Does skipping breakfast affect academic performance? Evidence from PISA

¿Afecta al rendimiento académico saltarse el desayuno? Evidencia en PISA

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Abstract

Breakfast has long been believed the most valuable meal of the day, since it has been shown to be an important determining factor of a healthy lifestyle. The aim of this research is to analyze the breakfast habits of 15-year-old students in the Organization for Economic Cooperation and Development (OECD) and to examine whether the positive effects of eating breakfast on health also translate into better levels of academic performance in reading, mathematical and scientific literacy. To this end, we use data from the Program for International Student Assessment (PISA) 2015 round and estimate ordinary least-squares regressions (OLS) applying final student weights and balanced-repeated-replication weights to consider the hierarchical structure of the data. School fixed effects and country fixed effects are also considered in all our estimations. The descriptive analysis shows that in some of the countries participating in PISA 2015 up to a 35% of 15-year-old students reported not eating breakfast before going to school. As for the relationship between eating breakfast and academic performance, our results evidence that eating breakfast before school is associated with higher scores in

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mathematics and science. Based on these results, we consider that it would be advisable to develop policies aimed at encouraging adolescents to eat breakfast, such as school breakfast programs or social network awareness policies, to take advantage of all the benefits that the habit of eating breakfast entails, including the advantages at the academic level demonstrated in this research.

Keywords: academic performance, breakfast, PISA, secondary education, student.

Resumen

Durante mucho tiempo se ha considerado que el desayuno es la comida más valiosa del día, ya que se ha demostrado que es un importante factor determinante de un estilo de vida saludable. El objetivo de esta investigación es analizar los hábitos de desayuno de los estudiantes de 15 años de países miembros de la Organización para la Cooperación y el Desarrollo Económico (OCDE) y examinar si los efectos positivos de desayunar sobre la salud se traducen también en mejores niveles de rendimiento académico en las competencias de lectura, matemáticas y ciencias. Para ello, utilizamos datos de la ronda 2015 del Programa para la Evaluación Internacional de Alumnos (PISA) y estimamos regresiones por mínimos cuadrados ordinarios (MCO) aplicando ponderaciones finales de los alumnos y ponderaciones de repetición equilibrada para considerar la estructura jerárquica de los datos. También se consideran efectos fijos de escuela y efectos fijos de país en todas nuestras estimaciones. El análisis descriptivo muestra que en algunos de los países participantes en PISA 2015 hasta un 35% de los estudiantes de 15 años declararon no desayunar antes de ir al colegio. En cuanto a la relación entre desayunar y el rendimiento académico, nuestros resultados evidencian que desayunar antes de ir a la escuela se asocia con puntuaciones más altas en matemáticas y ciencias. En base a estos resultados, consideramos que sería recomendable desarrollar políticas dirigidas a incentivar a los adolescentes a desayunar, tales como programas de desayunos escolares o políticas de concienciación en redes sociales, para aprovechar todos los beneficios que conlleva el hábito de desayunar, incluyendo las ventajas a nivel académico demostradas en esta investigación.

Palabras clave: rendimiento académico, desayuno, PISA, educación secundaria, estudiante.

Introduction

The Coleman Report (Coleman et al., 1966) introduced the idea of the "educational production function". An education production function considers that the cognitive performance of students is determined by a series of educational factors affecting a student's learning, such as students' characteristics, families, peers, teachers or schools. Among these factors, students' eating habits could play a relevant role. The theoretical basis for the previous assertion lies in the fact that the former literature has shown that there is a relationship between eating habits and cognitive development (Gómez-Pinilla, 2008).

Within the daily meals, breakfast is a meal that a significant percentage of the population continues to skip (see section 4.1), but which previous research has shown to play a positive role in cognitive performance (Widenhorn et al., 2008; Hoyland et al., 2009; Pivik et al., 2012; Wesnes et al., 2012). The aim of this research is to analyze the eating breakfast habits of 15-year-old students and to examine whether eating breakfast before going to the school is associated with students' academic performance in reading, mathematical and scientific literacy. For our research aim, we use data from the Program for International Student Assessment (PISA) 2015 round and estimate ordinary least-squares regressions (OLS) applying final student weights and balanced-repeated-replication (BRR) weights, as well as considering school and country fixed effects.

