Lamberti, Giuseppe; López Sintas, Jordi; Sukphan, Jakkapong. «Explaining the digital divide in the European Union : the complementary role of information security concerns in the social process of internet appropriation». Information Technology for Development, Vol. 29 Núm. 4 (2023), p. 665-691. 78 pàg. DOI 10.1080/02681102.2023.2202640

Explaining the digital divide in the European Union: the complementary role of information security concerns in the social process of internet appropriation

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Accepted version published in:

Lamberti, G., Lopez-Sintas, J., & Sukphan, J. (2023). Explaining the digital divide in the European Union: The complementary role of information security concerns in the social process of internet appropriation. *Information Technology for Development*, *29*(4), 665–691. https://doi.org/10.1080/02681102.2023.2202640

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Explaining the digital divide in the European Union: the complementary role of information security concerns in the social process of internet appropriation

Most theoretical and empirical explanations of the generation of digital divides have been integrated into the resources and appropriation theory, which proposes a sequential model reflecting a socially unequally distributed digital divide. The unequal social distribution is reflected in internet use that is sequentially influenced by motivations/ attitudes, physical access, and digital skills. We extend the sequential model by exploring the complementary role of information security concerns in producing the digital divide. Using a predictive approach, we tested a comprehensive partial least squares-structural equation model with data from a European Union survey, finding that information security concern is another significant determiner of the digital divide. Heterogeneity in social internet appropriation can be summarized in social mechanisms explained by education and age among well-educated Europeans, and by country digital development among less well-educated Europeans. We conclude with a discussion of theoretical and policy implications of our findings.

Keywords: Trust; information security concerns; digital divide; PLS- SEM; digital skills; internet use

1. Introduction

Ongoing innovations in information and communication technologies (ICTs) are increasingly digita- lizing life through smart devices in many fields, including medicine and health (van der Zeeuw et al., 2019). Growing numbers of traditional activities are being transformed into online digital activities (e.g. e-entertainment, e-shopping, e-health, etc). Digital skills are becoming increasingly essential yet are unequally distributed to the disadvantage of people, organizations, and nations, leading to a digital divide (Ayanso et al., 2010; Hidalgo et al., 2020; Shakina et al., 2021; van Deursen & van Dijk, 2015; van Dijk, 2005, 2020).

Our research aims to develop further the sequential production of the digital gap in the European Union (EU) when information security concerns are considered as a complement to digital skills. Thedigital divide initially referred to the gap between individuals with and without access to ICTs. However, evidence indicates that the divide is more than just a matter of access to devices (Pick & Azari, 2008; Sciadas, 2005; van Dijk, 2005, 2020); it also reflects the digital skills necessary to obtain, manage, and communicate information, and to solve data-problems. Digital skills are unequally distributed in society, and differences lead to inequality in the use of, and benefits of, the internet (Ayanso et al., 2014; Pick & Azari, 2008; Zillien & Hargittai, 2009). Of several theories proposed to explain the digital divide (Zillien & Hargittai, 2009), the most com- prehensive is the resources and appropriation (RA) theory, a sequential model that explains the social process of internet appropriation in terms of several digital divides, namely, access, skills, and uses and outcomes (van Dijk, 2005, 2012, 2020). Nonetheless, there is a surprising lack of research into whether the sequential digital divide model can be extended by considering other theoretical constructs, such as information security concerns.

Increasing attention is being paid to trust and its relationship with information security concerns as a determiner of both internet outcomes and tangible benefits (Benamati & Serva, 2007; Nelmset al., 2018; Pérez-Morote et al., 2020; Shah et al., 2021). If internet use is associated with outcomes and benefits (van Deursen & van Dijk, 2015), and if information security concern is associated with sequential digital gaps (Chang et al., 2017; Dutton & Shepherd, 2006; Suh & Han, 2002), as proposed by the RA theory, then – as suggested by Huang et al. (2003) in their research on the influence of trust on internet adoption rates in different countries – information security concerns may be yetanother digital divide determiner.

