hereinafter FLA) was administered to approximately 29,000 students in 13 OECD countries and economies (Australia, the Flemish Community of Belgium, the Czech Republic, Estonia, France, Israel, Italy, New Zealand, Poland, the Slovak Republic, Slovenia, Spain and the United States) and five partner countries and economies (Colombia, Croatia, Latvia, the Russian Federation and Shanghai-China), representing 40% of world GDP. In the FLA, 15-year-old students were evaluated in addition to those who participated in the core PISA assessment. In general, eight additional 15-year-old students were chosen at random from each participating school to undertake the financial literacy assessment. Questions about students' experiences with money matters were included at the end of the financial literacy test booklets. Students who took the assessment of financial literacy also answered the PISA student questionnaire about themselves, their homes, their school and learning experiences and attitudes. School principals received a questionnaire that asked standard questions about school policies and the learning environment, and also included questions about the provision of financial education in school.

[1]The pioneer study analysing the relationship between training in financial areas and the level of savings was conducted by Bernheim, Garrett, and Maki (2001). It was shown that adults who received a course in financial management during their secondary education studies had increased savings rates. Other studies belonging to this research line include the works published in the case study on Financial Literacy and Planning Retirement in the Journal of Pension Economics and Finance, vol. 10 (4) in the year 2011. A recent paper on this topic is that of Grinstein-Weiss, Guo, Reinertson, and Russell (2015).

[2]One excellent survey about this literature and about the economic importance of financial literacy is that of Lusardi and Mitchell (2014).

[3]These findings resist the conclusion of the meta-analysis by Fernandes, Lynch, and Netemeyer (2014) where interventions to improve financial literacy explain only 0.1% of the variance in financial behaviors studied. However, the meta-analysis does not incorporate any of the papers above cited.

The remainder of the paper is organized as follows. The next section introduces the methodological strategy used in the paper, which is inspired in the specific nature of our data and in the analysis we pretend to carry out. In section 3, we present and discuss the results of our estimations. The paper concludes with a summary of our findings and some implications for policies directed towards raising the financial culture of young consumers.

2 | METHODOLOGY

When studying the factors affecting financial literacy among the young, it should be underlined that one of the potential variables to take into account is mathematical knowledge (see Erner et al., 2016; Riitsalu & Pöder, 2016). The exploratory analysis of the data for Spain in PISA 2012 shows a correlation of 0.79 between math and financial scores. In addition, 73% of the schools participating in the fifth wave of PISA include financial education within their 'mathematics' classes, as shown by the responses given by school principals to question 37 of the PISA School Questionnaire. But the 'mathematical skills' predictor and the endogenous variable in the present study (financial literacy) are interdependent, since both are affected by a set of common influences (at least those operating at the student level) and determined simultaneously over time. These characteristics lead to a violation of the hypothesis of noncorrelation between regressors and the random term required by ordinary least square (OLS) techniques, leading to inconsistency in the estimates obtained. This is known as the simultaneity bias (Dougherty, 2011).

On the other hand, the data from PISA 2012 have a hierarchical structure, due to the fact that the sample selection of individuals occurs at two levels (students and schools). That is to say, data are nested. Consequently, some of the characteristics of students attending the same school are correlated, violating the hypothesis of independence of the observations upon which traditional (OLS) regression models are based (Hox, 2002).

The characteristics described immediately above are the basic factors conditioning the research method used in our paper. As explained above, a multi-level model of simultaneous equations (MSiEM) is estimated to allow for the consideration of: a) the possible simultaneous production of financial and math skills in students, and b) the hierarchical structure of the data supplied by PISA 2012. This model permits the examination of the joint production process conducted in schools. In addition, the multi-level model will permit differentiation between those influences acting on the student and those acting on the school. A detailed explanation of the technical issues about this method is offered in Appendix 1.

3 | RESULTS

This section explains the results obtained from the application of MSiEM to the data for Spain obtained from PISA 2012. The analysis conducted in this section has a dual objective: (a) to explore the interrelationships existing between financial and math skills of 15-year-old Spanish students and (b) to contribute to disentangling the determinants of the degree of financial literacy, as measured by PISA 2012.

The development of the empirical model is performed in two stages, applied sequentially. Firstly, simultaneity in the production of financial and math competencies is evaluated via the resolution of a simultaneous equations model, presented at student level. Secondly, and based on the conclusions of the first stage, a model of these characteristics is recalculated at two levels (student and school). This MSiEM permits the identification of the determinants of financial skills of those individuals evaluated in PISA 2012, differentiating between the influences operating at school level from those functioning at student level. The following two sections show the results obtained.