Our research makes a relevant contribution to the previous literature for various reasons. The first of them is that our study is the first to use international assessments (PISA data) to measure the relationship between breakfast and academic performance. Moreover, our research is novel because it focuses on analyzing the set of OECD countries participating in PISA 2015. Up to date, previous studies (see section 2) that have analyzed this relationship have been based on very particular contexts of specific regions, which in many cases, considering the techniques employed, limits the validity of the results. Our research aims to overcome these limitations by having a large number of observations and being able to evaluate different regions and countries. The consideration of all OECD countries is possible given that PISA works with standardized competence tests and allows the comparison between the participating countries. In addition, our research is also novel because we conduct an analysis by competences (reading, mathematical and scientific

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literacy), i.e., we want to study whether eating breakfast has an impact on academic performance and if so, whether this is more pronounced in some competences.

Our results show that eating breakfast before school is associated with higher scores in mathematics and science, while being not statistically significant in reading. Moreover, we find that the association is stronger for mathematics than for science. According to our findings, we consider it necessary to consider breakfast as an essential meal in adolescents and we suggest that it would be advisable to develop programs that promote breakfast (breakfast at school and awareness policies on social networks), especially in those countries where a high percentage of students still do not eat breakfast before going to school.

The remainder of this paper is organized in the following manner. In section 2, we provide an overview of previous studies that have analyzed the relationship between eating breakfast and academic performance. Section 3 then describes the PISA 2015 database and the variables included in our models, as well as the methodological approach. Section 4 presents the results of the descriptive analysis regarding breakfast eating habit across countries and of the analyses on the relationship between eating breakfast and academic performance. Finally, section 5 concludes with conclusions and reflections on the results, as well as possible routes for further research.

Literature review

The following is a review of the previous literature that analyses the relationship between eating breakfast, cognitive development and academic performance of children and teenagers at school age. So far, previous research shows a positive association between eating breakfast and students' cognitive function mainly based on laboratory experimental studies (Hoyland et al., 2009). In this regard, Widenhorn et al. (2008) ran an experiment with 104 American students between 13 and 20 years of age and found that eating breakfast has positive effects on students' cognitive function and attention in the short-term. In the same line, Wesnes et al. (2012) analyzed 1,386 UK students aged 6-16 years and also observed that those who had eaten breakfast showed superior performance on attention and memory tests. In the USA, Pivik

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et al. (2012) recruited 116 children between 8–11 years old and found that when children eat breakfast, neural network activity involved in processing numerical information is functionally improved. Therefore, the previous studies show that breakfast appears to have a positive effect on cognitive activity.

If we consider the results of the previously mentioned studies and conclude that eating breakfast leads to an improvement in attention and cognitive performance, it is to be expected that this is also reflected in a better academic performance of the student, especially if the habit of eating breakfast is continuous throughout the academic year. In this regard, we find several previous studies that have analyzed the direct relationship between breakfast and academic performance measured either through school grades or standardized test scores (Adolphus et al., 2013). In this line of research, Kim et al. (2003) collected data about eating habits from 6,463 boys and girls (10–17 years) in Korea and found that the grade point average (GPA) of students was strongly associated with dietary behaviors, including the frequency of breakfast consumption. In Oslo (Norway), Lien (2007) collected data from all junior high schools and found that skipping breakfast was a common feature among adolescents aged 15–16 and had negative implications on mental distress and school grades. Similarly, Gajre et al. (2008) collected data from 379 students aged 11–13 in India and found that the regular habit of eating breakfast, as opposed to irregular consumption or skipping breakfast, leads to significantly higher grades in science and English. In Spain, Fernández-Morales et al. (2008) did a nutritional study on the breakfast quality of 467 students aged 12-17 and found that students who habitually ate breakfast were more likely to achieve higher school grades than those skipping it. In a similar line, Edwards et al. (2011) used data from 800 sixth graders in a Midwest city school district in the United States and found that those students who ate breakfast 5 days or more per week obtained higher mean scores in mathematics (Measure of Academic Progress test) than those who ate breakfast 4 days or less, while no association was found for reading. In the Netherlands, Boschloo et al. (2012) used data from 605 students aged 11-18 years and also found that students who reported skipping breakfast twice or more times per week, had lower end-of-term grades and more self-reported attention problems. This positive association between breakfast and academic performance was also found by O'Dea and Mugridge (2012) in Australia. The authors

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analyzed 824 children aged 8–13 years and found that eating breakfast and the nutritional quality of breakfast significantly predicted NAPLAN (National Assessment Program—Literacy and Numeracy) literacy school grades. So (2013) analyzed data from 75,643 adolescents aged 12–18 year in Korea and also found that frequency of breakfast consumption was positively correlated with academic performance.