This research extends van Dijk's sequential model of the digital divide (van Deursen & van Dijk, 2015). First, we test whether a more comprehensive model that includes information security con- cerns could better explain the digital divide. Then, focusing on the relationship between securityconcerns and the other model constructs, we determine whether social heterogeneity exists in the extended model, and test the statistical significance of heterogeneous social mechanisms that produce the digital divide. In particular, we are interested in responding to the following researchquestions:

- To what extent do information security concerns enhance understanding of the RA model of social internet appropriation and better predict the digital divide?
- To what extent do social indicators explain variations in the relationship between information security concerns and other sequential model constructs, revealing heterogeneity in the social mechanisms that produce inequality in internet use?

2. Theoretical background

2.1. The sequential model of social internet appropriation

The sequential model that explains the social generation of differences in internet appropriation – formalized in the RA theory (van Deursen & van Dijk, 2015; van Dijk, 2005, 2020) – explains the repro- duction of social inequalities in the digital realm in terms of several sequential digital divides that reflect differences in enjoyment of the benefits of internet use: motivations/attitudes physical access, digital skills, and internet use. The RA theory has made an effort to offer a comprehensive relational social theory of the social generation of digital inequalities that encompasses most existing social (Bourdieu, 1984; Davis, 1989; Thierer, 2000; Tilly, 1998; Venkatesh et al., 2003) and technological theories (Compaine, 2001; Davis, 1989; Thierer, 2000; Venkatesh et al., 2003).

2.1.1. Barriers to internet use (motivations/attitudes)

van Dijk (2005) has proposed that attitudes categorize individuals as those motivated or unmoti- vated to access/use ICTs. Motivation is a reason for physical access, while attitudes are a set of beliefs regarding the benefits of using the Internet; hence, attitude is an antecedent of motivation (Ryan & Deci, 2000). However, a positive attitude and motivation to access ICT may require individ-uals to overcome perceived structural and psychological barriers (Durndell & Haag, 2002; Dutton & Reisdorf, 2017; Meuter et al., 2003; van Deursen & van Dijk, 2015). According to the World Economic Forum (2016), perceived barriers to internet use are socio-structural (infrastructure, awareness, cul- tural acceptance) and psychological (affordability, skills). In this research, instead of motivation or attitudes we measure their antecedent, perceived barriers to internet use (van Deursen & Helsper, 2015). Therefore, we can expect perceived barriers to internet use to have a negative impact on phys-ical access, digital skills, and internet use.

2.1.2. Physical access

Early studies of the first digital divide defined physical access as the opportunity to access the inter-net. Researchers first proposed that equipment superiority may affect internet use (Zillien & Hargittai, 2009), and later provided evidence that differences in physical access might also generate differ- ences in skill levels and diversity of internet use (Mossberger et al., 2012; van Deursen & van Dijk, 2010, 2019).

2.1.2. *Digital skills*

While digital skills have many dimensions, core skills are those for obtaining information, managing information, communicating, and solving problems (van Deursen & van Dijk, 2009, 2010, 2015). Researchers have found evidence that having those core digital skills positively impacts internetuse (van Deursen et al., 2014; van Deursen & van Dijk, 2015).

2.1.3. *Internet use*

Uses of the internet have been conceptualized in several ways, including intensity – e.g. frequency of use and connection duration – and also according to activities (Hargittai & Hinnant, 2008; van Deursen & van Dijk, 2014). Traditional social inequalities may be reproduced in the diversity of inter- net uses, classifiable as activities reflecting offline outcomes: economic (e.g. property, employment, education), cultural (e.g. identity and belongingness), social (e.g. networking), and personal (e.g. fitness, lifestyle, relaxation). For our purposes, we define internet use as the diversity of online inter-net activities.

The core argument of the causality chain is that a social process sequentially generates unequal access to the internet, from perceived barriers negatively related to physical access and the other sequential drivers, physical access positively related to digital skills and internet use, and finally, digital skills positively related to internet use.

2.2. The sequential model and information security concerns

In their interactions over the internet, the parties are expected to behave as agreed, as outcomes will otherwise be less than optimal for society. Individuals need to be reassured that organizations will take good care of their data and faithfully deliver ordered goods/services. In contrast, organizations expect to receive accurate data and to be paid. Before the internet age, institutional innovations ensured secure trading, while reputation was the mechanism that enhanced trust, reducing information security concerns and the possibility of litigation (Hemmert et al., 2014); previous transaction experiences thus came to be of paramount importance in predicting the behavior of sellers/buyers. Consequently, trust in the exchange system – between individuals and institutions – was the bridge that overcame information security concerns and perceptions of risk and uncertainty (McKnight et al., 2002; Pavlou, 2003; Pavlou et al., 2007).

