E-commerce by individuals in Spain using panel data 2008-2016.

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ABSTRACT

Digital technologies sometimes create digital divides. One of the remedies for certain divides in Europe is the creation of the Digital Single Market, of which e-commerce is one of the main elements. The focus of this work is e-commerce in Spain. The current study improves on existing international literature by using a large and representative panel data set on individual consumers, with 133,420 observations for the period 2008-2016. Moreover, it uses economic models and employs a variety of panel techniques. This paper measures digital e-commerce divides and their evolution along time. Next, a model that incorporates previously neglected explanatory variables, at the individual level, such as income and digital skills, is formulated. Individual demand models are estimated using panel logistic regression techniques. This allows quantifying the impact of each of the socioeconomic and geographic characteristics on the adoption of the service. Newly incorporated variables are significant as well as age, education, gender and geographical and time variables. The results allow novel regional comparisons. Policy recommendations are derived, suggesting effective and affordable measures targeted at specific socio-demographic groups.

1. Introduction

The Internet is one of the most powerful agents of change in recent history. Since the world-wide-web opened up the Internet for everyone in 1991[1], its diffusion has been so rapid around the globe and across new services that it has given rise to major changes in everyday life. According to recent data provided by the International Telecommunications Union (ITU, 2016), almost half of the world's population is using the Internet. However, there are important differences according to countries and groups of individuals which are called digital divides. The definition of digital divide has evolved considerably over time. The National Telecommunications and Information Administration, NTIA, (1995) focused first its studies mainly on infrastructure access. Later on the access to technology and services. There are also other facets of interest, such as the use of the Internet and the quality of use. The relevant definition for this paper is the one that considers the digital divide as the unequal use of the Internet between distinct groups of individuals (Hilbert, 2011).

E-commerce[2] is an important service of Internet and a European Union priority because it has social benefits, promotes competition, and advances towards the objective of a digital single market while avoiding digital exclusion[3]. Another reason for focusing on e-commerce is the relatively low penetration in Spain versus selected European Union countries.

Specifically, e-commerce has had important economic and social implications. Customers are changing their consumption habits, and businesses need to adapt to the new situation modifying their business and marketing strategies. This situation is evolving rapidly, and it could be considered a sort of social revolution. At this point, some authors wonder whether conventional shopping centers will survive or are doomed to disappear. In the early days of e-commerce, many consumers searched for information and products on the Internet, but they ultimately went to the physical store to shop. Now in some cases, the situation is the opposite: some individuals use the physical store as a catalog where to feel and try the products that may then be bought online[4].

The main objectives of this paper are twofold: first to measure the e-commerce digital gaps in Spain and categorize them by sociodemographic and regional groups, and second to identify and estimate the effects

[1] There is broad consensus in situating the birth of the World Wide Web in 1991 when Tim Berners Lee created it, combining three existing resources (HTML ─Hypertext Markup Language, HTTP ─Hypertext Transfer Protocol, URL ─Uniform Resource Locator) with a new program called Web Browser.

[2] Following Eurostat (2017) and INE (2017), the standard definition of e-commece is the placing of orders of goods and services via the Internet, excluding orders via manually typed e-mails or text messages. Only purchases made for personal reasons are considered.

[3] It is worth pointing out that digital exclusion refers to a variety of Internet services, not specifically to e-commerce.

[4] Nevertheless in Spain there is a high density of shops that are close to the final user, so this may be a partial explanation for the lower e-commerce figures.

of the determinants of the e-commerce adoption by individual consumers as well as formulate policy recommendations to narrow the relevant gaps.

This paper analyzes e-commerce using microdata on individual consumers from the "Survey on Equipment and Use of ICT in Households" (INE, 2017) which is similar to those carried out in the European Union and allows interesting comparisons across the 28 countries. Dynamic logistic models of adoption of e-commerce in Spain are estimated for the first time using individual panel data. The current paper improves substantially on existing literature by using a 9-year-individual panel, providing disaggregated measures of digital divide, and using an explicit and richer economic model for individual panel data. Additional relevant variables, such as individual-level income, individual digital skills, and geographical variables, are included as well as a variety of panel estimation techniques. The focus here is on specific individual consumer policy recommendations. The results reported may be amenable to further exploitation by other researchers.

The rest of the paper is organized as follows: Section 2 contains a literature review. In Section 3, the model is presented. Section 4 introduces the data, highlighting the construction of the panel database on individuals from the original data on dwellings. Section 5 presents the estimation results and discussion. The main conclusions, policy recommendations, caveats, and further research are shown in section 6.

2. Literature review

E-commerce has been an important subject of study as well as a political priority in the European Union and other international institutions; see, for instance, OECD (2001). There is a great amount of literature on the topic, which is classified below as three subsections: international literature on digital divide, international studies on e-commerce and studies on e-commerce and the Internet for Spain. In this section, we include some documents that may look somewhat old but are considered seminal papers in the area and have significant value as references for the current work. Producing a comprehensive survey of this literature is beyond the scope of this research.

International literature on digital divide

A seminal report by the National Telecommunications and Information Administration (1999) discusses the digital divides[5] (telephone, computer, and Internet use), and their evolution in the US using data for the previous 15 years. They define digital divide[6] (absolute and relative), and they relate it with its evolution

[5] "The gap between individuals, household, business and geographic areas at different socio-economic levels with regard to their opportunities to access information and communications technologies and to their use for a wide variety of activities" (OECD, 2001, pp. 8-9).

[6] A digital divide can be regarded as a situation in which the demand for access or use of a given digital service by a specific group is considered as insufficient (by policy makers or researchers), compared to that of other group of reference.

along time. The way of interpreting the level and evolution of the digital divide is similar to the one adopted in the current study.

Hilbert (2011) focuses on digital divides and their definitions. The author considers the adoption of a new service as a contagious disease instead of an economic decision that would depend mostly on income, price, and other factors. This paper suggests that there are heterogeneous digital divides which cannot be added up in a significant way since they are difficult to synthesize in a single index. This paper poses relevant questions that would need more specific answers.

Demoussis and Giannakopoulos (2006) deal with the determination and extent of Internet use as a facet of the digital divide in Europe. They use 2002-2003 individual cross-section data from a variety of European countries and focus on the decision to use or not use the Internet as well as how much to use it. This paper contributes with very useful discussions on the right way to account for the availability of the Internet and the relevant population groups concerned. This insightful study, however, is missing a measure of digital skills, so the estimates of the coefficients of the rest of the variables may have omitted variable biases.

A recent paper by Răileanu (2018) deals with the regional digital divide in the European Union. It uses panel data specific models aggregated at the levels of regions and countries, but no formal theoretical model is used. Variables such as digital skills are absent, and the level of education turns out to be insignificant in some models. The endogeneity of other explanatory variables may be an issue. The interpretation of the signs of the coefficients of several variables seems to be problematic in several cases.

The levels of the digital divide in firms have been studied in Bach et al. (2013). They review several papers that can be classified into three groups depending on the phenomena used as a measure: ICT usage, adoption of Internet and broadband adoption, and, ICT usage for specific business purposes. External and internal factors are identified as determinants of the digital divide among firms.

Concerning the indices used to measure the digital divide among individual consumers, Barzilai-Nahon (2006) criticizes policymakers who rely on simplistic measures. Besides presenting a conceptual definition of the digital divide, the researcher supports the use of comprehensive indices rather than monotopic ones. The article highlights the context as the most important framework for both the conceptualization of the digital divide and the construction process of an index to measure it. The author emphasizes that policymakers should embrace the analysis of the purpose of the tool, the level of observation, and the methodological approach to the data.

To understand a complex subject such as digital divide, Vehovar et al., (2006) argue that standard methodological approaches are not enough, and the measures must be considered in a multivariate setting. Three advanced methodological approaches are proposed to measure digital divides. 1) Multivariate log-linear modeling allows addressing interactions among variables. 2) Compound indices that integrate several variables into a single indicator. And, 3) Time-distances methodology, to analyze changes in digital divide

across time. The authors conclude that implementing these sorts of analysis yields often different conclusions compared with the usual bivariate comparisons.

Hacker & Mason (2003) argue that if researchers avoid the problem of ethical indifference concerning the analysis of data and pay more attention to the links of ethics with their findings related to digital divides, a better quality of research and policy considerations are likely. The paper claims that most analytical works on the digital divide tend to neglect ethical discussions, which "contaminates" studies and reports with ideological filtering.

Ruiz-Rodríguez et al. (2018) conduct a comparative analysis on the adoption and use of ICTs in enterprises and on the digital divide between them at a regional scale in Europe.

Salemink et al. (2017) address the relationship between digital developments and rural development. This work is a systematic literature review of 157 papers, focusing on the general conclusions to grasp the potential impact of the coming Next Generation Access revolution. The paper reports that connectivity and inclusion are the two major aspects. A relevant remark of the paper is that rural communities are less connected, and they are the most in need of better digital connectivity to compensate for problems associated with their remoteness.