More recently, Littlecott et al. (2016) carried out a research with 3,093 students in Wales (aged 10-11 years) and found significant associations between eating breakfast and better scores on Key Stage 2 Statutory Assessment Tests. Vishnukumar et al. (2017) also found a significant difference in the grades obtained between breakfast skippers and breakfast non-skippers. Specifically, the authors found that students aged 11-16 who do not eat breakfast score worse, based on an analysis of 195 students in Sri Lanka's Batticaloa district. In Canada, Sampasa-Kanyinga and Hamilton (2017) analysed a sample of 10,272 students aged 12-18 years and also found that students who ate breakfast on all five days were more likely to obtain higher school grades. In the same line, Masoomi et al. (2020) ran a cross-sectional study in Iran with 600 students in the first grade of high school and found that breakfast meal had a significant positive effect on academic performance. The most recent studies in this area date from 2021 and also find a positive association between eating breakfast regularly and academic performance levels. Specifically, Lee et al. (2021) analysed data from 835 children aged 6-12 years in China and found that eating breakfast regularly was associated with higher levels of academic achievement. Similar analysis were conducted in Chile with 1,181 adolescents aged 10-14 (Peña et al., 2021) and in Singapore with 82 adolescents (Kawabata et al., 2021), which also found positive effects of eating breakfast on academic performance.

While, on the basis of the above-mentioned studies, there seems to be consensus on the positive impact of breakfast on academic performance, previous studies face some limitations that we are trying to overcome in this research. In this sense, many of the studies we have cited use a very limited sample of participants (Gajre et al., 2008; Fernández-Morales et al., 2008; Edwards et al., 2011; Boschloo et al., 2012; O'Dea and Mugridge, 2012; Vishnukumar et al., 2017). Considering that a study's statistical power is directly related to the sample size and that most of the commonly used statistical methods rely on assumptions that are less likely to be satisfied under small samples (Morgan, 2017), the robustness

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of many of the results obtained by the previously described studies could be improved by using larger samples, as in the case of our research. Furthermore, most of the mentioned studies analyze the impact of eating breakfast on student school grades. However, in our research, instead of using school grades, we use data from PISA, a standardized achievement test. This makes our research the first paper to study the relationship between eating breakfast and academic performance measured through PISA results. As the PISA tests are designed to be independent of the curriculum and measure students' competences and their ability to cope with real-life problems, using these data allows us to include in our estimates all countries participating in the PISA tests and to be able to work with a large sample size. In addition to allowing us to work with a large sample size, using PISA data implies using data from one of the most well-known and best executed educational assessments in the world and that is taken into consideration by most governments when making educational policy decisions. Therefore, we believe that our research contributes to the previous literature by providing new empirical evidence with a large sample of students and making use of one of the most important databases in education, not analyzed so far for the study of the relationship between breakfast and academic achievement.

In addition to the novelties previously mentioned, we consider that it is still necessary to provide additional empirical evidence on this issue given that, as shown in section 4.1 of this paper, there is still a high percentage of students in the OECD who do not eat breakfast before going to school. Therefore, we consider it necessary to add new empirical evidence that can help convince policy makers of the importance of considering breakfast as a determining factor of academic performance.

Data and Methodology

Program for International Student Assessment (PISA)

This research uses data from PISA, an assessment programme that aims to assess the extent to which students near the end of compulsory education have acquired some of the knowledge and competences necessary for full participation in society. All OECD member countries participate in the study, as well as some partner countries. In the PISA 2015 wave a total

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of 519,334 students from 73 regions participated. Detailed information about the PISA test can be found on the website: https://www.oecd.org/pisa/.

PISA tests are conducted every three years and are taken by 15-year-old students in various key subject areas (mathematics, science and reading). In addition to the tests of competences, students, teachers, and schools answer contextual questionnaires that allow research such as this to be carried out and to link different factors in the student's environment to his or her academic performance. The test was first conducted in 2000 and the latest results available are for 2018. However, in this research we work with data from PISA 2015, given that it is the most recent round in which we find information on whether or not students eat breakfast before going to school.