3.1 | Analysis of simultaneity between financial and math performance

This section presents the results of the application of a simultaneous equation model at student level. Table 1 corroborates the overlapping relationship existing in the creation of financial and math skills in the Spanish students evaluated by PISA 2012. Financial skills are related to mathematical performance. The sign of the coefficient is positive and significant at 1%. As for the mathematical competencies equation, the relationship with financial skills is also statistically significant (up to 5%). The Hausman test value (11.28 in the explanatory equation for financial competencies and 25.05 for that of math competencies) indicates that there is an overlap in the production of the two types of cognitive skills examined.

3.2 | Analysis of the determinants of financial literacy

After verifying that the financial and math skills of 15-year-old Spanish students are determined simultaneously, this section presents the results of the MSiEM model. This type of model, as previously explained, permits the identification of the proportion of the total variance of the outcomes obtained by students which may be attributed to the different estimation levels. In our case, level 1 is represented by the student while level 2 is represented by the school.

The main advantage of the MSiEM models is that, as previously noted, they consider the hierarchical structure of the data supplied by PISA 2012, while at the same time allowing for integration of the simultaneous relationship existing between financial and math skills. The appropriateness of applying a multi-level model is justified empirically by the intra-class correlation values of the null model of financial (0.123) and mathematics (0.238) performance (see Table 2). Its values highlight the fact that school level explains some 12.3%

TABLE 1 Model of the simultaneous equations model at student level with only math (financial literacy) performance as predictors

	Dependent variable	
Independent variable	**Financial performance**	**Math performance**
Math performance	0.863***	
	0.041	
Financial performance		1.052**
		0.047
Observations	350	350
R^2	0.68	0.69
Hausman test	11.28	25.05
Hausman test (p-value)	0.001	0.000

**p <0.05; ***p <0.01.

and 23.8% of the variance of the outcomes for each of the two cognitive skills, respectively, thereby recommending the implementation of a multi-level regression model.[4]

Table 3 displays the results of the MSiEM model, where predictors of the two regressions are grouped by levels. The dependent variables in the regression are the scores attained by the 15-year-old Spanish students in the math and financial assessment tests of PISA 2012. However, financial literacy was excluded from the equation of mathematical skills. This decision responds to the belief that there are more reasons to assume that mathematics skills may affect financial competencies, rather than in the opposite direction. For example, the resolution of many of the issues regarding financial assessment requires the handling of mathematical tools, while the resolution of the mathematics questions is very technical and does not require the handling of financial concepts. Additionally, as mathematics forms part of the official school curriculum of 15-year-old Spanish students, their potential predictors are school, personal aptitudes and attitudes of students and family variables. Financial knowledge is not formally acquired in schools through a specific subject in the curriculum. However, there is no doubt that general cognitive development in other knowledge areas, particularly in that of mathematics, undeniably conditions differences in the financial literacy of students.

Based on Hausman (1983), the estimates were obtained through the application of the two-stage least squares method.[5] The final specification of the two equations estimated is the result of a parsimonious analysis that began with a broad model which was subsequently reduced, on the basis of the nonstatistical significance of the variables. The models were estimated by imposing fixed effects on the parameters (with the exception of the independent term).[6] Before estimating the simultaneous equation model, it was verified that the specification of equations fulfils the conditions of completeness and identification (order and range) that the resolution of this type of model requires, as previously explained.[7] It should also be noted that the estimates were obtained taking into account the special statistical treatment that must be given to the plausible values supplied in PISA. The first three columns of Table 3 show the results for math performance. The last three columns display the values corresponding to the financial performance regression.[8] The pseudo-R^2 returns values of 0.39 and 0.32, respectively.

The most relevant predictors of math scores at level 1 are those of 'Repeater' (students that retake the whole academic year) and 'Self-efficacy in mathematics.' The effect of the former is negative. This result is similar to that obtained in the works of Morrison and On No (2007), Greene and Winters (2007) and Brophy (2006). The positive effect of the 'Self-efficacy in mathematics' shows that self-esteem in the solving of math problems contributes to higher scores. This result suggests the need to incorporate noncognitive aspects into educational math programmes, given the potential influence of noncognitive skills on the improvement of cognitive skills (see García García, 2013). The positive sign of the 'Motivation in mathematics' variable leads to similar conclusions, although in this case the parameter is not significant.

Another result of interest, related to the equation of math scores, is the positive effect of family culture in the improvement of scores in this area. This variable was approximated by the mother's educational level and the number of books in the household. The sign of the effect of the mother's education is positive and significant, coinciding with that obtained in all previous studies carried out in this area.

