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New technologies in education. The case of Spain

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ABSTRACT

The use of active learning methodologies in higher education is a priority objective within the European Higher Education Area. The paradigm shift towards education in competences requires new teaching strategies focused on giving greater protagonism to students, putting them at the centre of their own learning process. In this transition, information and communication technologies (ICT) are playing a fundamental role. Virtual teaching has specific characteristics that make it possible to tailor the teaching-learning process in ways that are impossible by other means. Self-learning or 'learning to learn', promoted by the new paradigm of education in competences, is inseparable from the use of virtual learning tools. An analysis of data on the growth and prevalence of e-learning in Spain is conducted in the paper, and using new methodologies based on fractional integration we offer important insights into the growth of e-learning in volume and importance with respect to traditional teaching methodologies. This growing relevance has important implications for educators, educational institutions and governments that will have to adapt to the needs of a growing public that demands this type of training.

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1. Introduction

In our increasingly digitalised and globalised society, e-learning has revolutionised the way in which students acquire knowledge. In parallel to the development of information and communications technologies (ICT), new digital media and platforms have furthered the development of e-learning. E-learning, online learning or cyberlearning, are all terms used to refer to this type of learning. E-learning can be defined as any form of learning in which digital devices and electronic media are used as a vehicle or support for the teaching-learning process, regardless of whether lessons are imparted remotely or in person (RAE, 2023). However, e-learning is habitually understood as remote education through digital media and it is this methodology that will be considered in this paper.

This form of education or training is ideally suited to overcome a number of significant barriers presented by traditional methods, such as geographical distance, fixed schedules and limited interactivity with educational materials. E-learning offers educational opportunities to sectors of the population

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which would otherwise be unable to access education due to time restrictions or the difficulty in physically attending a classroom (Mastan et al., 2022). It may be argued that distance education existed long before the advent of digital technologies and thus suggest that distance or availability were not insurmountable barriers prior to the appearance of ICT. However, in reality only a small number of people pursued this form of education compared to presential learning, a trend which has dramatically changed since the development of ICT made it possible to learn using electronic means and devices, that is, e-learning. This is because e-learning has transformed distance education into a dynamic, interactive, personalised and even collaborative task, far removed from the tedious and solitary forms of distance learning which required iron discipline on the part of the student to successfully complete their studies (Isroani et al., 2022). E-learning has also democratised access to education, enabling any person anywhere to acquire specific knowledge about virtually any subject thanks to the endless offer of online courses.

However, the widespread use of e-learning presents challenges such as high-speed internet access in rural areas and access to computer equipment for the most disadvantaged sectors of the population. The reluctance of some teachers and institutions to adopt new distance learning technologies must also be overcome, often due to insufficient training in digital skills. In this regard, countries such as Finland and Australia, which offer ongoing training to their teachers in digital tools and encourage them to experiment with new methodologies, are examples for Spain to follow in improving teacher training and implementing innovative training models. An important part of this task involves the participation of institutions and educational centers, which are increasingly considering the promotion of technology in the classroom as a priority.

E-learning has seen exponential growth in the last decade and is expected to continue growing in the coming years. The success of Coursera, one of the leading e-learning platforms, illustrate this growth, rising from 21 million users in 2016 to 92 million users in 2021, an increase of 338% between 2016 and 2020, and rising to 438% the following year. Furthermore, the platform saw a rise not only in the number of students but also in the number of courses in which each student is enrolled, rising from an average of 1.2 courses per user in 2016 to 2.0 in 2021, with a total of 189 million courses conducted that year. It is estimated that the e-learning sector will become a 350 billion dollar global industry by 2025. In 2024, the European e-learning market is expected to exceed global average growth by some 14%, with an increase of some 28 billion dollars (Coursera, 2025).