The selection process for students participating in PISA has two stages: (1) first, public and private schools in the various countries are randomly selected, with a minimum of 150 schools per country; (2) then a minimum of 5,400 15-year-old students per country from the selected schools are selected. This sample selection process guarantees the representativeness of the sample. However, the hierarchical structure of the data makes it indispensable to use methodologies that consider the multilevel structure when performing statistical analyses, in order to obtain robust results.

Variables

Dependent variables

Our research aims to analyze the relationship between eating breakfast and academic performance. We measure academic performance with PISA scores, so the dependent variables in our analysis are the scores obtained by the students in the tests of the three following competences evaluated in PISA: mathematics, science and reading.

Mathematical competence analyses the student's capacity to formulate, use and interpret mathematics in different situations. It comprises reasoning mathematically and applying mathematical notions, methods, facts, and tools to define and predict events (OECD, 2015). The competence in reading comprehension assesses the student's ability to comprehend,

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use and analyze critical texts so as to accomplish their personal objectives, develop their chances and understanding and contribute to society (OECD, 2015). Finally, the competence in science analyses students' skills in dealing with scientific issues and ideas. According to PISA, a scientifically literate individual is someone who is willing to speak out about science and technology in a reasoned way (OECD, 2015). The scores obtained by the students in the tests of the different competences are scaled so that the OECD average in each competence is 500 and the standard deviation is 100 (OECD, 2015).

The PISA tests are designed on the basis of the use of different sets of items and various assessment models. In this way, each student is confronted with a subset of items from the available set. This design makes it necessary to use scaling techniques in order to establish a common scale for all students. To this end, in PISA 2015 the average scores for the three competencies assessed are estimated using the item response theory (IRT). IRT uses statistical models to predict the probability of responding correctly to an item. It does this by establishing response patterns and predicting this probability by considering the student's responses to other items. Thanks to the application of this methodology, the performance of students in the different competences is comparable and can be measured on the same scale, regardless of the fact that each student has been administered different items. Given that each student completed only a subset of items, the scores were estimated as plausible values. Specifically, ten plausible values are estimated for each student in each competence. These values represent the distribution of potential scores for all students with similar characteristics and the same patterns of item response (OECD, 2015). In our estimations, we have decided to use of all ten plausible values available in PISA 2015 as according to OECD (2017) it is the best estimate for a student's ability.

Independent variable: "Breakfast before going to school"

In PISA 2015, students are asked to report whether they eat breakfast before going to the school *("Before going to school did you: Eat breakfast")* with the answer choices being: no or yes. Although PISA 2015 questionnaire does not provide any information about the specific diet students may follow, the information about if students eat breakfast or

not before going to school allows us to obtain some first relevant results on this potential association that should of course be complemented with future research that also considers the quality of the breakfast. Therefore, the dependent variable used in this research is a dichotomous variable hereafter called "Breakfast before going to school" which takes values 0 (the student did not have breakfast before going to school) and 1 (the student did have breakfast before going to school).

We find it necessary to indicate that the PISA estimates on eating breakfast may overestimate the actual number of students skipping breakfast. This can be explained by the fact that some students might decide to have breakfast when they arrive at school. However, since the questionnaire only asks if students had breakfast before going to school, some students who eat breakfast at school might answer "no" and would count as students who skipped breakfast, when in fact they did not. Nevertheless, we do not expect this to have much impact on our data given that, with the exception of the School Breakfast Program in the United States, programs advocating school breakfast are rare in most countries participating in PISA. Even in the United States, where this program has been in place for years, only about 4% of students participated in this program last year. Bearing this in mind, we do not expect overestimation in this variable to be a problem that biases our results.

Control variables

To properly measure the relationship between eating breakfast and academic performance, confounding variables must be controlled. In this research, we have made used of different control variables that previous literacy has shown to be relevant to explain academic performance and that are asked in PISA 2015.

At the student level we use as control variables the gender, the index of economic, social and cultural status (ESCS), the index of immigration status (native, second generation or first generation), the repetition of a grade and the starting age of International Standard Classification of Education (ISCED) level 0. ESCS is a composite score built by: (1) indicator of parental education; (2) highest parental occupation; (3) and home possessions including books.