Trust has individual, organizational, and institutional dimensions. A person's ability to interpret and rely on narratives and behaviors (Benamati & Serva, 2007; Mayer et al., 1995; Shah et al., 2021) is crucial to developing trust and reducing information security concerns and transaction risks. In addition, online transaction risk is diminished by organizational innovations; e.g. Paypal (a financial intermediary) and eBay (a market) jointly developed an innovative system for secure online transactions for buyers and sellers (Nahari & Krutz, 2011). Going even further, Amazon inte- grated both those innovations and offers a money-back guarantee, and AliExpress and Alibaba have incorporated Paypal's functionality using Alipay to process transactions. Such innovations increase 'relational trust' between online exchange partners (Morgan & Hunt, 1994) by reducing the perceived risk of information asymmetry and fears of seller opportunism in securing banking data through inappropriate access (Benamati & Serva, 2007; Pavlou et al., 2007).

Institutional innovations can more broadly raise the level of trust in society. The need for insti- tutional-based trust arises from social and geographical distance and extensive networks of interde- pendent transactions (Zucker, 1986). Innovative technologies include online transaction encryption and secure website certification, which reduce the risk and uncertainty associated with data privacy and security through trustworthiness signals designed to reduce information security concerns and increase trust in e-commerce activities (McKnight & Chervany, 2001; Pavlou, 2003; Pavlou et al., 2007).

Legislation, like Convention 108 for the Protection of Individuals regarding Automatic Processing of Personal Data, is another institutional innovation aimed at increasing seller responsibility regard- ing the post-purchase security of data provided, knowingly or unknowingly, by individuals over the internet for many different purposes, such as purchasing goods and services, gaming, e-learning, paying taxes, etc.

Trust and its effects on information security concerns has only recently become a topic of keen interest to researchers (Adjerid et al., 2018; Heirman et al., 2013; Malhotra et al., 2004; Pavlou et al., 2007; Vishwamitra et al., 2017), most especially trust in the internet (Benamati & Serva, 2007; Dutton & Shepherd, 2006; Huang et al., 2003; Robinson, 2018; Shah et al., 2021; Suh & Han, 2002). If willingness to provide personal data over the internet depends on the accumulated experi- ence of individuals interacting over the internet, and if this experience, in turn, depends on motiv- ations/attitudes, physical access to the internet, and digital skills and internet use, then increasing trust and reducing information security concerns must be of paramount importance for internet use (Giantari et al., 2013; McKnight et al., 2002; Pavlou, 2003; Pavlou & Gefen, 2004).

In this research, we are concerned with the role of information security concerns in (re)producing the digital divide. Information security concerns stem from ‘a buyer’s difficulty in assessing a seller’s ability and willingness to safeguard monetary information’ (Pavlou et al., 2007, p. 114). It is therefore negatively related to trust and positively to a buyer’s perceptions of risk. If people trust the digital environment, then they will have fewer concerns about data privacy and information security, will provide more personal data, and will use the internet more; however, if people are concerned with the security of the information they provide during a transaction, their perceptions of uncer-tainty will increase (Pavlou et al., 2007; Vishwamitra et al., 2017). Information security concerns, therefore, are an antecedent of the user's willingness to provide personal and financial data and of their expectation that sellers will ethically safeguard that data. Even if we cannot directly measure trust, we know that trust is negatively related to information security concerns, and the latter can be inferred from whether people send their data over digital highways, share data with organizations, and allow their data to be stored by third parties (Pavlou et al., 2007; Steedman et al., 2020). Individuals with fewer information security concerns will make greater use of, and expect positive outcomes from, the internet, whether in doing business, cooperating with others, sharing information, etc (Beaudoin, 2008; Chang et al., 2017; Dutton & Shepherd, 2006; Giantari et al., 2013; Jarvenpaa et al., 2000; McKnight et al., 2002; McKnight & Chervany, 2001; Shin, 2010).