Spain exemplifies these global trends through its high adoption rates. Thus, Spain is one of the largest markets for e-learning in the EU. According to a study by Eurostat, Spain ranked second in the number of on-line courses in 2022. A survey conducted for the study showed that 42% of the Spanish population had enrolled in a course in the last three months. The COVID-19 gave a significant boost to e-learning throughout the world and the figures for the increase in the number of students and growth in the revenues of companies dedicated to online education show that the greatest growth was seen between 2019 and 2020, coinciding with the onset of the pandemic. In the case of Spain, 2020 saw an 11% rise in the number of students compared to the previous year. These figures show that there is a high demand for on-line courses around the world and in Spain in particular. To respond to this demand, courses are provided by both national and foreign companies, given that these products can be distributed easily via internet around the world. In Spain, there are currently some 300 companies dedicated to e-learning with an annual turnover of approximately 5 billion euros with 30% of these companies offering exclusively online courses. This production is consumed within Spain and abroad just as some e-learning courses offered by foreign companies are also consumed in Spain. In terms of revenues, Spain has seen a large growth in e-learning turnover, from 213.5 million euros in 2014 to 1629.3 million euros in 2023, according to data from the CNMC 2024. Around 60% of this volume corresponds to the domestic market and the rest to domestic production consumed abroad or vice versa. Detailed data on this evolution of the Spanish market will be analysed in this article.

The aim of this work is to analyse the relation between the growth of e-learning in higher education in Spain and the volume of online courses developed according to their place of origin. This analysis will help evaluate the degree of development of active learning technologies in Spain within a larger global marketplace. Thus, the hypothesis that we formulate is that the series corresponding to the

revenues in Spain in the e-learning sector are persistent though with a mean reverting pattern, i.e. with shocks disappearing by themselves in the long run.

This is due to the versatility of e-learning, which has permitted the incorporation into distance learning of active and dynamic teaching methodologies such as gamification, simulators or adaptive learning, among others, oriented towards education in competences in line with the aims of international organisms such as the EHEA and UNESCO and articulated in the Bologna process. The development of online courses involves the harnessing of active pedagogical technologies which break with the traditional mechanics of classroom teaching by putting the student at the centre of the learning-teaching process (Imawan et al., 2025; Sokolova et al., 2025).

Additionally, e-learning resolves the barriers to accessing education mentioned above thanks to its unique characteristics:

- Online access to courses and materials.
- Learning activities can be done at the convenience of the student, facilitating the balancing of personal and professional responsibilities.
- Continuous oversight, support and assessment of student performance.
- Learning can incorporate various formats such as videos, readings, interactive activities, online simulations or debates, etc.
- Self-directed learning is facilitated, permitting the personalised oversight of progress in the activities and tasks to be completed.
- Collaborative learning is also facilitated through the creation of virtual spaces for encounter and cooperation.

However, e-learning also has some shortcomings or drawbacks, such as the lack of direct interaction with teachers and classmates, replaced by virtual meetings in a digital environment; the difficulty in filtering the enormous quantity of information which can be obtained through digital media to find and process relevant information; the problem of proper time management and concentration on appropriate tasks and avoiding losing time on peripheral tasks or distractions.

Also, the methodology used, and based on fractional integration is another novel contribution of this work, since it is a relatively novel technique in time series, and captures extremely well long-term patterns in revenue data throughout the differencing parameter.

The rest of the paper is structured as follows. Section 2 presents a historical context on new technologies in education. In Section 3 the model is presented. Section 4 displays the data used in the work. Section 5 is devoted to the empirical results while Section 6 concludes the manuscript.

There are numerous studies in the literature on e-learning that address various aspects, such as current models, operating trends, the range of offerings offered by public and private universities, student satisfaction with this type of education, and its effectiveness compared to traditional education, among others. Although many of these studies present data on the percentage of distance education compared to traditional education or annual growth over a specific period, there are no studies based on a detailed analysis of the growth of e-learning in Spain and its relationship to the volume of courses offered. This study therefore fills this gap.

2. Historical context

According to García Aretio (2013), the factors that led to the emergence and development of distance learning were the needs of lifelong learning, the scarcity of traditional media, and the evolution of technological means. Thus, the first distance learning courses began through correspondence in the mid-19th century, evolving hand in hand with advances in telecommunications technologies to the present day. The policies that have most driven the adoption of new technologies in education are those postulated in the Bologna Process, the result of the globalization of education, as indicated by Palés-Argullós et al. (2010).