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We control for the student gender as research to date has reported a gender gap in academic success, with boys falling behind girls (Clark et al., 2008; Parker et al., 2018). Regarding the inclusion of the ESCS, the meta-analysis conducted by Sirin (2005) evidences a strong relationship between the socioeconomic status and academic achievement. We also consider the migration status to be a relevant factor affecting academic achievement. According to current research, immigrants are typically at a disadvantage compared with natives in terms of academic performance (Makarova and Birman, 2015; Borgna, 2016). As for the repetition of a grade, Allen et al. (2009) examine the effect of grade retention on academic outcomes and conclude that there is a negative effect of grade repetition on academic outcomes. Finally, regarding the starting age of ISCED 0, research evidence suggests that students that have been exposed to pre-school education prior to their entry into the regular school system out-perform their counterparts without such experience (Meyers, 1992; Taiwo et al., 2002).

At the school level, we control for: (1) class size; (2) school ownership (public, semi-private or private); (3) school location; and (4) the average index of economic, social and cultural status of students in the school. The inclusion of class size is relevant since previous research has found a statistically significant negative effect of class size on academic achievement (Heinesen, 2010; Krassel and Heinesen, 2014). On the other hand, the ownership of the educational institution has also been shown to be a determining factor in academic performance (Lubienski and Lubienski, 2006; Boulter, 2017; Sakellariou, 2017). As for the school location, previous research has also shown that urban students tend to perform better than rural students (Alordiah et al., 2015). Finally, we have included the average ESCS of students in school as a proxy of the peer effect (Dannemann, 2019).

The definition of the categorical variables and the main descriptive statistics of all the variables used in this research are shown in tables A.I and A.II in the Appendix. Additionally, it is important to mention that the correlation between all the variables included in the estimates has been checked and it has been confirmed that in no case there are correlation coefficients greater than 0.3.

Methodology

Regarding the methodological approach followed in this research, first of all it is necessary to highlight that survey weights are required to analyze PISA data, to calculate proper estimations of sampling error and to make valid estimations and inferences of the population (OECD, 2015). As explained in section 3.1, the students participating in PISA were chosen randomly but the selection probabilities of the students vary. Therefore, in our estimations we incorporate survey weights to ensure that each sampled student properly represents the precise number of students in the full PISA population. Specifically, each student was assigned a weight that was defined by the reciprocal of the student's sample selection probability. In each step of our estimations, we apply the student weight for student j in school i proposed by OECD (2015) that consists of: (1) two base weights, the school base weight (the reciprocal of the probability of inclusion of school i into the sample) and the within-school base weight (the reciprocal of the probability of selection of student j from within the selected school i); (2) and five adjustment factors to compensate for: (i) non-participation by other schools that are rather comparable to school; (ii) for schools in some participating countries where only 15-year-old students who were enrolled in the modal grade for 15-year-old students were included in the test; (iii) for non-participation by students within the same school non-response cell and explicit stratum; (iv) to reduce unpredictably large values of the school base weight; (v) and to decrease the weights of students with remarkably large values for the product of all the previous weight components. All the results presented in this paper (both descriptive statistics and regressions) have been obtained using the corresponding weighting variables.

As explained previously, the PISA tests have a multilevel hierarchical structure, since students are nested into schools and schools are nested into countries. In order to obtain valid estimates, it is necessary to take this multilevel structure into account and account for divergences between schools and between countries. There are two options for considering this structure: resampling procedure and multilevel modeling. In this research we apply a resampling procedure by using the replicated weights provided in the PISA database together with the final weights at the student level and including country-fixed effects. Replicate weight techniques are believed to yield unbiased parameters by using numerous

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subsamples to determine the parameter in each one and estimate the sampling variance as from the variability of the parameter among the various samples and the estimate for entire sample.

Specifically, we have estimated the Ordinary Least Squares (OLS) model presented in equation (1) using the statistical software Stata and applying final student weights and balanced-repeated-replication (BRR) weights though the command *repest (*Avvisati and Keslair, 2014*):*

$$Y_{ijk} = \alpha + \beta B_{ijk} + \delta X_{ijk} + \lambda Z_{jk} + \varepsilon_{ijk} \quad (1)$$

Where denotes the score achieved by student "i" at school "j" in country "k". As mentioned in section 3.2, we use all the plausible values in our analysis in order to produce consistent standard errors. Therefore, the estimates of our principal models are derived from computing average estimates of each parameter obtained in regression models on plausible value scores. B_{ijk} is the answer of student "i"" to the question "*Before going to school did you: Eat breakfast"* ; X_{ijk} refers to a set of control variables related to socio-demographic characteristics of student "i" (gender, ESCS, index of immigration status, repetition of a grade, the starting age of ISCED 0), Zj_k represents a set of control variables related to school characteristics (class size, school ownership, school location, average school ESCD) and ε_{ijk} represents the individual error term. School fixed effects and country fixed effects are considered in all our estimations to control for the correlation between the values of the school variables of students from the same school and for systematic cultural and institutional differences at the country level.