Personal data revealed to organizations is a manifestation of information security concerns. As confidential data (contact and payment details, etc) is often requested for online transactions, we can measure information security concerns through its consequences: user reports of data disclosures (Adjerid et al., 2018; Crossler & Posey, 2017; Pavlou et al., 2007; Söllner, 2020; Vishwamitra et al., 2017). We can expect that individuals with fewer information security concerns will more willingly reveal data and will use the internet more (Dutton & Shepherd, 2006). We therefore hypothesize:

H1: The fewer the information security concerns, the more use is made of the internet.

Information security concerns may be related to other digital divide drivers, including perceived bar- riers to access (reflecting motivations/attitudes), which the literature suggests are positively associated with trust (Bansal et al., 2016; Blank & Dutton, 2012; Chang et al., 2016; Dinev & Hart, 2006; Joinson et al., 2010; Shin, 2010). We can therefore expect that fewer perceived barriers to access lead to fewer information security concerns and more information will consequently be shared over the internet; the inverse relationship can also be expected to hold (Joinson et al., 2010; Meuter et al., 2003; van Deursen & Helsper, 2015). We therefore hypothesize:

H2: The greater the perceived barriers to internet use, the greater the information security concerns and the less infor- mation is shared over the internet.

The concept of information security concerns is also related to physical access and internet use. Indi- viduals with better equipment are likely to have fewer information security concerns and to use the internet more. They may even have the necessary skills to create virtual private networks, ensure more secure browsing, block cookies, protect against malware or intrusions, etc. (Maple, 2017). Using trustworthy devices and mechanisms will enhance service reliability and security (Køien, 2011; Mahatanankoon et al., 2006). We therefore hypothesize:

H3: The better the quality of physical access, the fewer the information security concerns and the more information isshared over the internet.

People with advanced digital skills can better interpret organizational and institutional signals regarding information security (Dutton & Shepherd, 2006; Steedman et al., 2020), and so can better mitigate online risks. For instance, people with more advanced skills and greater awareness of risk use prepayment cards to avoid data leaks over the internet, or use only secure means of payment, like Paypal, Alipay, or, more recently, Apple Pay. Researchers have argued that digital skills are associated with generalized trust, suggesting that developing digital skills may reduce infor- mation security concerns and increase the probability of data sharing over the internet (Dutton & Shepherd, 2006; Monforti & Marichal, 2014; van Dijk, 2020). We therefore hypothesize:

H4: The more advanced an individual's digital skills, the fewer information security concerns and the more infor-mation is shared over the internet.

This extended causality chain is depicted in Figure 1. The original model, which included four con- structs namely perceived barriers to internet use, physical access, digital skills, and internet use, was adapted from van Deursen and van Dijk (2015) sequential model, and already tested using the 2016 EU ICT survey data in Lamberti et al. (2021). The contribution of the present study is to expand the Lamberti et al. (2021)'s model by including the information security construct, and testing whether this construct is another significant determiner affecting internet use, throwing further light on the understanding of social internet appropriation.

[Figure 1. The role of information security concerns in the social process of internet appropriation about here.]

2.3. Inequalities in social internet appropriation

The digital divide's social mechanisms may vary according to individuals' social positions between and within countries (van Deursen & van Dijk, 2015; van Dijk, 2005, 2012, 2020). The RA theory (van Dijk, 2005, 2012, 2020), which posits an unequal social distribution of motivations/attitudes, physical access, digital skills, and internet use in society, has proposed a set of indicators of social position and categories to explain this unequal social distribution within and between countries.

The main within-country indicators that reflect unequal access to the internet point to gender (women versus men), age (younger versus older), education (well-educated versus less well-edu- cated), and occupational status (employed versus inactive) (van Dijk, 2020; Wilson et al., 2003). The between-country causes of the digital divide seem to be associated with greater or lesser country-level development (Ayanso et al., 2010, 2014; Pick & Azari, 2008; van Dijk, 2005, 2020),