The field of e-learning is in constant evolution, integrating newly developed technologies such as artificial intelligence, virtual reality, augmented reality and gamification, in order to offer a better learning experience that is increasingly tailored to the particular needs of each student (García et al., 2020).

To cover this wide spectrum of individual learning needs, there are any number of educational platforms with different pedagogical objectives (MOOCs, microlearning, LMS). Another factor in the evolution of e-learning is the adaptation of common technological devices such as smart phones and tablets, referred to by authors such as Chao (2019), Pérez and Díaz (2021) and Criollo-C et al. (2021) as 'mobile learning'.

E-learning encompasses not only learning but also the assessment and oversight of learning (Vivas Escalante et al., 2023). Thus, techniques of data analysis, such as Big Data, permit the identification of learning patterns that can help in the design of more effective learning programs (Gao et al., 2021). Course development increasingly involves inclusive design techniques which facilitate access for different groups with a diverse range of disabilities and disadvantages as indicated by Hernández Sánchez and Ainscow (2020).

With regards to the teaching methodologies used in e-learning, various studies highlight the affinity between active learning methodologies and e-learning. Mora-Vicarioli and Salazar-Blanco (2019) note that students take a more active role thanks to the flexibility, support and close interaction between students and teachers in the e-learning environment. Similarly, Zambrano et al. (2020) found that the use of ICT in higher education has been an effective strategy in language learning and other areas of knowledge.

Research by authors such as Vanegas et al. (2022) underscore some of the challenges and difficulties to be overcome in the area of e-learning, including digital literacy, accessibility and the potential isolation of the student. Among the solutions to these problems, according to Crisol Moya et al. (2020) and others, is greater teacher training in digital technologies, the incorporation of a universal design oriented specifically towards accessibility and the creation of collaborative environments and communities to further online learning.

A number of studies (Affouneh et al., 2020; Abumalloh et al., 2021; Bygstad et al., 2022) coincide in signalling the COVID-19 pandemic as a factor which accelerated the development of digital learning, pushing thousands of students and teachers to take up digital e-learning tools which had previously remained dormant. The data on e-learning turnover in Spain in Table 1 show this acceleration in growth, increasing by more than 200 million in 2021 compared to 2020, the highest in the series. Specifically, the third quarter of 2020, coinciding with the start of the school year and the second confinement, is where the highest growth is observed, rising from 185.9 million in the second quarter to 328.6 million in the third quarter. Once the pandemic was over, the data on the volume of e-learning in Spain did not fall back, but rather continued to grow, demonstrating a trend which, although occasionally increased by this circumstance, is based on factors not only of mobility but also of adaptation to new teaching methodologies and greater versatility.

E-learning has always been closely linked to the development of new digital technologies, such as Web 2.0, social media, wikis, blogs, LMS platforms, and others, Thus, as Bai et al. (2021) have concluded, future avenues of research and experimentation in the field of e-learning will most likely be determined by advances in artificial intelligence, robots, cloud-computing, augmented reality and other developments.

3. The model

The methodology used in this work is based on a time series technique denominated fractional integration. Originally proposed in the 80s by Granger (1980), Granger and Joyeux (1980) and Hosking (1981) a fractionally integrated model can be represented as follows

$$(1-L)^d x_t = u_t, \quad t = 1, 2, \ldots, \tag{1}$$

where x(t) indicates the time series under examination; L is the lag operator, i.e. Lx(t) = x(t-1); d may be a real value (and thus potentially fractional); and u(t) is an integrated of order 0 or I(0) process (i.e. a well defined covariance stationary series). At this point, it is important to mention that the polynomial in

Table 1. Quarterly and annual growth of revenues in e-learning in Spain (€) according to direction of transaction.