Results

Descriptive analysis

Table I shows the frequency distribution of the answers for the question "*Before going to school did you: Eat breakfast*" in each of the participating countries in PISA 2015. The results are displayed from highest to lowest percentages of students skipping breakfast.

TABLE I. Answers for "Before going to school did you: Eat breakfast". Frequency distribution by country: PISA 2015

Jurisdiction	No (%)	Standard Error	Yes (%)	Standard Error	Number of observations
Austria	35.83	0.85	64.17	0.85	6,420
Slovenia	34.52	0.66	65.48	0.66	6,007
Singapore	34.34	0.59	65.66	0.59	6,022
Hungary	30.75	0.84	69.25	0.84	4,975
Chile	30.28	1.13	69.72	1.13	6,191
Slovak Republic	29.93	0.79	70.07	0.79	5,789
Czech Republic	29.60	0.65	70.40	0.65	6,556
Germany	29.30	0.73	70.70	0.73	3,299
United Kingdom	28.91	0.68	71.09	0.68	13,205
Israel	28.56	0.94	71.44	0.94	6,260
United States	28.26	0.66	71.74	0.66	5,436
Croatia	27.89	0.87	72.11	0.87	5,568
Switzerland	27.76	1.53	72.24	1.53	4,771
Bulgaria	26.42	0.80	73.58	0.80	4,825
Italy	25.94	0.75	74.06	0.75	10,955
Luxembourg	25.32	0.87	74.68	0.87	4,746
Canada	25.15	0.62	74.85	0.62	18,820
United Arab Emir	24.66	0.72	75.34	0.72	13,087
Brazil	24.23	0.58	75.77	0.58	12,757
France	23.69	0.57	76.31	0.57	5,547
Qatar	23.13	0.47	76.87	0.47	10,028
Australia	22.06	0.69	77.94	0.69	12,242
Belgium	21.55	0.40	78.45	0.40	8,622
Greece	21.36	0.43	78.64	0.43	5,303
Korea	21.17	0.82	78.83	0.82	5,519
Turkey	20.90	0.50	79.10	0.50	5,637
Lithuania	20.89	0.62	79.11	0.62	6,094
New Zealand	20.73	0.63	79.27	0.63	4,081

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Poland	20.24	0.73	79.76	0.73	4,403
Costa Rica	19.97	0.60	80.03	0.60	5,416
Iceland	19.60	0.75	80.40	0.75	3,103
Mean participating countries	19.54	0.17	80.46	0.17	399,840
Latvia	19.39	0.61	80.61	0.61	4,695
Uruguay	19.09	0.56	80.91	0.56	4,874
Mexico	18.98	0.64	81.02	0.64	6,620
Norway	18.85	0.74	81.15	0.74	5,075
Tunisia	18.30	0.74	81.70	0.74	4,371
Estonia	17.95	0.53	82.05	0.53	5,424
Finland	17.61	0.61	82.39	0.61	5,486
Hong Kong	17.35	0.60	82.65	0.60	5,247
Ireland	17.08	0.63	82.92	0.63	5,531
Sweden	16.97	0.63	83.03	0.63	4,849
Denmark	16.61	0.61	83.39	0.61	6,179
Dominican Republic	16.50	0.52	83.50	0.52	3,541
Spain	15.42	0.55	84.58	0.55	6,427
Chinese Taipei	15.39	0.83	84.61	0.83	7,685
Colombia	15.17	0.32	84.83	0.32	10,872
Thailand	14.93	0.47	85.07	0.47	7,927
Macao	13.22	0.63	86.78	0.63	4,466
Russian Federation	13.16	0.47	86.84	0.47	5,578
Netherlands	12.69	0.49	87.31	0.49	5,151
Montenegro	11.57	0.43	88.43	0.43	4,950
Peru	11.57	0.53	88.43	0.53	5,481
Japan	11.18	0.52	88.82	0.52	6,530
Portugal	10.35	0.47	89.65	0.47	7,103
B-S-J-G (China)	9.82	0.54	90.18	0.54	9,763

Source: Own elaboration with PISA 2015 data.