e.g. inequalities in terms of telecommunication infrastructures, digital policies, wealth, and edu-cation (Chen & Wellman, 2004; Cueto et al., 2018; Kajol et al., 2022; Kos-Łabędowicz, 2017; OECD,2001; Park et al., 2015). Cruz-Jesus et al. (2012) have proposed the existence of two kinds of drivers of digital inequality, one each operating at the between-country level and the within-country level (Jauhiainen et al., 2022). Digital infrastructure development, for instance, is a major challenge for less digitally advanced countries with large rural populations (Van Dijk, 2013, 2019; World Economic Forum, 2016), as building up an interconnected digital network requires a massive and very costly investment by firms, governments, and individuals. Digital devices are not, logically, of much use to individuals if they cannot connect through stable and affordable con- nections. Since most developing countries cannot afford this investment, they cannot move on to more advanced digital technologies (Reggi & Gil-Garcia, 2021; Reggi & Scicchitano, 2014; Vicente & López, 2011). Furthermore, even if individuals can digitally connect, to reduce the digital gapwithin a country, local content has to be available in mother tongues and cultures (Napoli & Obar, 2014, p. 330), given that only the most privileged individuals will be able to access contentavailable in other languages (English mainly). Findings reported by several researchers (Cruz-Jesuset al., 2012; Wang et al., 2022) suggest that countries need to advance along two dimensions of the digital divide: access to and use of the internet at the individual level, and actions by firms and governments at the organizational and institutional levels.

Contrasting with research to date, which has focused on the unequal distribution in society of the theoretical constructs of motivations/attitudes, physical access, digital skills, and internet use (van Deursen & van Dijk, 2015), we are interested in uncovering heterogeneity in the social mechanisms producing inequalities in internet use at both the within- and between-country levels. We thus focus on exploring differences in the relationship between trust (i.e. information security concerns) and the other theoretical constructs, and on identifying the social mechanisms that explain the digital divide. According to the RA theory, the relative importance of between-country and within-country social generators of unequal access to internet use is an empirical matter (van Dijk, 2020).

3. Research design

3.1. Sample

To test our model, we used 2016 data on ICT use by individuals in the EU, collected by each country's statistical office under the supervision of Eurostat, which aggregated the data.[1] The statistical unit of analysis was the individual, even for data regarding the household in which the individual lives (for more information refer to the *Methodological Manual for Information Society Statistics – Survey Year 2016*). The survey included representative data from the 27 European member states plus the UK (EU27 + UK). Given the large number of countries involved in the study, data collection occurred between January and August 2015. All statistical offices used probability sampling except for Greece, which used multistage stratified area sampling. Face-to-face or telephone interviews were used, except in Belgium and Germany (a self-administered mail survey), and the Netherlands (an online survey). No other data source was used. From the original survey, we selected 38 indicators to measure our constructs. Appendix Table A1 describes each construct's indicators and the main descriptive statistics (mean (M) and standard deviation (SD) or frequencies, depending on the nature of the indicators). As country sampling design differs strongly across countries, no weights are applied to the available survey data; however, the very large sample sizes meant that there was no fear of biases in the global analysis.

We selected indicators reflecting the main resources and social categories underlying inequality according to the RA theory. Following van Deursen and van Dijk (2015) and van Dijk (2005, 2020), we used one social position indicator (education level) and three individual social category indicators (gender, age, and occupational status). Drawing on the classification proposed by Cruz-Jesus et al. (2012) for EU countries, at the country level, we used a single digital development indicator, based on (1) ICT infrastructure, and (2) ICT adoption by the population and e-business and internetaccess costs. These two factors were used to cluster the EU countries according to factor scores, pro- ducing a taxonomy reflecting digital development scores and digital development balance (Cruz-Jesus et al., 2012). The three clusters were as follows: digital leaders (Denmark, Finland, Luxembourg, Netherlands, and Sweden), digital followers (Austria, Belgium, Germany, Ireland, Malta, UK, Poland, Portugal, Spain, and Slovakia), and digital laggards (Estonia, Italy, Latvia, Romania, Bulgaria, France, Lithuania, Croatia, Slovenia, Cyprus, Greece, Czechia, and Hungary).

From the total ICT survey sample, we selected individuals applying the following filters: individ- uals older than 15 years, and individuals who had used the internet in the previous three month. The few 'not applicable' values (n = 1815) regarding education level were excluded from the sample. Sample sizes for each country before and after applying the filters are reported in Table 1, and social indicator distributions are depicted in Figure 2. Of the 151 660 survey respondents, 51.6% were female, 77.5% were aged 25–64 years, 32.7% had a high education level, and 62.7% were employed. As for digital development level, 47.7% of countries were classified as digital leaders or followers.