		Direction of transaction				
Year	Quarter	Within Spain	From abroad to Spain	From Spain to abroad	Quarterly growth (€)	Annual growth (€)
2013	T1	19,662,353.2	6,857,057.8	10,873,049.0	37,392,459.9	37,392,459.9
2014	T1	26,108,607.9	7,772,152.3	13,121,688.2	47,002,448.4	213,513,325.4
	T2	20,225,261.9	10,507,119.7	14,971,317.1	45,703,698.7	
	T3	39,328,868.5	11,793,837.0	16,463,656.9	67,586,362.4	
	T4	27,363,460.4	11,509,801.1	14,347,554.5	53,220,816.0	
2015	T1	34,261,513.1	13,507,107.4	18,517,319.1	66,285,939.5	289,206,826.5
	T2	27,158,915.5	15,168,894.6	21,436,679.4	63,764,489.5	
	T3	52,460,818.8	16,029,452.8	21,931,651.6	90,421,923.2	
	T4	35,521,765.4	14,487,458.7	18,725,250.2	68,734,474.2	
2016	T1	44,784,782.0	17,094,661.9	25,647,186.8	87,526,630.7	393,560,739.0
	T2	36,904,206.5	20,954,747.0	27,945,920.8	85,804,874.2	
	T3	70,125,782.6	23,282,879.9	28,667,336.6	122,075,999.0	
	T4	49,426,624.4	25,209,081.9	23,517,528.8	98,153,235.1	
2017	T1	62,395,756.4	27,790,446.7	28,251,628.3	118,437,831.4	505,666,447.4
	T2	52,187,778.6	31,026,894.1	29,741,134.5	112,955,807.1	
	T3	90,118,338.9	29,737,483.2	34,140,342.3	153,996,164.4	
	T4	63,682,990.2	29,779,009.1	26,814,645.2	120,276,644.5	
2018	T1	79,781,684.8	33,149,588.0	33,492,317.8	146,423,590.6	657,236,031.5
	T2	72,937,059.6	36,632,535.1	36,834,383.4	146,403,978.1	
	T3	119,135,217.3	38,024,821.4	44,494,457.6	201,654,496.4	
	T4	89,257,025.0	38,551,449.2	34,945,492.1	162,753,966.4	
2019	T1	96,447,688.3	43,352,456.5	41,881,904.6	181,682,049.4	799,709,903.1
	T2	93,855,422.6	48,280,045.1	40,130,531.0	182,265,998.8	
	T3	139,891,631.1	55,388,621.9	38,443,024.7	233,723,277.7	
	T4	113,128,786.9	54,845,251.5	34,064,538.8	202,038,577.3	
2020	T1	118,747,673.3	54,572,429.2	37,753,796.2	211,073,898.6	973,625,102.9
	T2	102,676,428.3	45,114,566.7	38,155,809.8	185,946,804.7	
	T3	224,710,975.9	57,543,942.4	46,350,198.5	328,605,116.8	
	T4	144,028,357.5	56,045,461.5	47,925,463.8	247,999,282.8	
2021	T1	155,089,576.8	61,971,676.3	47,949,014.8	265,010,267.9	1,213,929,906.3
	T2	163,427,619.8	62,969,410.2	43,605,445.5	270,002,475.6	
	T3	262,178,697.2	78,979,538.5	56,670,831.4	397,829,067.1	
	T4	160,445,672.6	69,055,170.2	51,587,252.9	281,088,095.7	
2022	T1	177,409,009.7	76,517,260.5	57,217,838.9	311,144,109.1	1,422,089,524.4
	T2	189,565,053.7	75,977,605.5	57,528,410.1	323,071,069.3	
	T3	292,603,703.1	90,936,345.5	72,282,567.7	455,822,616.3	
	T4	183,510,078.2	81,246,141.1	67,295,510.5	332,051,729.8	
2023	T1	207,772,653.1	88,326,673.1	71,728,041.4	367,827,367.6	1,629,323,093.0
	T2	215,889,790.1	92,098,010.5	67,887,891.5	375,875,692.1	
	T3	327,354,489.5	104,248,343.7	79,416,452.8	511,019,286.0	
	T4	202,952,057.6	96,377,559.5	75,271,130.2	374,600,747.3	

Source: The authors based on data from the CNMC CNMC Comisión Nacional de los Mercados y la Competencia, CNMC Comisión Nacional de los Mercados y la Competencia, (2024).