[4]The intra-class correlation (ICC) is the proportion of the total variance explained by the differences between schools (level 2). If the ICC were zero, a hierarchical model would not be necessary, since in this case the total variance of the scores would not be explained by the differences existing between students attending different schools.

[5]A recursive estimation was also used to estimate the model, given that the mathematical competencies equation only contained predetermined variables and no endogenous regressor. More information about recursive models is offered by Gujarati (2004). The results obtained are similar to those presented in the text and are available upon request.

[6]The model with randomized effects for the parameters for which these effects were statistically significant was also estimated. The results were very similar and are available upon request.

[7]These requirements are: the number of equations should equal the number of endogenous variables to be estimated (in our case, mathematical and financial performance), in each equation the number of excluded regressors (K − k) should be greater than or equal to the number of endogenous variables included in the same, minus one (m − 1), and the second equation should contains at least one exogenous variable that was not included in the first equation. This document does not present the results of the verification of these three assumptions, but they are available upon request.

[8]These results show the statistical association between covariates and mathematics and financial test scores but causal effects are not warranted.

TABLE 2 Percentage of variance explained and pseudo-R^2 in the multi-level models with simultaneous equations

	Math competencies		Financial competencies	
	Null model	Complete model	Null model	Complete model
Schools	1672.6	995.2	748.5	337.2
Students	5,357.1	3,090.1	5,357.1	3,156.0
Total	7,029.7	4,085.4	6,105.6	3,493.2
Intra-class correlation (ICC)	23.8%	24.4%	12.3%	9.7%
% of total variance explained by the variables		41.9%		42.8%
% of level 1 variance (students) explained by the variables		42.3%		41.1%
% of level 2 variance (schools) explained by the variables		40.5%		55.0%
Pseudo-R^{2*}		39.8%		32.1%

*Calculation based on the reduction of squared prediction errors (Snijders & Bosker, 1994).

TABLE 3 Results of the multi-level model with simultaneous equations

	Math competencies (1st stage)			Financial competencies (2nd stage)		
Variables	Coefficient	*SE*	*t*-ratio	Coefficient	*SE*	*t*-ratio
Level 1 (students)						
Gender (female)	−20.19**	8.34	−2.42	12.68**	6.55	1.94
Father's occupation (BFMJ2)	0.26	0.17	1.51			
Highest occupational status of parents (HISEI)				0.38**	0.17	2.18
Mother's education (years of study)	1.86*	1.06	1.76	−2.85***	0.87	−3.27
Over 200 books	16.86	10.53	1.60	−2.51	7.65	−0.33
Native (born in Spain)	4.73	16.56	0.29	−8.55	11.82	−0.72
Math motivation (INSTMOT)	4.37	3.89	1.12			
Self-efficacy in mathematics (MATHEFF)	20.81***	5.27	3.95			
Repeater	−88.32***	10.48	−8.43	−7.48	13.24	−0.56
Math scores				0.88***	0.11	8.28
Level 2 (schools)						
Constant	517.64***	19.92	25.99	508.66***	17.09	29.76
Financial education not available	−2.94	9.47	−0.31	−4.57	8.25	−0.55
Private school	−5.14	9.92	−0.52	−7.45	6.31	−1.18
Infrastructure quality (SCMATBUI)	8.79	6.06	1.45			

*Standard errors calculated based on Gujarati (2004): *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

TABLE 4 Direct, indirect and total effects on financial literacy

	Direct effect			Indirect effect			Total effect		
Variables	**Coefficient**	***SE***	***t*-ratio**	**Coefficient**	***SE***	***t*-ratio**	**Coefficient**	***SE***	***t*-ratio**
Gender (female)	12.68**	6.55	1.94	−17.74**	7.64	−2.32	−5.06	7.29	−0.69
Mother's education (years of study)	−2.85S***	0.87	−3.27	1.64*	0.95	1.73	−1.21	1.06	−1.15
Over 200 books	−2.51	7.65	−0.33	14.82	9.43	1.57	12.31	9.09	1.35
Native	−8.55	11.82	−0.72	4.15	14.57	0.29	−4.40	12.77	−0.34
Repeater	−7.48	13.24	−0.56	−77.63***	13.15	−5.91	−85.10***	9.93	−8.57

*Standard errors for indirect effects based on Sobel test: *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

It is worth noting the negative sign of the variable gender, indicating worse math skills for girls in comparison to boys, a common result in the literature involved in study of the educational production function (Fryer & Levitt, 2010; Stoet & Geary, 2013). However, it has not been possible to tease out in the literature what is nature and what is environmental yet.

Finally, none of the variables introduced in level 2 (type of school and quality of school infrastructure) are statistically significant.