Zoroja (2011) studies the digital divide between European developed and post-communist countries. Internet usage, e-commerce, and e-government are at the center of the analysis. The study reports the average penetration rates for the three areas considered, aggregating the measures for the developed European countries and Post-communist countries. Based on the comparison among groups of countries, the article concludes that the group of developed countries have significantly better access and shows higher intensity in use than the group of post-communist countries. The work also discusses digital divides and link them to socioeconomic factors, especially education.

International papers on e-commerce

Limayem et al. (2000) study e-commerce empirically. They use the Theory of Planned Behavior with a longitudinal sample of 705 consumers from the US. Their methodology is not directly comparable with that of the present work. Theirs is based mostly with unobservable variables, while ours deals with observable variables.

Hackl et al. (2014) focus on the interaction between market structure and market performance of e-commerce centered on supply-side considerations of the retail sector for the case of Austria, using cross-section data.

The European Commission (2018) shows that Spain has an average level of digital development within Europe. The main barriers for development are in the demand side, in particular, the shortcomings in human

capital related to ICT as consumers. The document contains a useful account of recent and current programs for the advancement of the Information Society in Spain, both from the supply and the demand sides.

Based on internationally comparable micro-aggregated data for the period 2002-2010, Biagi & Falk (2017) present empirical evidence against the hypothesis that the utilization, by firms, of complex and sophisticated forms of ICT and internet applications is leading to labor substitution overall.

A multivariate perspective is adopted by Billon et al. (2016) to study the links and determinants of ICT use by households and firms in the EU. Using canonical correlations analysis, the authors investigate the presence of regional patterns that combine ICT use by firms and by households in the EU. The research also explores the drivers of the patterns detected, identifying synergies and regional factors explaining the use of ICT both by households and by firms in the EU.

Bose and Luo (2011) go a step further at analyzing information technologies adoption by firms, proposing a different perspective from an environmental point of view. The main goal of this work is to contribute to the literature with a model that incorporates technological, organizational, and environmental factors linked to the firm's potential to undertaking Green IT initiatives via process virtualization.

Valarezo et al. (2018) identify two dimensions of trust among the factors driving the adoption of cross-border e-commerce by individuals in Spain: trust in the product and supplier, and trust in the channel. Oliveira et al. (2017) conduct more specific research on the topic of consumer trust, modeling, and assessing three dimensions: competence, integrity, and benevolence. Based on a structural equation model, using a sample of 365 individuals, this last paper discusses how consumer and firm characteristics, and website infrastructure and interactions with consumers are sources of trust. Both works coincide that the higher the consumer trust, the higher the intention to purchase online.

Papers on e-commerce and internet use in Spain:

Previous studies on e-commerce or closely related topics that use cross-section data of the ICT-H survey for Spain are:

Cerno and Pérez-Amaral (2006, 2009) deal with Internet access and use as well as e-commerce use in Spain using cross-section data on individual consumers. Garín-Muñoz and Pérez-Amaral (2011) concentrate on the factors affecting e-commerce use in Spain using cross-section data on individual consumers from the ICT-H survey.

Garín-Muñoz et al. (2019) specify and estimate binary response models for individual consumer adoption of e-commerce, e-banking, and e-government in Spain, using cross-section data obtained from the ICT-H survey of INE for 2016. This paper discusses the signs and effects of demographic and socioeconomic individual characteristics on the probability of adoption of the mentioned digital services.

Using data from the ICT-H survey of INE for the year 2016, Valarezo et al. (2018) study the drivers and barriers of Spanish individual consumer adoption of cross-border e-commerce for private use. In addition to the socioeconomic and demographic variables, this work includes the variable "how often the consumer sees other customer reviews before buying online", to account for the effect of trust in the product and vendor.

Pérez-Hernández, J. and R. Sánchez-Mangas (2011) study online shopping jointly with having Internet at home using the ICT-H survey of INE in Spain for the period 2004-2009 employing pooled individual data. In this paper, they cannot control for unobserved individual heterogeneity since they use pooled instead of panel data. Likewise, they omit relevant variables like individual digital skills, geographic variables, and individual income (which are available only from 2008 onwards). This omission can cause inconsistency in the estimates as recognized by the authors in p. 221.

Robles and Torres-Albero (2012) analyze individual cross-section data from INE for the year 2009 to calculate penetrations of the use of the Internet. They conclude that "…between the most advanced communities and the communities with the lowest percentage of users these differences, far from decreasing, have remained stagnant or even increased slightly over the last five years". They also model the decision of using the Internet. Their logistic model does not control for individual heterogeneity and fails to include two variables such as digital skills and individual income that were available at the time. This omission leads to inconsistent estimates and an upward bias in the estimation of the effect of "level of education," which is positively correlated with the two omitted variables. These flaws undermine some key conclusions of the paper.

A report by Correa et al. (2015) of BBVA Research deals with previous waves of the same TIC-H survey of INE for Spain during the period 2008-2014. They study the adoption of broadband and e-commerce. They use pool data, not a panel, so they cannot control for unobserved individual heterogeneity. They do not use an explicit economic model, but they do use time dummies and geographical variables. Their conclusions are subject to caveats due to the type of sample and model they use and the importance imposed on e-banking.

A recent report by Fundación BBVA (2018) found that the digital divide in Spain disappeared in 2017. However, they only analyze, at an aggregate level, the digital divide in access and use of the Internet but not e-commerce, like the present study does, which is more relevant for this paper. They use descriptive statistics as well as intuition, but they do not use economic or econometric models. The effect of mobile broadband access is not explicitly considered.

Another study by Burgos et al. (2018) focuses on e-commerce in Spain. It uses a highly mathematical model based on epidemiology but fails to consider the economic nature of the decision of adopting e-commerce as well as the findings contained in previous literature. The treatment of the data seems perfunctory. The multiple factors that may affect the adoption of e-commerce are largely ignored.

The above papers are defective in one way or another. Some use aggregate data only, while others do not use economic models. Some others use cross-section or pool data, instead of panel data, while others omit relevant variables such as income and digital skills. Due to these limitations, the policy recommendations are limited or subject to caveats. In the next sections, we present results that fill these gaps in the existing literature.

3. The model

The present study follows an economic perspective using the neoclassical utility maximization approach (Varian, 2002). The demand for access is determined by the size of consumer surplus associated with Internet usage and the cost of access. Regarding access to e-commerce, the relevant theory is that of the telephone demand framework of Artle and Averous (1973), Squire (1973), Von Rabenau and Stahl (1974), Rohlfs (1974), Taylor (1994), Kridel et al. (1999) and Rappoport et al. (2002).

In telecommunications, the use of a specific service is conditional on the access to this service, (Taylor (1994)). The current approach assumes that Internet access is a prerequisite for adopting e-commerce. In any case, Internet access could be obtained in the period considered through a variety of channels and places: buses, trains, airports, ships, work, home, school, university, hotels, restaurants, public Wi-Fi zones, community access centers, libraries, post offices, internet parlors, as well as using a variety of technical solutions: dial-up, cable, ADSL, broadband, narrowband, or through mobile phones, tablets and portable computers. Summing up, Internet access has been ubiquitous during the years of the sample 2008-2016.

In many cases, access to the Internet is not an explicit decision, but rather a circumstance governed by the commercial policies of carriers that incorporate Internet to a traditional service, even without explicit knowledge by the consumer. A similar argument is sustained by Demoussis and Giannakopoulos (2006) for the European case using 2002-2003 data. The argument is compelling in the sample considered. Nevertheless, in the Appendix, Table A1, a model incorporating a Heckman-style mechanism is estimated and presented, suggesting that the selection mechanism is not necessary in this case, and model 1 is an adequate approximation.

When access to the Internet is widespread, the decision to use the Internet no longer needs to be modeled. The hypothesis is that consumers decide to use e-commerce, given that they have access to the Internet[7].

In this context, an individual derives utility (U) from adopting a particular Internet service (Y), if the benefits from using that service B(Y) exceed its costs C(Y). Empirical works based on this approach are Demoussis and Giannakopoulos (2006); Fairlie (2004); Vicente and López, (2008); Lera-López et al., (2011) and Valarezo et al. (2018, 2019), the last four referred to the case of Spain.

[7] Effective use by 100% of individuals across the population cannot be expected, since there are people who are severely ill, physically or mentally handicapped, very old, very young, and minorities for whom Internet may not be attractive.

From a standard neoclassical utility optimization approach, the maximization of the utility (U) of an individual obtained from e-commerce (Y_i), will be a function of the benefits $B(Y_i|x)$ of doing so and the costs, $C(Y_i|x)$, where x is a set of conditioning variables associated with it. The conditional probability of using e-commerce is:

$$P(Y_i|x_i) = P[B(Y_i) - C(Y_i) > 0|x_i] \quad i = 1, \dots, N, \ individuals. \qquad \textbf{(1)}$$

The individual consumers considered are those e-commerce users who purchased online goods or services for private use in the last year with respect to the total population.

The model used in this paper follows Valarezo et al. (2018) and Garín-Muñoz et al. (2019), where binary models of e-commerce adoption are estimated.