L in the left hand side in (1) can be expanded for all real d as:

$$(1-L)^d = \sum_{j=0}^{\infty} \binom{d}{j} (-1)^j L^j = 1 - d\ L + \frac{d\ (d-1)}{2} L^2 - \ldots,$$

and x(t) can be expressed as

$$x(t)\ \ = d\ x(t-1)\ \ - \frac{d\ (d-1)}{2}\ x(t-2)\ \ + \ldots + u(t)$$

Implying that the higher the value of d is, the higher is the degree of dependence between the observations. Thus, the differencing parameter d can be taken as a measure of persistence in the data.

The obvious advantage of this methodology is the higher flexibility of the fractional model compared with the classical approaches based on d = 0 (for stationary series) and d = 1 (for nonstationary ones). Allowing d to be a fractional value permits us to consider for example, cases of series which are nonstationary though with mean reversion, i.e. with shocks disappearing by themselves in the long run. Moreover, the magnitude of d will indicate us how fast (slow) this convergence process is.

In the empirical application presented in the following section, we permit x(t) in (1) to be the errors in a regression model with a constant and a linear time trend, i.e.

$$y(t) = \alpha + \beta t + x(t), \quad t = 1, 2, 3, \ldots. \tag{2}$$

where y(t) indicates now the observed data, and α and β are unknown parameters referring to a constant and a linear time trend.

The estimation of the parameters in (1) and (2) is conducted via likelihood function in the frequency domain by using a simple version of a testing procedure developed in Robinson (1994) (see, Gil-Alaña & Robinson, 1997) that has been widely used in the analysis of time series data (see, e.g. Abbritti et al., 2016; Claudio-Quiroga & Gil-Alana, 2022; Infante et al., 2024; etc.)

4. Data

The data used in the study were taken from the National Commission of Markets and Competition (CNMC). The CNMC is a public body that promotes and preserves the proper functioning of markets. It has extensive statistical information that can be consulted by any citizen thanks to Law 19/2013, of December 9. The CNMC maintains a census of all electronic commercial transactions through virtual point-of-sale terminals with Spain as the point of origin and/or destination. This data collection method has the limitation of reflecting only transactions made through electronic payment methods, but it is adequate because this is the most widely used payment method for e-learning.

Table 1 shows the revenues in Spain in the e-learning sector between 2013 and 2023. The table, created by the authors based on data obtained from the CNMC (Comisión Nacional de los Mercados y la Competencia) CNMC Comisión Nacional de los Mercados y la Competencia, CNMC Comisión Nacional de los Mercados y la Competencia, (2024) referring to the volume of electronic transactions within the education sector. These data only include transactions conducted by means of a virtual point of sale (POS) terminal originating or terminating in Spain, and so excludes data on other types of transactions, such as bank transfers or other payment methods. Although these figures do not precisely reflect the exact revenues of the sector although they do provide a revealing approximation since the most common form of payment for courses is by bank card. Transactions are categorised according to origin and destination, generating three distinct groups: operations from locations abroad into Spain, operations to locations abroad from Spain, and operations entirely within Spain. The total volumes of the transactions are provided at quarterly and by yearly frequencies and due to the longer dataset based on the quarterly data we have chosen this frequency for the rest of the analysis. It would have no sense to conduct the analysis on annual data since the number of observations per series would be 11, clearly too short to conduct any reliable time series analysis. On the other hand, seasonality, though relevant in the quarterly case, does not affect the long run properties of the data, based on fractional integration.

If we compare these data with those published by Eurostat (2024) on the use of e-learning in the 27 countries of the European Union, it can be seen that the growth of this training modality is not exclusive to Spain. With a few exceptions, such as Romania and Slovenia, the rest of the EU countries have experienced an increase in the use of e-learning from 2019 to 2023, with Spain being the fifth country with the greatest growth, after the Netherlands, Finland, Sweden, and Norway.