With regard to the results of the regression of financial skills (the last three columns of Table 3), the variable showing the greatest influence on this type of skill is the 'mathematics' variable, which reflects scores obtained in the PISA math test. The parameter value (0.88) indicates that for each additional point in mathematics the score for the financial test increases by 0.88 points. If it is taken into consideration that the correlation between the two skills is 0.79, it may be concluded that the effect is strong (see Cohen, 1988).[9] Therefore, it may be stated that education in financial issues is acquired by individuals through the acquisition of math skills, a result similar to that of Riitsalu and Pöder (2016).

Together with this result, Table 3 also leads to the conclusion that household socio-economic level and family culture have a statistically significant effect on the degree of the financial literacy of students, similar to results reached regarding math performance. Moreover, the effect of the family on financial skills is independent of the effect that this variable has on math skills. Clearly, the significant effects shown by these variables in the financial literacy regression (which includes mathematics as a predictor) show that the family influences the acquisition of financial skills, not only via mathematics education, but also in an autonomous way. It should be noted that this influence is positive for the HISEI variable,[10] although the mother's years of education have a negative sign. These results are in line with the conclusions other studies have reached on the influence of parents on their children's financial knowledge (see Grinstein-Weiss et al., 2012; Gudmonson & Danes, 2011 or Friedline, Elliot, & Nam, 2011, among others). However, while the mother's educational level is usually a key positive factor in the case of reading, mathematics and science skills (see Baker, Goesling, & LeTendre, 2002), its effect on financial literacy shows a negative influence in our study.

Table 4 displays the estimation of the direct, indirect (through math skills) and total effects on financial literacy. The indirect effect of mother's education on financial literacy through math competencies reveals as positive and significant whereas its direct effect is negative and significant. As a result, both effects neutralize in a non-significant total effect. Although this outcome might seem counter-intuitive, other papers have reached negative effects of the maternal education on children achievement. For example, Behrman and Rosenzweig (2002) find a negative effect of mother's education on her child attainment when the influence of her endowments is eliminated; and Abuya, Mutisya, and Ngware (2014) found a negative association between mother's education and children's achievement in both literacy and numeracy in Kenya.

Student gender is also a factor affecting the degree of financial literacy, although unlike the effect of this variable on mathematics performance, here girls have better scores than boys. As with mother education, total effect is not significant, but direct effect of gender on financial literacy is significantly positive and indirect effect through math competencies is significantly negative. Although there are no clear reasons for the difference in signs, it could be related to the fact that boys have some comparative advantage in visuospatial abilities (more related to math skills) and girls appear to have stronger verbal ability and memory (financial competencies involve not only math skills but also other cognitive abilities such as verbal ones). However, this interpretation exceeds the aim of the paper and further research should pay attention to this topic.

With regard to the school level variables, no one of these are statistically significant. In particular, school type (public vs. private) displays, as in the regression of math competencies, a negative and statistically insignificant effect on financial performance.

4 | CONCLUSIONS

The analysis performed in the previous sections leads to various conclusions that may contribute to enriching the debate about interventions to improve the youth's economic and financial knowledge. Such improvements are very important, as they would enhance the

[9]Observe that the effect is quite significant, statistically speaking (p-value = 0.000).

[10]HISEI stands for Highest occupational status of parents.

ability of individuals to make economic decisions that might boost their financial well-being.

An initial conclusion of the present study is that the development of financial abilities of young consumers is mediated by their mathematical skills. This result suggests that an improvement in financial skills might be attained by improving the population's math knowledge, thereby questioning whether it is really necessary, as some authors propose, to increase the supply of specific economic/financial subjects in the official school curriculum for primary and secondary students' classes. Adding hours to mathematics classes and modifying the orientation of teaching in this area towards a positive student attitude to this subject[11] may be a more effective strategy, while also being easier and less costly to implement than the introduction of specific financial courses in the Syllabus of secondary schools. In any case, this conclusion, which is the result of initial research into this topic in Spain, should be placed in the context of other studies where a positive impact on financial skills has been achieved by the implementation of specific financial education programmes (see Batty, Collins, & Odders-White, 2015 for a recent contribution in this field).[12] Whatever the case, new assessments need to be made in order to gain further knowledge as to how schools may improve the financial culture of their students.

A second conclusion, in accordance with those of other international studies (see Van Campenhout, 2015), is the importance of the family on the financial literacy of 15-year-old Spanish students. The family, a first-order determinant in reading, science and math scores, is also a key variable in the development of financial skills. Our results show that its influence is produced dualistically. On the one hand, the educational level of the mother positively conditions adolescents' math skills. On the other hand, the parents' professional status influences the financial skills of their children. With regard to these financial skills, the educational level of the mother, as well as the number of books in the home, shows a negative influence, which may indicate a special feature of financial skills as opposed to other cognitive dimensions in which parental education tends to have positive effects. Finally, school type does not display any effect on either the financial or math performance of Spanish young people.