4. Data

Figure 1 shows the evolution of the aggregate use of the Internet and e-commerce in Spain for the years 2008 to 2017, obtained from Eurostat (2017). The penetration of both services grows over time. The percentage of Internet users increases from 59% to 85% of the population aged 16 to 74. Likewise, the percentage of the population that uses e-commerce grew from 19% to 50% of those aged 16 to 74[8], which suggests that there has been a strong increase, but that there is still room for improvement.

Figure 1
Internet and e-commerce use as percentage of people aged 16 to 74 in Spain (2008-2017)

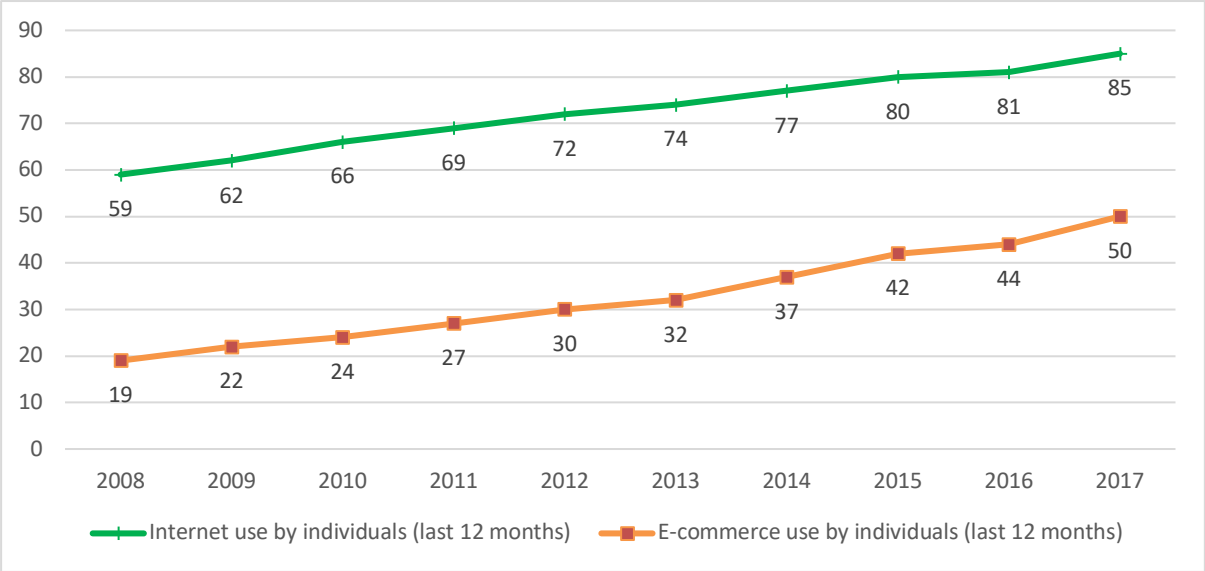
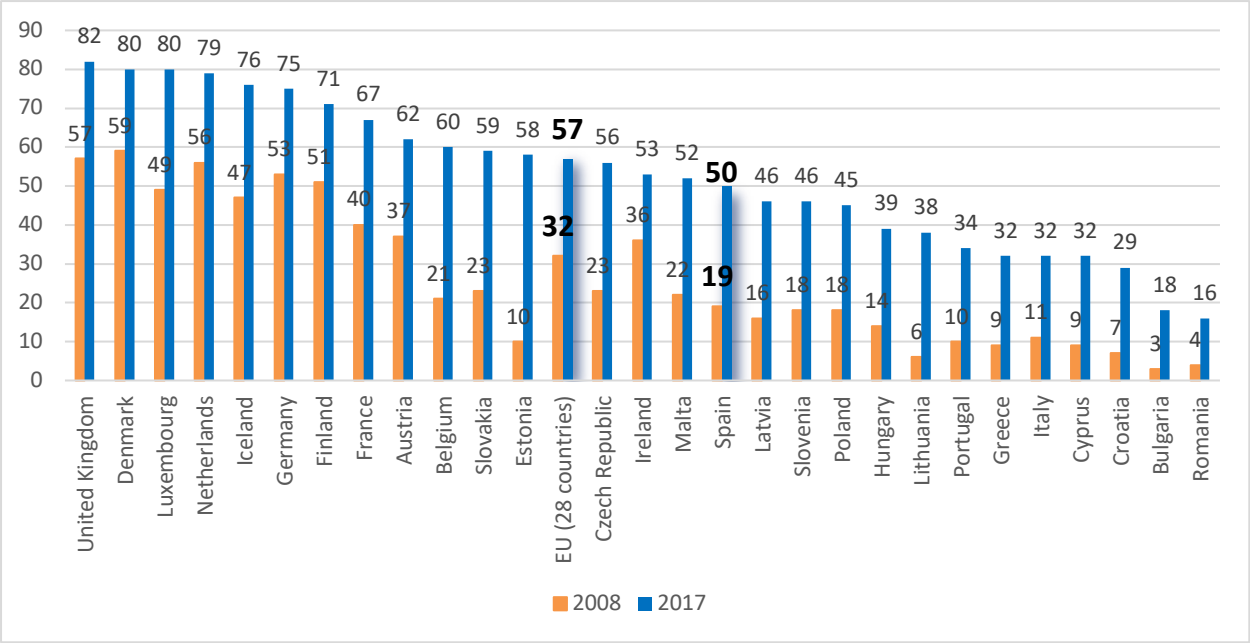


Figure 2 shows an international comparison of the penetration rates of e-commerce for European Union countries and Spain in 2008 and 2017. The European Union average increases from 32% to 57% in the period, while Spain increases from 19% to 50%. The increase in penetration is 31pp in Spain and 25 pp for

[8] The data of our survey, INE (2017), contains information on people of all ages, including those over 74 years of age. However the data in this section contains information only on people up to the age of 74, for compatibility with the corresponding data of Eurostat.

the European Union between 2008 and 2017. The gap is closing significantly between Spain and the European average by 6pp in the period considered 2008-2017. However, there is still a significant gap for the first seven countries on the left of figure 2, which are those that could be the reference for the policy objectives of Spain. This gap is still around 28 pp in 2017, when comparing it with the average of the seven countries.

Figure 2
Penetration rates of e-commerce in the EU-28 as percentage of people aged 16 to 74 (2008 and 2017)



This work starts by using annual data on individual dwellings from the survey on Equipment and Use of Information and Communication Technologies in Households (ICT-H Survey) from 2008 to 2017.

The survey is conducted by the Spanish National Statistical Institute (INE, 2017) using the methodology of Eurostat. It includes an elevation factor, and it is representative at both national and regional levels. The raw data are available at INE (2017), as well as a variety of documents related to the design, implementation, and statistics (except for the individual identifier). It is a rotating survey which includes 15,000-20,000 dwellings each year. The same dwelling is interviewed a maximum of four (consecutive) years, and around 30% of the dwellings are replaced every year. 60% of the interviews are conducted by phone (CATI) and 40% in person (CAPI). Following Eurostat's guidelines, similar surveys have also been performed in the rest of the EU countries.

During the writing of this paper, Pool data were available for 2008-2017, but panel data could only be used for the period 2008-2016 due to the lack of a dwelling identifier for 2017. The raw panel data underwent meticulous analysis and filtering to extract and homogenize the information about individuals uniquely identified throughout the observation period. The process goes as follows:

Pool data

Read the information on dwellings for each year (publicly available from INE, see INE 2017). For each year, there is a zip file containing a raw data file with the sociodemographic information of all the members of each dwelling, a raw data file with the information of the dwelling's responses to the survey, and an Excel file with the full description of both raw data files.

Homogenization of variables across years: the survey's questionnaire varies each year according to the evolving situation of ICT. This implies that some new variables may emerge, and old ones may disappear. Besides, each year, the names of most variables change (in the publicly available microdata, most variables are named after their ordinal order in the questionnaire –which usually changes). To homogenize the variables, we developed a script in R that scraps the description excel files in order to identify, across years, same variables with different names and different variables that were assigned the same name.

Panel data

Incorporate the dwelling identifier supplied by INE to the previous pool database. However, we are interested in identifying individuals rather than dwellings (a dwelling participating in the survey several years may have different respondents across years). Using the sociodemographic information available for each member of a dwelling, we applied filters (like gender and date of birth) to identify whether the respondent of a particular dwelling was always the same individual or not.

In the end, we obtained a Panel 2008-2016 database consisting of 133,420 observations (corresponding to 59,252 different individuals) and around 700 different variables.

This was the final micro panel database that was used in all of our models.

a. **The explanatory variables** used are classified as follows:

Sociodemographic	
Gender:	2 groups: 1 if male, 0 if female
Age:	6 groups
Habitat:	4 groups
Household Members:	5 groups
Nationality:	2 groups: Spanish, Foreign
Individual skills	
Education:	4 levels of study
Digital Skills:	4 levels
Economic	
Employment Situation:	6 groups
Income:	4 groups, monthly net income of the family
Time and Geographic	
Yearly Dummies:	1 for each year

Regional Dummies:	17 Autonomous Communities + 2 Autonomous Cities

The variables were categorized as shown in table 1, which also contains the penetrations of e-commerce on the different groups, measured in the years 2008 and 2017. The table suggests a general increase in the penetrations in the period considered.