Figure 1 provides a visual summary of Table 1 in the form of a bar graph illustrating the growth in annual revenues in distance learning according to the total bank card transactions registered by the CNMT either originating or terminating in Spain over the last 10 years. The data shows a steady growth with an annual increase of around €200 million per year since 2019. Due to the special characteristics of online learning, it is worth noting that the pandemic situation caused by COVID-19 did not affect this economic activity, even registering a slight increase in transactions. In these 10 years the turnover of the e-learning sector in Spain has experienced a strong growth from 200 to 1600 million per year. The factors that have driven this growth are varied and include technological advances, the global context of demand for education, flexibility and autonomy in learning, lower costs, greater institutional drive, and the greater familiarity of new generations with the digital world, among others (Tawafak et al., 2023). In view of this trend, it is foreseeable that the sector's turnover will continue to increase, driven also by new technological trends that have appeared recently, such as artificial intelligence. In the global context, according to data published by the National Association of e-Learning Centers and Providers (ANCYPEL, 2024), the global e-learning market was valued at $399.3 billion in 2022, and a compound

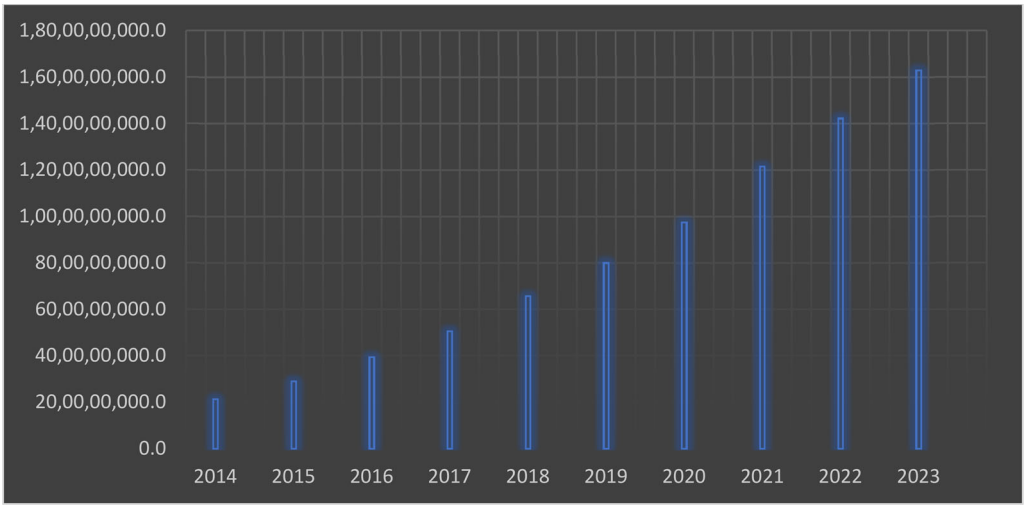

Figure 1. Annual growth in revenues in the e-learning sector in Spain (€).
Source: The authors based on data from the CNMC CNMC Comisión Nacional de los Mercados y la Competencia, CNMC Comisión Nacional de los Mercados y la Competencia, (2024).

Table 2. Estimated coefficients on the logged series.

i) White noise errors			
Series	d (95% band)	Intercept (tv)	Time trend (tv)
Spain	−0.27 (−0.44, −0.04)	16.944 (484.34)	0.065 (37.74)
From abroad with Spain IN	0.36 (0.15, 0.67)	16.380 (200.70)	0.045 (12.56)
From Spain with abroad	0.72 (0.53, 0.97)	15.575 (162.11)	0.068 (9.72)
ii) Autocorrelated errors			
Series	d (95% band)	Intercept (tv)	Time trend (tv)
Spain	0.16 (−0.18, 0.57)	16.243 (136.00)	0.048 (6.10)
From abroad with Spain IN	0.68 (0.33, 1.09)	16.934 (161.52)	0.064 (14.31)
From Spain with abroad	0.81 (0.52, 1.21)	15.7215 (162.51)	0.068 (7.46)

Note: All computations were carried out using the logged values. Column 2 indicates the estimates of d and the associated 95% band; columns 3 and 4 show the intercept and the time trend (with their t-values in parenthesis).

annual growth rate (CAGR) of 14% per year is expected until 2032. The educational policies necessary for the implementation of technology in education require a combination of investment in technology and data transmission infrastructure, specific teacher training, appropriate regulatory frameworks, and the promotion of equity and universal access to education.