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[11]It should be remembered that one of the variables displaying a very significant influence on the mathematics scores was that referring to self-confidence in this area.

[12]As an example, the evaluation of a Spanish pilot programme on financial education (applied to students attending the third year of secondary education during 2010–2011 and sponsored by the Central Bank of Spain, the National Stock Market and the Spanish Ministry of Education, Culture and Sport) has shown a positive impact on students' technical knowledge (see CNMV, 2013).

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APPENDIX 1: MULTI-LEVEL MODELS OF SIMULTANEOUS EQUATIONS (MSiEM)

The selection of the ideal regression model to conduct our estimates is conditioned by two peculiarities that affect the present study and have been mentioned previously. The first is the presumably simultaneous nature of the development of financial and mathematical performance. The second is the hierarchical structure of the PISA data.

Of all the available regression models, the multi-level models of simultaneous equations (MSiEM) adapt best to these peculiarities. Their main advantage is that they allow for differentiation between those influences acting at the student level (first level of analysis) and those acting at the school level (second level), while also allowing for the simultaneous determination of math and financial skills (i.e., the potential cross effects between the two types of cognitive skills evaluated in our study).

Models of simultaneous equations have been surprisingly underutilized in the literature on the functioning of educational production, despite the fact that the knowledge production process is an ideal example of joint production. The application of simultaneous equation models in this area of research is not only natural but essential because the problems of simultaneity, reciprocal causation and feedback are ubiquitous in education (Goldberger, 1991). Studies by Levin (1970), Boardman, Davis, and Sanday (1977) and García García (2013) offer three contributions of interest regarding the potentiality of simultaneous equation models in the study of the process of educational production.

The application of multi-level models to the educational context has been considerably more numerous. For example, there are the studies of Somers, McEwan, and Willms (2004) and Mancebón, Calero, Choi, and Ximénez-de-Embún (2012), with the latter applying to Spanish data from the PISA 2006 survey. In the specific context of financial literacy, multi-level models have been utilized in Erner et al. (2016). To our knowledge, the application of MSiEM models to the educational field has only been performed by Steele, Vignoles, and Jenkins (2007).

The creation of a model of simultaneous equations presents certain challenges to estimation (see Gujarati, 2004). These models have a complex structure and their functioning is based on certain assumptions which should be verified prior to their application. The two most important assumptions are that the number of equations should equal the number of endogenous variables to be estimated (i.e., math and financial skills). As for identification, this requires that the conditions of order and range are satisfied. The first, order, requires that in each equation the number of excluded regressors is greater than the number of endogenous variables included minus one. The range condition requires the second equation to contain at least one exogenous variable not included in the first equation. The specification proposed in our work fulfils the three above-mentioned assumptions.

Multi-level models are especially appropriate for working with data nested at various levels, for example those data supplied by almost all educational databases. This is because this data structure, as well as the intra-group correlation, causes the characteristics and outcomes of students attending different schools to vary (Hox, 1995). These models permit the analysis of variables acting at different levels (individuals and schools, for example) and they allow the identification of the proportion of the total variance of an outcome that is attributed to each of the specified levels (Bryk & Raudenbusch, 1988). In analytical terms, the level 1 equation is determined as follows:

$$y_{ik} = \pi_{0k} + \sum_{p=1}^{P} \pi_{pk} a_{pk} + e_{ik} \text{ with } e_{jk} \sim N(0,\sigma^2) \quad (1)$$

where Y_{ik} is the expected result for individual i in school k; a_{pk} is an explanatory variable p of level 1 for the individual i from school k, π_{pk} are the level 1 coefficients (p = 0, 1 ,..., P) and e_{ik} is the random effect of level 1. For level 2 (schools), the coefficients π are treated as variables to be estimated, and thus:

$$\pi_{pk} = \beta_{0pk} + \sum_{q=1}^{Q_p} \beta_{qpk} X_{qpk} + r_{qpk} \quad (2)$$

where β_{qpk} (q = 0, 1, ..., Q_p) are the level 2 coefficients, X_{qpk} is a level 2 predictor and r_{qpk} is a random effect. The model assumes that, for each unit k, the vector $(r_{q0k}, r_{q1k}, ..., r_{qPk})'$ is distributed based on a normal multivariate where each element has a mean of zero and a covariance matrix T_π, with a maximum dimension of (P + 1) × (P + 1).