Digital skills are among the key elements to foster digital inclusion (European Commission, 2019b). The digital skills variable used in this study is a synthetic index based on the former[9] European Commission's Digital Skills Indicator, which accounts for the number and complexity of activities involving the adoption and use of digital equipment and internet services (European Commission, 2019a). The index covers four areas of competence: information and data literacy, communication and collaboration, problem-solving, and software skills for content manipulation.

Answering specific questions in each area, the respondent reveals his or her competences. Information skills area accounts for individuals who have copied or moved a file or folder, used Internet storage space, search for information online, search for information about goods and services, search for information about health-related topics. Communication and collaboration areas are approximated by the use of email, social networks, telephone calls through the Internet, and web sites for sharing own content. The problem-solving area of competence regards to transfer files between devices, installing software and apps, change the settings of the software, selling of goods or services through the Internet, taking online courses, using online education material, and carrying out online banking activities. The software skills for content manipulation area includes using text processing software, spreadsheet software, software to edit audiovisual content, creating documents that integrate different files, writing a computer program using specialized programming language, and using spreadsheet's advanced functions.

In this work, four categories of digital skills are used: low, medium, high, and very high. These correspond to the quartiles of the percentage of tasks that an individual consumer declares to be able to perform.

Table 1 reports the e-commerce penetration rates for different groups, which represent, among others, the digital skills divide. For the considered period substantial improvements are seen for groups with medium, high and very high levels of digital skills, but the same is not true for those with low levels of digital skills. This is one of the main concerns of the European Commission (2019b). The DESI report for Spain identifies that the human capital dimension needs to be improved in order to bridge the gap respect the EU average.

[9] The later indicator includes information about ICT specialist employment and ICT graduates. This data is not available for the sample of this study.

Table1.
Penetration rates of e-commerce in Spain (2008 and 2017)

Characteristics	Categories	2008	2017
Gender	Female	14.2	41.4
	Male	20.5	48.5
Age	<25	25.1	64.5
	[25,35)	31.4	68.1
	[35,45)	21.3	62.3
	[45,55)	16.2	51.0
	[55,65)	7.2	31.8
	65+	1.0	9.3
Education	Primary	1.4	6.5
	Secondary	16.6	44.7
	Bachelor's Degree	29.7	71.1
	Master´s or PhD	42.6	81.8
Digital Skills	Low	9.8	12.3
	Medium	25.1	44.5
	High	47.4	71.2
	Very High	69.2	89.8
Habitat	500,000+	22.2	51.2
	100,000-500,000	18.2	42.2
	20,000-100,000	16.3	45.4
	<20,000	13.0	38.7
Household Members	1	12.4	31.1
	2	14.6	32.5
	3	18.1	51.2
	4	21.5	58.7
	5+	14.9	43.0
Employment Situation	Employed	25.1	63.9
	Unemployed	12.7	38.8
	Retired	2.2	13.3
	Student	27.8	64.2
	Housekeeper	4.0	13.1
	Other	11.2	27.6

Note: percentage of individuals between 16 and up that have used e-commerce for private purposes at least once in the previous 12 months.

Table 1 (continued).
Penetration rates of e-commerce in Spain (2008 and 2017)

Characteristics	Categories	2008	2017
Nationality	Foreigner	14.5	41.0
	Spanish	17.7	45.3
Income	Low	3.6	23.6
	Medium	11.8	37.5
	High	28.3	61.0
	Very High	41.0	79.7
Autonomous Community or Autonomous City	Andalucía	13.1	41.0
	Aragón	18.7	49.1
	Asturias	16.1	44.3
	Baleares	24.3	52.9
	Canarias	12.2	37.6
	Cantabria	18.6	49.8
	Castilla y León	14.6	39.4
	Castilla-La Mancha	12.6	41.7
	Cataluña	21.2	49.1
	Valencia	15.3	43.7
	Extremadura	14.4	37.1
	Galicia	13.9	36.0
	Madrid	23.8	53.9
	Murcia	14.2	39.2
	Navarra	20.1	53.2
	País Vasco	21.1	46.7
	La Rioja	18.3	44.0
	Ceuta	12.6	48.6
	Melilla	17.9	47.8
TOTAL		17.3	44.9

Note: percentage of individuals between 16 and up that have used e-commerce for private purposes at least once in the previous 12 months.

The following map can be used as a reference for the geographic location of the above Autonomous territories.

Figure 3.
Autonomous Communities of Spain.

Graphs of Figure 4 shows selected entries of table 1 and the values of the relative digital divides. It shows the evolutions of the penetration of e-commerce by selected categories, also the absolute divide in perpendicular. It is worth pointing out that the absolute digital divides for gender, age, education, and income increase along time. They are measured in terms of the absolute difference between the two rates of penetration in 2008 and 2017[10]. The absolute age divide increases by 31.1 pp, while the gender divide increases by 0.8 pp, the education divide increases by 34.1 pp, the income divide increases by 18.7 pp, the employment divide increases by 29.7 pp, and the digital skills divide by 18.1 pp along the 10 years.

However, the relative divides measures shown (gender, age, education, income, and employment) decreased by 16.1, 10.4, 4.7, 20.8, and 4.6% respectively.

[10] An alternative measure of the relative divide consists in dividing the difference between the two categories at a given point in time over the highest of the two rates of penetration. This measure can give different results from the absolute measure. An additional measure of divide can be the ratio of penetration rates. That is, the ratio between two penetration rates of two different categories at a given point in time, using the highest as the denominator. Different measures may generate apparent contradictions and different impressions for the readers. Graphs like those in figure 3 may be useful to help the researcher or policy maker decide for him/herself.

Explanations of the variations in inequality along time and across sociodemographic and geographical groups may be interesting by themselves.

In particular, OECD (2001) deals specifically with the digital divides, although the report does not provide a precise definition of digital divide, or a method to compare digital divides at two different points in time, or its temporal evolution. An additional reference for the specific case of Spain is Robles and Torres (2012). The study of variations on inequality is deferred to further research.

Figure 4.
Digital divides: E-commerce penetration rates by Gender, Age, Education and Income in Spain 2008-2017