5. Empirical results

Table 2 summarizes the empirical results. We compute the estimates of d for both original and logged transformed data; however, since they were fairly similar, we only display in Table 2 the estimated coefficients for the logged values. The upper part (panel i) refers to the model with white noise (uncorrelated) errors, while those in the lower panel (ii) refers to a model with autocorrelation in the error term by means of the model of Bloomfield (1973). This is a non-parametric approach of approximating high order autoregressions (AR) with very few parameters, and that accommodates very well in the context of fractional integration (Gil-Alana, 2004). We estimated the coefficients in the model given by equations (1) and (2). Thus, column 2 displays the estimates of d (and their associated 95% confidence bands), and the following two columns display respectively the intercept and the linear time trends (with their corresponding t-values in parenthesis).

The first thing we observe in the upper part of Table 2 (based on white noise errors) is that the time trend is statistically significant in the three series examined, and the estimate of d is negative for the data corresponding to operations entirely conducted with Spain but positive for the other two series. In

fact, looking at the confidence intervals, we observe that the short memory or I(0) hypothesis (i.e. $d = 0$) cannot be rejected in the first of the series (since the value 0 is included in the interval for d), while d is significantly positive for the remaining two series. Focussing now on the selected coefficients, the most interested observed feature is the significantly positive value of the time trend in the three series examined.

The results for the case of autocorrelated errors are fairly similar; we observe that d is equal to 0.16 (with the confidence interval including $d = 0$) for the case of Spain, and it is 0.68 and 0.61 respectively for operations from abroad with Spain and from Spain with abroad. Once more, the coefficients for the time trend are significantly positive in the three series implying a continuous increase in the historical evolution of the data.

These results indicate first that for the transactions of the whole country the hypothesis of short memory or I(0) behaviour cannot be rejected implying that if shocks occur in this series it will have a short lasting (transitory) effect; however, for the remaining two series, since the I(1) hypothesis cannot be rejected, shocks will have permanent effect, requiring major efforts to recover the original trends, which are positive in the three cases. Though not reported, other fractionally integrated approached (based on parametric, Sowell, 1992, and semiparametric, Geweke & Porter-Hudak, 1983, approaches were also conducted, and though quantitatively there were some differences in the magnitudes, qualitatively they were very similar to those reported in the present manuscript, finding support of positive linear trends and long memory and long lasting effects of shocks in the series corresponding to transactions from Spain to abroad and from abroad to Spain.

6. Conclusions

In this article we have investigated data related with the growth and prevalence of e-learning in Spain, using some advanced methodologies in time series based on fractional integration. Our results indicate that a much higher degree of integration in the transactions from abroad to Spain and from Spain to abroad than with those conducted entirely in Spain. That means that a shock in the former two series will take longer time to disappear than in the case of Spain only where shocks are expected to disappear relatively fast. Another interesting fact is that a time trend coefficient is found to be significantly positive in the three series, being this value the highest for the transactions from Spain to abroad.

The expansion of the e-learning market offers strategic opportunities for universities, governments, and e-learning providers, but leveraging them requires concrete and coordinated actions. Universities are recommended to adopt more flexible education models: a combination of in-person and virtual classes, microcourses on specific topics for professionals seeking to update themselves, investment in their own e-learning platforms, development of specific courses for faculty, and seeking collaborations with private companies. For governments, it is essential that they constantly update and make regulations more flexible so as not to hinder new initiatives and innovations as they emerge. Investment in infrastructure and funding for initiatives that improve and make access to education more flexible are essential. E-learning providers are recommended to improve the customization of content and platforms, offer a wider variety of languages and formats for courses, improve pricing through scalable models, meet accessibility standards, and focus on teaching future skills such as artificial intelligence and sustainability.

The results reported in this work can be extended in several directions. First, the results reported in this work for the case of Spain can be extended to other countries in order to know if the same conclusions hold. Moreover, from a methodological viewpoint, other alternative long memory methods can be taken into account though our results tend to support this hypothesis of the three series under consideration. Non-linear models and structural breaks are issues that can also be considered and that may alter the estimation of the differencing parameter.

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