As can be seen, we obtain a wide range of average values that suggests important differences in eating breakfast habits in the PISA countries. At the lower end we have countries such as Austria, Slovenia and Singapore, where we observe that still around a 34-35% of the 15-year-old population reported not eating breakfast before going to school. At the other extreme, we find jurisdictions such as Beijing, Shanghai, Jiangsu, and Guangdong (B-S-J-G, China), Portugal or Japan where only 6-7% of students reported not eating breakfast before going to school. If we look at the average values for all the countries participating in PISA, we see that 19.54% of the total number of students who participated in the test reported not eating breakfast before going to school.

Based on these results, we believe that it is evident that there are still many students who do not eat breakfast before going to school and that further research is needed on the impact this may have on academic performance. The results obtained in the OLS estimates research will allow us to be in a position to make recommendations for educational policy in this regard.

OLS models

This section presents the main results of the estimated OLS models with school and country fixed effects. According to the results reports in Table II, we find a positive association between eating breakfast and students' test scores in mathematics and science, while in reading no statistically significant association is observed. If we look at the magnitude of the coefficients, we can conclude that the relationship seems to be somewhat higher in mathematics than in science. Reflections on these results are presented in section 5.

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TABLE II. Estimates for the association between eating breakfast and academic performance: PISA 2015.

VARIABLES	(1) Mathematics	(2) Reading	(3) Science
Breakfast before going to school	9.546***	-0.563	3.274***
	(1.175)	(1.135)	(0.999)
Controls			
Gender (female)	-15.19***	16.51***	-10.99***
	(0.890)	(0.976)	(0.930)
Starting age ISCED 0	-1.137***	-0.785*	-0.198
	(0.395)	(0.423)	(0.379)
Grade repetition	-53.65***	-55.51***	-52.13***
	(1.781)	(1.757)	(1.691)
Immigration status	-6.784***	-4.726***	-6.732***
	(1.379)	(1.705)	(1.381)
ESCS	11.67***	11.86***	12.50***
	(0.471)	(0.538)	(0.457)
Class size	1.127***	0.775***	1.020***
	(0.131)	(0.118)	(0.124)
School Ownership	-8.274***	-6.457***	-7.570***
	(2.653)	(2.208)	(2.388)
School Location	2.287***	0.305	2.692***
	(0.837)	(0.767)	(0.757)
ESCS school	42.14***	44.23***	45.55***
	(1.373)	(1.249)	(1.229)
Constant	480.0***	483.1***	494.4***
	(3.537)	(3.335)	(3.251)
R-Squared	0.247***	0.284***	0.273***
	(0.00655)	(0.00666)	(0.00596)
Observations	275,507	275,507	275,507

* Standard errors in parenthesis. Significance levels: ***p<0.01, **p<0.05, *p<0.1.

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While our focus is on the influence of breakfast on academic performance, other parameters in the estimates are also statistically significant and are in line with previous literature. In this sense, we find that most of the coefficients for the control variables included in our regressions are statistically significant. Specifically, we find that test scores in mathematics and science are clearly higher for boys, while in reading are higher for girls. We also find that students who earlier attended pre-primary school get better marks in mathematics and that in all the competences higher levels of ESCS are associated with better test scores. Likewise, we find a strong negative relationship for all the competences between repeating a grade, being immigrant and academic performance. With regard to the control variables at the class and school level, we find a positive and significant relationship for the class size, size of the city/region where the school is located and the socioeconomic characteristics of schoolmates.

Concluding remarks

The results of this research lead to two main conclusions: (1) the descriptive analysis showed that there is still a high percentage of students in many OECD countries who do not eat breakfast before going to school; and (2) the econometric analysis showed that there is a positive association between breakfast and academic performance in mathematics and science. With these two conclusions in mind, we believe it is particularly pertinent to make recommendations to policy makers. This is relevant given that, on the basis of the empirical evidence shown in this research, those countries with high percentages of students who skip breakfast would benefit, in terms of academic performance, if they were able to reduce these rates.