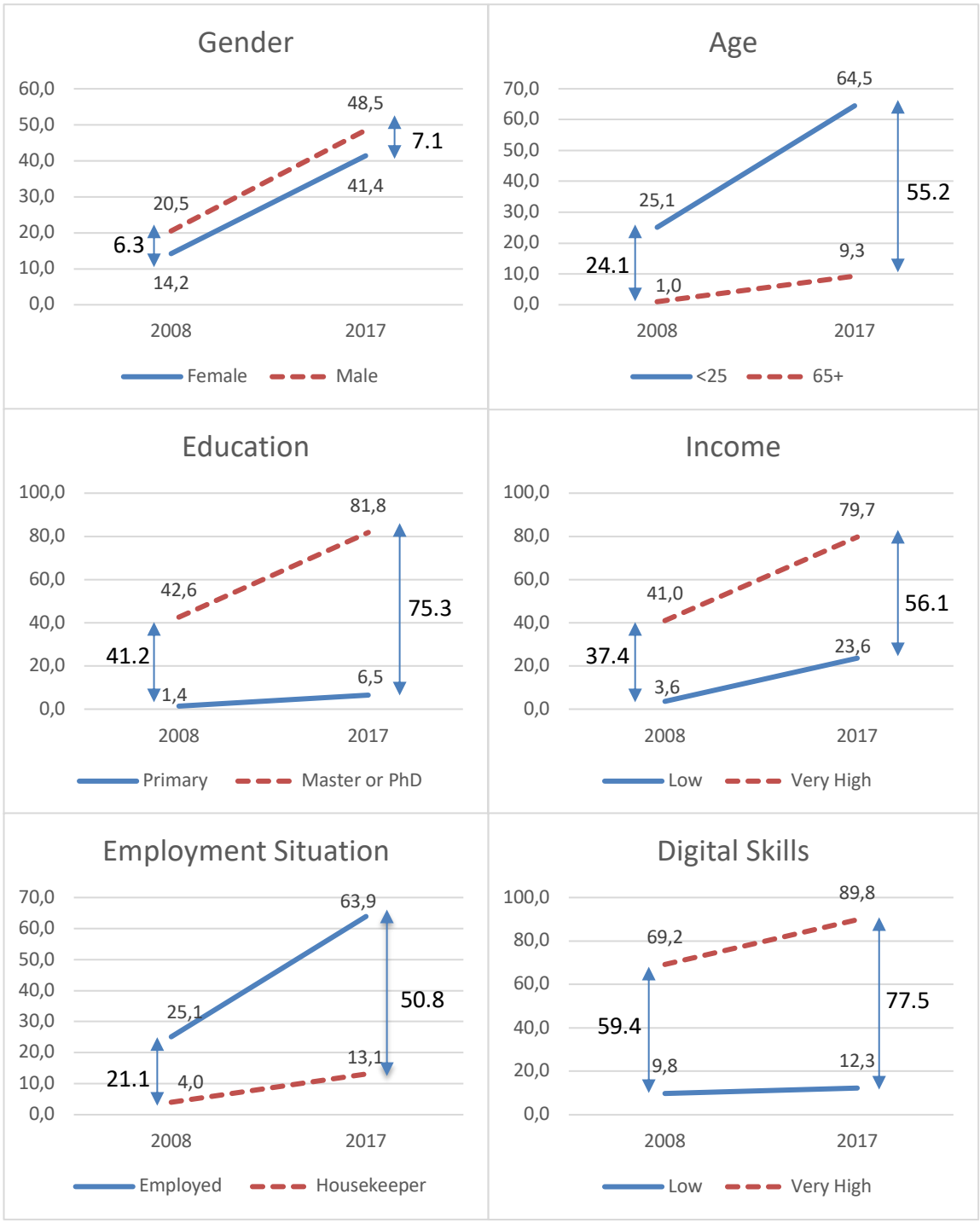
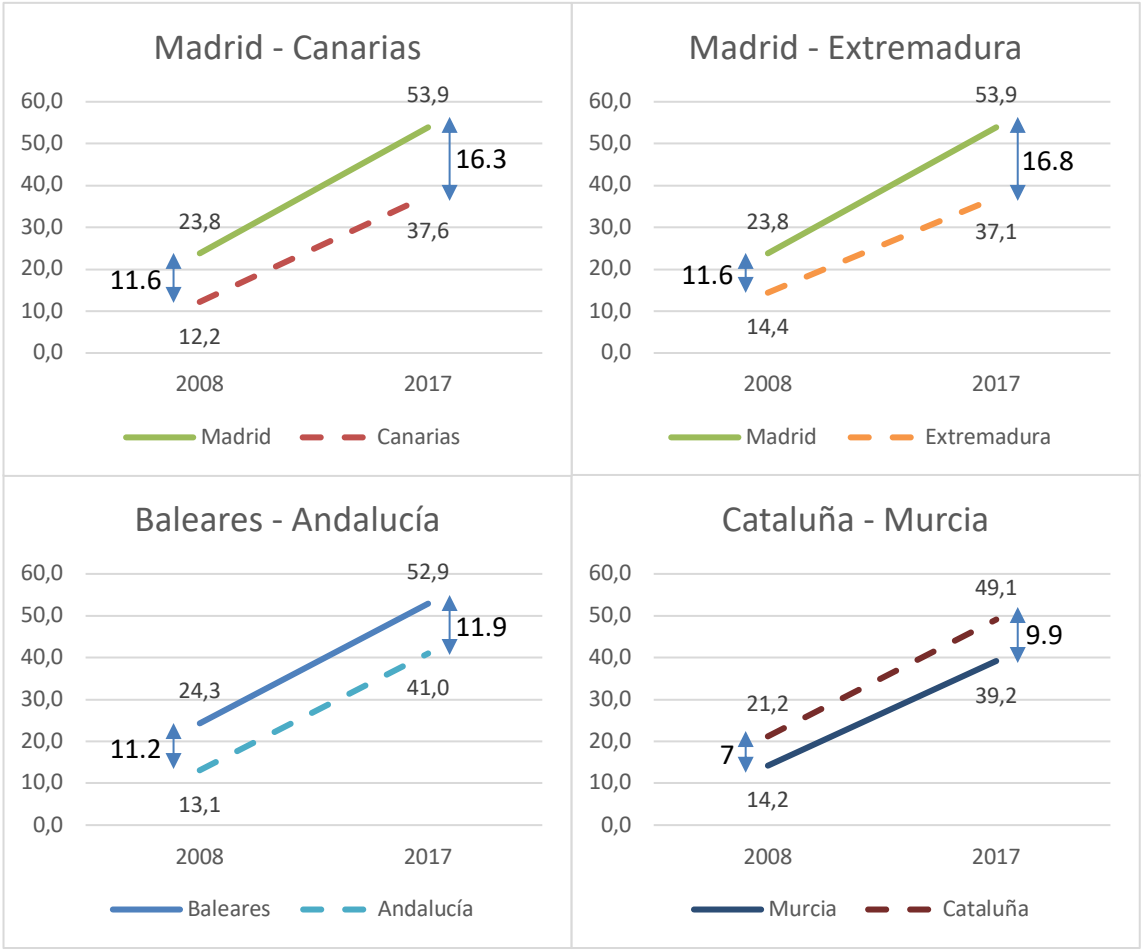


Figure 5
Evolution of selected penetrations of e-commerce by regions in Spain 2008-2017



A similar situation occurs when the regional differences are analyzed, Figure 5. The digital divides between selected regions are shown in figure 4, where the digital gaps between richer and poorer territories seem to be increasing by 4.7, 5.2, 0.7 and 2.9 pp respectively in the specific regions shown. Meanwhile, the measures of the relative gap decrease along time. Notice that the choice of cases shown is not random. The cases that display less convergence are chosen here to underscore the overall convergence of the different groups and regions along time.

5. Estimation results and discussion

This section contains the main results obtained from the empirical models. They are displayed in tables for easiness of reading. The main explanatory variables of the models have been introduced in the previous sections. Lagged values of e-banking and e-government, which are meant to capture the dynamics and the cross effects on e-commerce are also introduced as explanatory variables in the second model.

Table 2 contains the two logistic specifications of the model, static and dynamic, including the point estimates of the odds ratios and the corresponding z statistics[11].

Both models are similar in several respects. The signs and sizes of most coefficients and z statistics are similar and have similar interpretations. This can be regarded as a sign of the robustness of the models.

The two lagged variables, e-banking, and e-government are significant with positive effects and with odds ratios of 2.56 and 1.31, respectively. However, there seems to be little gain in the dynamic[12] model, which loses almost half of the observations due to the lags, so we concentrate on the results for model 1.

[11] All estimations are performed using Stata 15.

[12] The model is dynamic in the sense that the information set at time t incorporates the values of some variables at time t-1.

Table 2.
Models of adoption of e-commerce by individual Internet users.
Panel data (2008–2016)

	Variables		(1) E-commerce static logistic model		(2) E-commerce dynamic logistic model	
			Odds ratios	z	Odds ratios	z
Lagged variables	eBanking_{t-1}				**2.56**	**21.37**
	eGovernment_{t-1}				**1.31**	**6.20**
Sociodemographic	Gender	Female				
		Male	**1.45**	**11.90**	**1.52**	**9.51**
	Age	16-24				
		25-34	0.85	-0.81	0.94	-0.16
		35-44	**0.56**	**-3.12**	0.49	-1.82
		45-54	**0.38**	**-5.03**	**0.38**	**-2.49**
		55-64	**0.23**	**-7.19**	**0.26**	**-3.30**
		65<	**0.14**	**-8.37**	**0.17**	**-4.00**
	Education	Primary or less				
		Secondary	**1.58**	**7.12**	**1.51**	**3.94**
		Bachelor	**2.34**	**11.95**	**1.98**	**5.99**
		Master/PhD	**3.36**	**16.86**	**2.68**	**8.64**
	Digital Skills	Low				
		Medium	**2.56**	**4.90**	**2.74**	**2.55**
		High	**7.95**	**11.22**	**7.16**	**5.17**
		Very high	**25.32**	**17.36**	**24.29**	**8.32**
	Habitat	<20,000				
		20,000-100,000	0.94	-1.49	1.00	-0.03
		100,000-500,000	**0.78**	**-3.82**	**0.73**	**-3.52**
		500,000<	1.00	-0.05	1.03	0.63
	Household Members	One				
		Two	**0.87**	**-2.69**	0.87	-1.78
		Three	**0.73**	**-6.02**	**0.75**	**-3.74**
		Four	**0.71**	**-6.42**	**0.76**	**-3.57**
		Five or more	**0.60**	**-7.15**	**0.64**	**-4.35**
	Nationality	Foreigner				
		Spanish	**1.26**	**3.67**	1.00	-0.02
Economic	Employment Situation	Employed				
		Unemployed	**0.73**	**-6.94**	**0.76**	**-4.21**
		Retired	**0.84**	**-2.16**	0.84	-1.52
		Student	**0.70**	**-4.78**	**0.77**	**-2.38**
		Housekeeper	**0.81**	**-2.79**	0.83	-1.66
		Other	0.83	-1.89	0.93	-0.51
	Income	Low				
		Medium	**1.60**	**10.43**	**1.52**	**6.01**
		Medium-high	**2.58**	**19.04**	**2.42**	**11.74**
		High	**4.00**	**23.43**	**3.67**	**14.73**

Table 2 (Continued)