[Table 1. EU countries sample size about here.]

[Figure 2. Social indicator details about here.]

3.2. Measurements

Table 2 describes the operational measures regarding the five constructs (perceived barriers to inter-net use, physical access, digital skills, internet use, and trust) reflected in the Eurostat survey data. For each construct, we include a definition, the indicators used to measure it, how it was operationalized, references, and a comparison with the construct employed in the van Deursen and van Dijk (2015) model. Measurements were as follows:

1. Information security concerns were measured on a scale (Pavlou et al., 2007) ranging from 0 (nodata disclosure) to 4 (disclosure of four kinds of data such as contact details, payment details, etc; see Table A1 for further details). As information security concern is negatively related with the

   amount of data shared over the internet, the scale as used in Pavlou et al. (2007) has been modified to range from 0 to −4 (i.e. more data disclosed over the internet indicates fewer infor- mation security concerns).

2. Perceived barriers to internet use were measured using eight items reflecting reasons for not accessing the internet from home (e.g. ‘equipment costs are too high’).

3. Physical access was measured according to use of up to six devices (desktop computer, laptop, notebook, tablet, mobile phone or smartphone, other mobile device).

4. Digital skills were measured in terms of obtaining, managing, and communicating information, and problem-solving, scored on a four-item Likert scale from 1 to 4 (no skills to advanced skills).

5. Internet use was measured using 16 dichotomous items reflecting a broad range of internet activities. Adapting the scale proposed elsewhere (Blank & Groselj, 2014; van Deursen & van Dijk, 2014), these were grouped and summed in terms of the four categories of social interaction, information-seeking, leisure, and commercial transactions, scored on a four-item Likert scale from1 to 4 (no use to highest use).

[Table 1. Construct comparison for the Eurostat and the van Deursen and van Dijk (2015) Netherlands surveys about here.]

Note that, given the nature of the first three theoretical constructs, to form optimal scales we used the first dimension scores of multiple correspondence analysis (MCA) (Greenacre, 1993).[2] The resulting scales explain most variation: 83.08%, information security concerns; 89.09%, perceived barriers; and 94.96%, physical access. A direct comparison was not possible due to differences between the Eurostat and the van Deursen and van Dijk (2015) Netherlands surveys (see Table 2). We used similar indicators for physical access as proposed by van Deursen and van Dijk (2015), with the main difference lying in how we operationalized physical access: while van Deursen and van Dijk (2015) just summed the items, we obtained the MCA first dimension scores. As for the internet use, while van Deursen and van Dijk (2015) again summed the indicators, availing of a larger set of activities than we did, we defined four use categories (summing the indicators in each) and used these to estimate the internet use construct (interestingly, our approach was probably statistically more accurate, as defining a scale seems preferable to assigning the same weight to all indicators). Our digital skills construct differed in that we used the Eurostat digital skills scale, whereas van Deursen and van Dijk (2015) considered the two subdimensions of medium- and content-related internet skills, Finally, as there was no measure available for van Deursen and van Dijk's (2015) motiv- ations/attitudes in the Eurostat survey, we used perceived barriers to internet use as a proxy.

3.3. Modeling

To fit the model, we used partial least squares structural equation modeling (PLS-SEM), previously used to evaluate online trust (Chang et al., 2017; Ogonowski et al., 2014). PLS-SEM is a multivariate technique that tests the psychometric properties of scales used to estimate parameters in a causal model – specifically, the strength and direction of relationships between variables. PLS-SEM allows complex models with many theoretical constructs and variables to be estimated following a 'soft approach' (Hair et al., 2019), i.e. without imposing distributional assumptions regarding the data (for a review, see Esposito Vinzi et al., 2010; Hair et al., 2015).

To explore social indicator effects on the relationship between information security concerns and the other sequential model constructs, we implemented the hybrid multigroup PLS-SEM approach (Lamberti, 2021), which combines classical multigroup analysis (MGA) with pathmox analysis (Lam-berti et al., 2016, 2017).