In order to make appropriate recommendations to policy makers to reduce the percentage of students skipping breakfast, it is first necessary to know what causes young people to decide whether or not to eat breakfast. These causes are not investigated in this article, but previous studies have focused on them and are referenced below. In this sense, research up to date has shown that students living in families that enjoy higher family functioning (e.g., communication, closeness, problem solving, behavioral control) are more likely to eat breakfast before school

(Berge et al., 2013). Additionally, research has also shown that a higher socio-economic status is positively associated with eating breakfast before school (Hussein, 2014; Chen et al., 2018). Considering the second of these causes, the socio-economic level, we believe that one appropriate recommendation would be to implement breakfast programs in schools. Implementing such programmes is a way to ensure that children and adolescents from households where socio-economic status is one of the reasons why students do not eat breakfast, have the opportunity to enjoy this meal and thus improve their academic performance levels. An example of the success of these type of programmes is the "School Breakfast Program" in the United States. This program, which began in 1966, has lasted until today and has fundamentally improved the nutrition and dietary needs of children in low income families and with working parents. Since these type of policies are designed to respond to the needs of the neediest households, we also believe that it would be necessary to develop parallel campaigns (for example on social networks) to raise awareness of the importance of breakfast. In this way, those students who do not meet the characteristics to join school breakfast programmes but often skip breakfast for other reasons, may also realize the importance of eating breakfast and change their eating habits. Furthermore, we believe that schools, in addition to the measures taken by public administrations, could also raise awareness of the importance of breakfast among children and adolescents. In this sense, tutorial action could play a key role.

Although our results provide empirical evidence to the scientific debate and are novel for the reasons explained in the introduction of this article, we consider that there are still some limitations that could be overcome and which justify the need for further research on this topic. In this respect, we consider that it would be especially relevant to carry out natural experiments in those countries where there are still high percentages of students who do not eat breakfast before going to school. In this way, a causal relationship could be confirmed. However, given the difficulties in carrying out this kind of experiments with a sufficient sample to validate the results, this research sheds light on the positive relationship between eating breakfast and academic performance and makes recommendations to promote breakfast among children and adolescents.

Even if this research focused on analyzing the benefits of eating breakfast on academic performance, we would like to point out that

potential advantages of eating breakfast go beyond the academic scope and it has been demonstrated that eating breakfast has an important positive influence on factors such as health, mood states, self-regulation and self-esteem (Birch et al., 2007; Cooper et al., 2011). Therefore, the recommendations put forward in this research would not only improve academic performance but based on previous studies, would also have other beneficial effects on children and adolescents. In summary, we believe that the results achieved in this research - based on empirical evidence from a prestigious database such as PISA and using a large number of observations - can serve as a reference for policy makers to develop campaigns and policies aimed at making breakfast a fundamental meal that no child or adolescent skips before starting the school day.

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Appendix

TABLE A.I. Definition of the categorical independent and control variables.

	Categories
Independent variables	
Breakfast before going to school	0=No 1=Yes
Control variables at student level	
Gender (female)	0=male 1=female
ISCED 0	0=1 year or younger 1=2 years 2=3 years 3=4 years 4=5 years 5=6 years or older 6=I did not attend <ISCED 0>
Repeater	0=No, never 1=Yes, once or more
Immigrant status	0=Native 1=Second-Generation 2=First-Generation
Control variables at school level	
School ownership	0=Public school 1=private government dependent 2=Private
School location	0=A village, hamlet or rural area (fewer than 3 000 people) 1=A small town (3 000 to about 15 000 people) 2=A town (15 000 to about 100 000 people) 3=A city (100 000 to about 1 000 000 people) 4=A large city (with over 1 000 000 people)

TABLE A.II. Descriptive statistics of the dependent, independent and control variables*

	Observations	Mean	Std. Deviation	Min.	Max.
Dependent variable					
PV1MATHS	275,507	480.31	97.90	65.85	870.51
PV1READING	275,507	484.82	98.29	0	882.12
PV1SCIENCE	275,507	485.23	97.64	108.99	888.36
Independent variable of interest					
Breakfast	275,507	0.80	0.40	0	1
Control variables at student level					
Gender (female)	275,507	0.53	0.50	0	1
ISCED 0	275,507	2.68	1.43	0	6
Repeater	275,507	0.13	0.34	0	1
Immigrant status	275,507	0.19	0.53	0	2
ESCS	275,507	-0.20	1.08	-7.26	3.96
Control variables at school level					
Class size	275,507	28.40	9.20	13	53
School ownership	275,507	0.30	0.62	0	2
School location	275,507	2.22	1.18	0	4
School ESCS	275,507	-0.21	0.73	-4.02	1.54

* The descriptive statistics are calculated for the subsample of students participating in PISA who have information for all the variables included in our OLS estimations.