	Variables		(1) E-commerce static logistic model		(2) E-commerce dynamic logistic model	
			Odds ratios	z	Odds ratios	z
Interaction	Digital Skills × Age	High × 55-64	**2.44**	**4.02**	1.62	1.15
		High × 65 or more	**2.33**	**3.24**	1.53	0.92
		Very high × 55-64	**1.80**	**2.53**	1.21	0.44
		Very high × 65<	**3.09**	**3.90**	1.67	1.05
Time effects	Year	2008				
		2009	**0.84**	**-3.28**	0.87	-1.85
		2010	**1.17**	**2.88**	1.11	1.28
		2011	1.05	0.76	0.91	-1.10
		2012	**1.13**	**2.03**	1.16	1.77
		2013	**1.23**	**3.57**	**1.20**	**2.22**
		2014	**2.09**	**12.57**	**2.01**	**8.25**
		2015	**4.21**	**24.33**	**3.90**	**15.94**
		2016	**4.09**	**23.94**	**3.90**	**16.04**
Socio-geographic effects	Autonomous Community	Andalucía				
		Aragón	1.16	1.81	1.25	1.96
		Asturias	**1.26**	**3.01**	**1.33**	**2.65**
		Baleares	**2.35**	**9.39**	**2.07**	**5.37**
		Canarias	**0.82**	**-2.24**	**0.69**	**-2.86**
		Cantabria	**1.60**	**5.36**	**1.67**	**4.11**
		Castilla la Mancha	**1.26**	**2.71**	**1.29**	**2.09**
		Castilla León	1.04	0.45	1.15	1.28
		Cataluña	**1.55**	**6.58**	**1.40**	**3.60**
		Extremadura	1.12	1.29	1.26	1.79
		Galicia	1.04	0.46	0.97	-0.32
		La Rioja	**1.27**	**2.58**	**1.36**	**2.35**
		Madrid	**1.42**	**5.16**	**1.32**	**2.93**
		Navarra	**1.66**	**6.92**	**1.85**	**5.83**
		País Vasco	**1.79**	**7.27**	**1.72**	**4.83**
		Murcia	0.94	-0.75	0.98	-0.18
		Valencia	0.91	-1.34	0.86	-1.57
		Ceuta	0.72	-1.72	0.73	-1.10
		Melilla	0.98	-0.11	0.87	-0.41
	Constant		0.05	-15.36	0.02	-10.25
	N. observations		66,169		34,032	
	Wald χ^2		7982.03, DF: 69		3704.33, DF: 71	

Notes: Odd ratios and z statistics significant at the 5% are represented in bold. Random-effects logistic model (Equation 1). Random effects dynamic logistic model (Equation 2). Heteroskedasticity robust estimates. Estimations refer to all Internet users that have purchased (or not) online in the last year. The first category of each variable is the reference, and it is omitted. The samples reflect the fact that some variables are missing for some observations, which reduces the usable sample size. The dynamic model loses almost half of the sample due to the lagged variables. All estimations have been calculated using Stata 15.

The estimates are presented in the form of odds ratios; estimated odds ratios with values smaller than one are associated with variables that have negative effects on the adoption of e-commerce relative to the

reference group. Odds ratios above one are associated with explanatory variables that have a positive effect on the dependent variable. The individual significance of each coefficient is tested using the z (standard normal) statistic. Corresponding z statistics are calculated from the null of the odds ratio being equal to one (no effect). Odds ratios below one have corresponding negative values of z, while odds ratios above one have corresponding z with positive signs.

The interpretation of the estimation results of the static model is as follows:

Males have higher odds than females of using e-commerce 1.45, which is highly significant. This is revealing of a gender gap that may be disappearing in a relatively short time as women incorporate to e-buying.

Meanwhile, age has a negative impact on e-commerce. As the age of the individual increases from one age range to the next, the odds ratios decrease monotonically from 1 for ages 16-24 to 0.14 for ages of 65 and above. This is also compatible with an age divide, which may be diminishing as new cohorts of young people reach more mature ages. Age, like most other variables, cannot be manipulated by policy, so it cannot be considered a policy instrument in this context. However, identifying age groups with a low likelihood of e-commerce adoption allows more precise targeting of policies.

Education has an important and positive effect measured by odds ratios that go from 1 for primary or less to 3.36 for the case of Master/Ph.D. This, as the previous ones is a purely education effect (not incorporating income) and shows that individual consumers with higher levels fo formal education tend to engage in e-commerce with higher likelihood than consumers with lower education.

Next, digital skills have important positive effects, measured by odds ratios that go from 1 for the category of low digital skills to 25.32 for the category of very high digital skills. This is a variable that can be partially manipulated in the short run, and thus, it is the center of intense debate on whether and how to do it more efficiently. This variable can be manipulated through education on digital skills as well as information and technical support. The European Commission (2018) points out that one of the main barriers for the development of e-commerce in Spain is in the demand side, in particular, the shortcomings in human capital related to ICT as consumers.

The effect of habitat is essentially negligible for most of the categories, say below 20,000, between 20,000 and 100,000 and also for above 500,000. However, it is negative for middle size populations between 100,000 and 500,000 inhabitants with an odds ratio of 0.78, which is significantly below 1. This may suggest that inhabitants of middle size populations are less prone to engaging in e-commerce than the rest of the population. It would be very interesting to have more disaggregate information regarding habitats below 20,000 inhabitants to be able to assess the effect of rural and remote areas which may have important differences with the rest of the population.

The number of household members has a decreasing effect, with an odds ratio of 1 for the families of size one, to a value of 0.60 for the families of 5 or more individuals. This is measuring the effect of the size for a given amount of the other variables, in particular, it would mean lower income per individual for a given amount of income.

Being Spanish has a positive effect reflected in an odds ratio of 1.26. The effect of nationality is not obvious since foreigners could be more prone to cross border e-commerce than nationals. However, the measure of e-commerce used here does not distinguish for origin, intensity, or expenditure on e-commerce just if there has accessed to e-commerce or not.

Those individuals currently employed tend to do more e-commerce (odds ratio of 1) than the rest of the categories, specifically the unemployed, with an odds ratio of 0.73, the retired, with an odds ratio of 0.84, students with an odds ratio of 0.70, housekeeper (0.81) and other (0.83). These results seem intuitive, while the exact estimates and significance cannot be anticipated by previous intuition.

Income has a positive and significant effect. The estimated odds ratios vary from 1 to 1.60, 2.58, and 4.00, respectively, when income increases. The inclusion of income is important in this article. While several previous papers ignored its importance and omitted its effect (but not others like Valarezo et al. (2019) and Garin et al. (2019)), it is the typical variable that intervenes in most economic decisions.

Notice that if we are interested in the possibility of doing policy to promote e-commerce, there are few variables amenable to manipulation by policymakers. The variables gender, age, education, habitat, household members, nationality, employment situation, and income cannot be manipulated in the short term. Only digital skills can be altered in the short run for policy purposes. This coincides with the emphasis placed by the European Commission in the deficiency of these specific skills in Spain and the suggestions of putting in place new programs in this area.

The time effects, shown in figure 6 of the Appendix are dummies that can be thought of as capturing other demand-side variables, like time-varying effects and the economic crisis, as well as supply-side effects not included in the explicit explanatory variables. The time effects are significant and mostly growing over time.

The first two variables that belong only to the dynamic model correspond to the first lags of e-banking and e-government. They have significant effects, signaling that the adoption of e-commerce may be anticipated by the adoption of e-government and e-banking by a given individual.

The dummy variables corresponding to the 17 autonomous communities (and two autonomous cities) capture specific effects not accounted for in the rest of the model. They would be essentially autonomous community individual effects.

A list of the autonomous communities together with its individual specific odds ratios in descending order are, first, the group of high and significant values: Baleares (2.35), País Vasco (1.79), Navarra (1.66), Cantabria (1.60), Cataluña (1.55) and Madrid (1.42).

Second, the group of middle and significant values of individual-specific effects consists of la Rioja (1.27), Asturias (1.26), and Castilla La Mancha (1.26).

The third group consists of those territories that have individual effects which are not significantly different from the reference (which is Andalucía). These are Aragón (1.16), Extremadura (1.12), Castilla León (1.04), Galicia (1.04), Melilla (0.98), Murcia (0.94), Valencia (0.91), and Ceuta (0.72). The archipelago of Canarias (0.82) is an outlier with a negative and statistically significant effect.

Interestingly enough, the first and last positions are occupied by the two archipelagos of Spain: Baleares and Canarias. This suggests that the effects are mostly due to income and wealth, and not so much by geography, in this particular case.

These effects seem to be capturing a divide which is based on an income and wealth (private and public) divide. Additionally, in some cases, like the Canarias archipelago, the logistic costs may be so high as to substantially limit the supply of certain products that are readily available in continental Spain.

Additional diagnostic of the empirical model

Multicollinearity may be a concern in this model. However, due to the panel structure of the data together with the type of categorical data which are orthogonal within each variable, the issue is not especially relevant. In any case, polychoric correlations among the relevant explanatory variables have been computed to obtain formal tests, as shown in table 3.

Table 3. Polychoric correlations among selected independent variables

	Gender	Age	Education	Digital Skills	Household Members	Income
Gender	1.00					
Age	0.02	1.00				
Education	-0.08	0.00	1.00			
Digital Skills	0.07	-0.29	0.43	1.00		
Household Members	0.02	-0.31	-0.02	0.06	1.00	
Income	0.07	0.06	0.46	0.30	0.24	1.00

The values of all off-diagonal elements that lie below .5 suggest that there is a limited amount of multicollinearity between the data of the independent variables.