Regarding pathmox, in a nutshell, the underlying intuitive idea is that binary segmentation principles produce a tree with different models in each node. The algorithm starts by fitting a global model to all the data (i.e. the tree root) and identifies models with the most significant differences between child nodes. The available data are then recursively partitioned according to the categorical variables – not included in the models – that yield the most significant differ- ences between the child nodes. Partitions are identified using a test based on the F-test (as pro-posed by Lebart et al. (1979) and Chow (1960) to compare two linear regression models) to determine the degree of difference between two compared sub-models. Finally, pathmox avoids overfitting by using stopping rules based on maximum depth, minimum node size, and non-significance of the partitioning criterion.

Multigroup analysis (MGA) tests statistical differences in path coefficients between groups defined according to a categorical variable. The procedure is as follows: the data is separated into groups according to the categorical variable, and coefficients calculated for each group are then compared to identify significant differences. This comparative analysis is based on testing the null hypothesis against the alternative hypothesis, i.e. that coefficients between groups are the same or different, respectively. The statistics used to test the null hypothesis can be calculated using several procedures, e.g. those described in the review by Hair et al. (2017).

The hybrid multigroup PLS-SEM approach first identifies the most significantly different groups using pathmox, and then compares the resulting groups using MGA; in our case, groups were com-pared using the permutation test (Chin, 2003; Hair et al., 2017), after ensuring measurement invar- iance by applying the measurement invariance of composite models (MICOM) procedure. The MICOM procedure involves three components: (1) configural invariance, (2) compositional invar- iance, and (3) equality of composite mean values and variance values. Following Hair et al. (2017), it was necessary to establish both configural and compositional invariance to apply the MGA and establish partial measurement invariance. Configural invariance, which ensures that each latent vari-able has been specified in the same way for all the groups, exists when constructs are equally para-meterized and estimated across groups. Therefore, to establish configural invariance, each latent variable in the PLS-SEM model must be specified equally for all the groups, ensuring, in our case, identical indicators for each measurement model, identical data treatment, and identical algorithm settings across groups. Compositional invariance means that composite scores measure precisely the same construct across groups. Compositional invariance is tested by calculating the latent score cor-relations between groups and comparing them with the reference distribution of correlations obtained by permutation of the two groups. If the observed correlation falls in the upper 95% of the distribution ($p > 0.05$), then the null hypothesis that the theoretical correlation is 1 is accepted, and the composite invariance of the specific construct is established. If the constructs have equal mean values and variances across the groups, full measurement invariance is confirmed, which means that the data of different groups can be pooled.

Our statistical analysis was conducted using R software (R-Core Team, 2020).

4. Results

4.1. To what extent do information security concerns enhance understanding of the sequential model of social internet appropriation and better predict the digital divide?

Information security concerns, perceived barriers, and physical access, were single-item scales, i.e. as the indicators were factors, we used the first MCA dimension to build the scales, meaning that no additional validation was needed when the measurement model was analyzed (MCA scales are optimal scales, according to Greenacre & Blasius, 2006). Digital skills and internet use were modeled assuming that each was an antecedent of its indicators (i.e. we adopted a reflective approach), and were validated by checking three common reliability indexes (Esposito Vinzi et al., 2010; Hair et al., 2017), namely, Cronbach's α and Dillon's ρ to measure internal consistency (which should be greater than 0.7), and unidimensionality as measured through the difference between the first and second eigenvalues, with only the first eigenvalue expected to be greater than 1. We also checked the significance of the loadings according to the boot- strap intervals (calculated with 500 repetitions) and their length, which should be greater than 0.7 for reflective indicators, and also the average variance extracted (AVE), which should be greater than 0.5 (indicating that the constructs reflect at least 50% of the variance in the indi- cators). No further validations were needed for perceived barriers and information security con-cerns as single-item constructs (Hair et al., 2017). Results for digital skills and internet use are reported in Figure 3.

Cronbach's α was above the threshold of 0.7 for digital skills and almost reached the threshold for internet use. Dillon's ρ was high for both constructs, and the evidence favored construct unidimen- sionality. All item loadings were close to or greater than the 0.7 threshold and significant according to the confidence interval (CI), while the AVE was more significant than 0.5 for both digital skills and internet use.

The extended causal model of internet use, reporting path coefficients and CIs, is depicted in Figure 4. Due to the large sample size, we focused our analysis on the relative size of path coefficients and the overall R^2 to interpret and validate the results of the model.