6. Conclusions

This paper contributes to the literature on e-commerce. First, by improving on some of the limitations of the models used in previous papers. This is done by using a large and representative panel database of individual consumers and a variety of economic models. Variables such as income and digital skills at the individual level are included here, allowing for a natural interpretation as an income effect and a cost effect. By employing appropriate panel data econometric models, individual heterogeneity can be controlled, and estimates that are consistent and efficient are obtained.

The second contribution is measuring the importance of digital skills, which gives quantitative support to the current EC policy of promoting the training of specific sociodemographic groups. High digital skills have a positive influence on the adoption of e-commerce; insufficient digital skills seem to be partly responsible for the digital divide, as it is highlighted by the European Commission (2018).

The third contribution is to characterize penetrations across different groups of individuals: it can be noted that several digital divides appear for gender, age, education, digital skills, occupation, and income, as seen in table 1. Some absolute digital divides do not tend to close over time while others do, however relative digital divides generally tend to decrease over time.

Based on these conclusions some policy recommendations can be formulated as follows: when promoting e-commerce is a priority, several measures can be implemented at national and regional levels with the restriction of representing low costs on the part of the governments, firms, and citizens. The measures proposed here are low cost, specific, and targeted at individuals or groups, independently of their geographical location.

Focusing first on demand-side measures, for example, may be desirable to reinforce a training program on specific digital demand-side factors, like digital skills (pointed out by the EC as a critical bottleneck for demand) in order to bridge the digital divides. These measures could be focused on females, people over 55, those with low digital skills and homemakers. A complementary measure could be to provide technical support online, by phone or in person, to those groups that are more at a disadvantage. A training program may be more effective when focused on those that could increase from low to medium level of digital skills.

Focusing on supply-side measures, the government has recently implemented some interesting general measures, like the “digital by default” program (Estrategia 2015-2020), aimed at digitalizing all interactions of public services. It also created Offices of assistance on the use of public services for serving citizens using e-government, see European Commission (2017). Another measure for 2018 is the Grant program that offers basic training in ICT to young digital professionals so that they can gain access to jobs in this sector, see European Commission (2018).

Additionally, central and regional governments could promote complementary services such as e-health and identify and re-edit supply-side programs that were successfully implemented, whether in their territory

or others. The administrations could also reduce transaction costs, red tape, and trade barriers. Some territories, like the archipelago of Canarias, still do not have access to some e-commerce transactions that are available in the mainland, possibly due to its long-distance across the Atlantic Ocean and high logistic costs. Guidelines or incentives for efficient e-commerce platforms could also be established.

For the private sector, practical recommendations could be to implement easy-to-use platforms, facilitate legitimate customer reviews for their products and services, and assure more security for payment and transaction processes (which includes the handling of credit card fraud).

These results and conclusions present some caveats and limitations. The data set is large, but it is declarative, not observed data, which limits the quality of the data due to the difficulty of recollection. Moreover, the data are not specifically designed for this research on e-commerce, which also limits the applicability of the results.

An exercise similar to this one using data for services other than e-commerce and each European country is feasible. We leave this for further research.

The continuation of the analysis of the data set for topics like spending in e-commerce, broadband access, cloud services, trans-border e-commerce, and use by children constitute a rich research agenda. An in-depth study of digital divide using individual data and employing additional indicators is another priority. Clearly stating its definition and formulas for its computation, as well as the calculation of its differences across groups and the interpretation of its evolution over time, is also in the research agenda. Testing the hypotheses that the evolution of a given digital divide is analog to a life cycle model along time is another avenue of research. On the other hand, the availability of data on actual behavior would be useful for defining new priorities of research.

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Appendix

Figures 5-8 represent selected estimated coefficients of the equations in section 4.

Figure 5

Odds of e-commerce adoption. Panel (2008-2016)

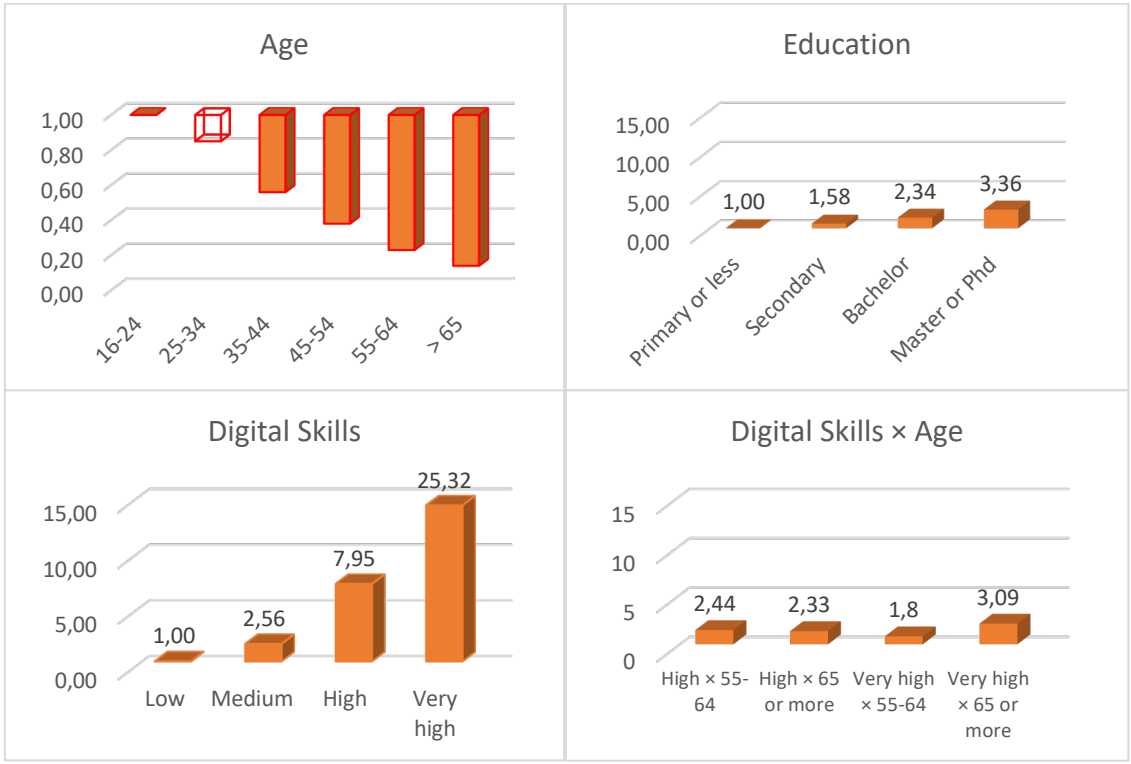

Figure 6:
Odds of e-commerce adoption. Panel (2008-2016)

Figure 7:
Odds ratios of yearly dummies. Panel (2008-2016)

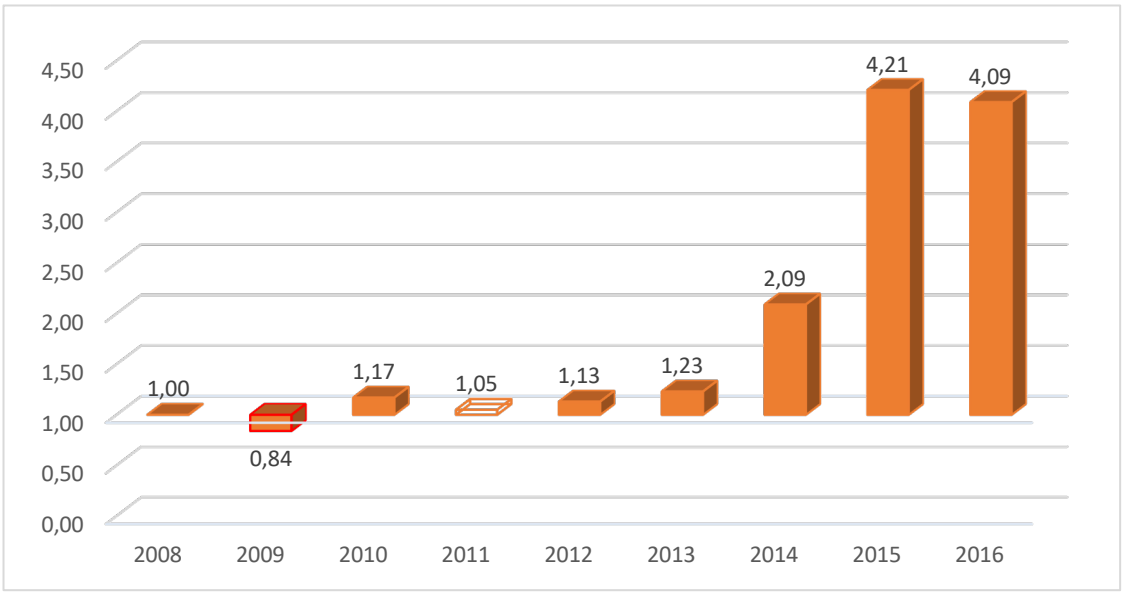

Figure 8:
Odds ratios of e-commerce adoption by regions. Panel (2008-2016)

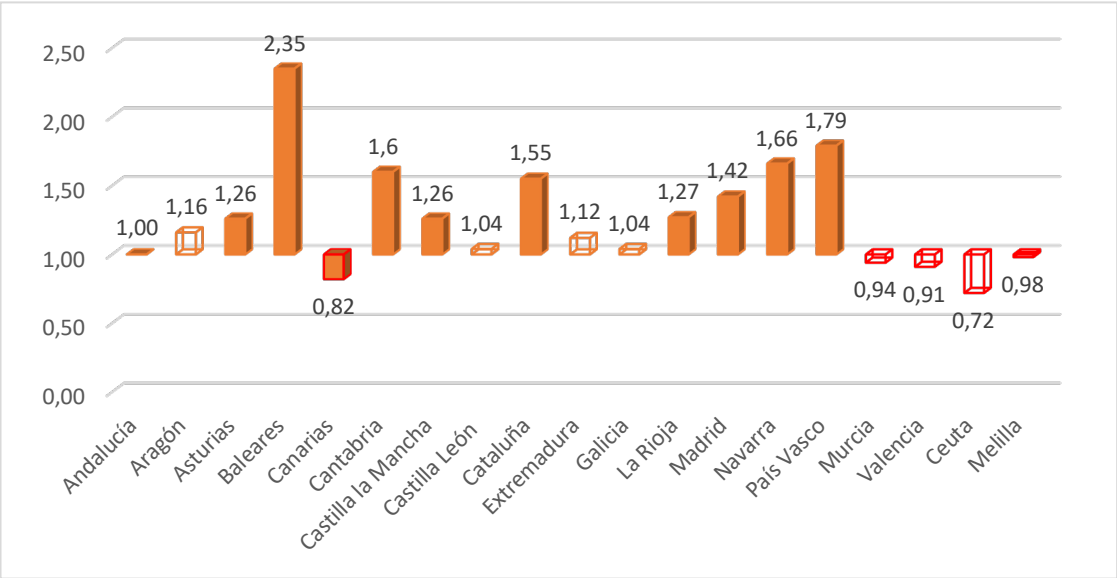

Table A1.
Heckman selection model of adoption of e-commerce by individual Internet users (2008–2016).

	Variables		(3) Internet use. Selection equation. Probit		(4) E-commerce adoption. Probit	
			Coef.	z	Coef.	z
	Gender	Female				
		Male	0.05	1.08	**0.15**	**11.17**
Exclusion restriction	Broadband	No				
		Yes	**1.10**	**21.71**		
Sociodemographic	Age	16-24				
		25-34	0.01	0.08	-0.08	-1.00
		35-44	-0.01	-0.09	**-0.29**	**-3.77**
		45-54	-0.24	-1.69	**-0.43**	**-5.41**
		55-64	**-0.43**	**-2.91**	**-0.63**	**-7.47**
		65<	**-0.40**	**-2.48**	**-0.84**	**-8.67**
	Education	Primary or less				
		Secondary	-0.06	-1.15	**0.19**	**6.70**
		Bachelor	**0.03**	**0.38**	**0.33**	**10.37**
		Master´s/PhD	**0.01**	**0.13**	**0.47**	**14.97**
	Digital Skills	Low				
		Medium	**1.32**	**4.47**	**0.39**	**4.87**
		High	**5.53**	**40.47**	**0.89**	**11.52**
		Very high	**5.45**	**39.65**	**1.44**	**18.67**
	Habitat	<20,000				
		20,000-100,000	**0.12**	**1.98**	-0.03	-1.46
		100,000-500,000	0.03	0.27	**-0.12**	**-4.32**
		500,000<	0.00	-0.02	-0.01	-0.46
	Household Members	One				
		Two	-0.03	-0.51	**-0.07**	**-2.91**
		Three	-0.15	**-2.06**	**-0.15**	**-6.45**
		Four	-0.13	-1.65	**-0.16**	**-6.71**
		Five or more	-0.11	-1.05	**-0.22**	**-6.98**
	Nationality	Foreigner				
		Spanish	-0.10	-1.20	**0.08**	**2.88**
Economic	Employment Situation	Employed				
		Unemployed	**-0.15**	**-2.42**	**-0.14**	**-7.02**
		Retired	**-0.43**	**-5.22**	-0.06	-1.57
		Student	**1.15**	**2.81**	**-0.15**	**-4.64**
		Housekeeper	**-0.24**	**-3.10**	-0.04	-1.34
		Other	**-0.35**	**-3.07**	-0.06	-1.35
	Income	Low				
		Medium	0.08	1.52	**0.21**	**10.41**
		Medium-high	0.12	1.65	**0.43**	**19.67**
		High	0.10	0.99	**0.62**	**23.89**

Table A1. (Continued)

	Variables		(3) Selection equation: Internet use. Probit		(4) E-commerce adoption. Probit	
			Coef.	z	Coef.	z
Interaction	Digital Skills × Age	Medium × 25-34	-0.19	-0.59	0.15	1.64
		Medium × 35-44	-0.16	-0.51	**0.34**	**3.85**
		Medium × 45-54	0.28	0.80	**0.33**	**3.65**
		Medium × 55-64	-0.10	-0.31	**0.34**	**3.63**
		Medium × 65 <	-0.13	-0.40	**0.37**	**3.49**
		High × 25-34	0.06	0.39	**0.24**	**2.70**
		High × 35-44	0.06	0.42	**0.37**	**4.36**
		High × 45-54	0.21	1.39	**0.37**	**4.24**
		High × 55-64	**0.44**	**2.80**	**0.41**	**4.40**
		High × 65 <	**0.46**	**2.70**	**0.40**	**3.65**
		Very high × 25-34	0.09	0.56	**0.27**	**3.02**
		Very high × 35-44	0.01	0.07	**0.43**	**4.97**
		Very high × 45-54	0.19	1.23	**0.42**	**4.72**
		Very high × 55-64	**0.45**	**2.54**	**0.33**	**3.34**
		Very high × 65 <	**0.62**	**2.93**	**0.54**	**4.50**
Time effects	Year	2008				
		2009	-5.90	-1.86	**-0.08**	**-3.67**
		2010	0.08	0.03	**0.07**	**2.79**
		2011	-5.97	-1.86	0.01	0.44
		2012	**-6.07**	**-2.01**	0.03	1.13
		2013	-0.10	-0.03	**0.07**	**2.92**
		2014	-5.87	-1.89	**0.29**	**11.53**
		2015	-0.08	-0.03	**0.60**	**23.96**
		2016	-0.10	-0.03	**0.58**	**23.24**
Sociogeographic effects	Autonomous Communities	Andalucía				
		Aragón	0.15	1.38	0.06	1.56
		Asturias	0.05	0.46	**0.11**	**3.16**
		Baleares	0.27	1.90	**0.35**	**8.78**
		Canarias	0.09	0.74	**-0.09**	**-2.33**
		Cantabria	0.22	1.70	**0.20**	**5.14**
		Castilla la Mancha	0.09	0.81	**0.09**	**2.37**
		Castilla León	**0.36**	**3.08**	0.02	0.52
		Cataluña	0.01	0.10	**0.18**	**6.35**
		Extremadura	0.22	1.92	0.05	1.24
		Galicia	0.17	1.64	0.01	0.41
		La Rioja	**0.27**	**2.02**	**0.10**	**2.42**
		Madrid	0.16	1.56	**0.13**	**4.53**
		Navarra	0.17	1.70	**0.22**	**6.72**
		País Vasco	0.11	0.91	**0.26**	**7.34**
		Murcia	0.01	0.12	-0.02	-0.56
		Valencia	**0.20**	**2.12**	-0.05	-1.51
	Autonomous Cities	Ceuta	0.47	1.39	-0.15	-1.77
		Melilla	0.05	0.15	-0.04	0.15
Constant			6.88	2.23	1.71	-20.26
N. observations			66,099		66,999	
Wald χ^2			4592.85, DF: 70		13666.89, DF: 70	
Pseudo R^2			0.5116			
Wald χ^2: H_0 = independent equations			1.12 DF:1 p-value = 0.2900			

Notes: Coefficients and z statistics significant at the 5% are represented in bold. Probit model, selection equation (3). Probit model, e-commerce adoption equation (4). Heckman probit clustered standard errors. Estimations equation (3) refer to all Internet users that have purchased (or not) online in the last year. The first category of each variable is the reference and is omitted. The samples reflect the fact that some variables are missing for some observations, which reduces the usable sample size. All estimations have been calculated using Stata 15.

Statistical significance and signs of coefficients of all explanatory variables coincide between the probit estimation results (second stage of Heckman selection model), Table A1, and estimations of the two logistic specifications, Table 2. On the other hand, a formal test of independence of two equations of the selection model (equations (3) and (4), with $\chi 2 = 1.12$, and p-value = 0.29) does not provide sufficient evidence to reject the hypothesis of independent equations, implying that, for the considered sample, the initial decision of using the Internet is unrelated to the decision of adopting e-commerce for private use. This may suggest that the modeling approach of using just one step delivers a useful model for e-commerce.