Perceived barriers to internet use have a negative effect on physical access (β =

−0.107), digital skills development (β = −0.058), and internet use (β = −0.018). As expected, physical access strongly

affects digital skills development (β = 0.615), but hardly affects internet use (β = 0.248). Physical access is thus revealed to be a necessary condition to develop the digital skills that have the most significant effect on internet use (β = 0.517). Those results, which support the sequential caus- ality proposed elsewhere (van Deursen & van Dijk, 2015; van Dijk, 2005, 2020), suggest that the more significant influences are direct causal links in the sequential model, i.e. between perceived barriers to use and physical access, between physical access and digital skills, and between digital skills andinternet use.

[Figure 3. Digital skills and internet use validation about here.]

As for the causal relationship between the sequential model and information security concerns, asexpected, perceived barriers to internet use have a low and positive effect on information security concerns (β = 0.004), while physical access has a moderately negative effect on information security concerns (β = −0.177). Digital skills have the highest negative effect on information security concerns

(β = −0.394), and internet use is also negatively linked to information security concerns (β = −0.155).

We thus find support for hypotheses H1, H2, H3, and H4, suggesting that information security concern is another critical dimension potentially affecting social internet appropriation and contri-buting to the digital divide. Regarding predictive power, the model yields an R^2 of 0.631, a value con- sidered high in the PLS-SEM context.

[Figure 4. Path coefficients (95% CI) in the sequential model of inequality production about here.]

4.2. To what extent do social indicators produce differences in the relationship between information security concerns and the other sequential model constructs, revealing heterogeneity in the social mechanisms that produce inequality in internet use?

As mentioned, we used the hybrid multigroup PLS-SEM approach (Lamberti, 2021) to uncover poss- ible heterogeneity in the social mechanisms that produce the digital divide.

4.2.1. Heterogeneity in social internet appropriation

In identifying the social indicators that best explain heterogeneity in social internet appropriation, we restricted the procedure to two levels. The pathmox segmentation tree was set to yield a maximum of four social mechanisms, the minimum permissible social mechanism size was set to10% of the total sample, and threshold significance was set to $p = 0.001$ (due to the large sample). The results of the segmentation procedure, depicted in Figure 5, provide a graphical overview of the social internet appropriation process differentiated according to three social indicators: edu-cation ($F = 1620.239$, $p < 0.001$), digital development ($F = 917.562$; $p < 0.001$), and age ($F = 469.449$;

[Figure 5. Uncovering the social mechanisms underlying internet appropriation.]

$p < 0.001$). The models associated with the four terminal nodes were labeled as follows: LM1, less- educated Europeans living in digitally non-advanced countries (LEE_DNAC); LM2, less-educated Eur- opeans living in digitally advanced countries (LEE_DAC); LM3, well-educated young Europeans (WEYE); and LM4, well-educated European adults (WEEA).

4.2.2. Group comparison

4.2.2.1. Measurement invariance test. Before we compared groups, we checked for measurement invariance applying the MICOM procedure (Hair et al., 2017; see Section 3.3). Configural invariance was assured as we used the same PLS-SEM model for all the groups. Compositional invariance and equality of composite mean and variance values were tested by comparing and calculating a *p*-value for the reference distribution of values obtained by permutation of the two groups with latent score correlations, score mean difference, and score log-ratio variance between groups. Equal scores for the constructs verified compositional invariance in all cases ($p > 0.05$). Not verified was equality of composite mean and variance values ($p < 0.05$), meaning that mean scores and their variances were different for the theoretical constructs. Appendix Table A2 shows MICOM results for compositional invariance and the equality of composite mean and variance values.

4.2.2.2.MGA. The permutation test (Chin, 2003; Hair et al., 2017) was used to compare the four social mechanisms, with a difference only considered significant for $p < 0.001$, due to the large sample. Results, as reported in Table 3, indicate differences in the causal relationship between informationsecurity concerns and the other theoretical constructs. Appendix Table A3 reports details of the global comparison of all coefficients of the extended sequential model.

Table 3 shows that, for the perceived barriers to internet use, there were no differences in effectson information security concerns. In contrast, the effect of physical access on information security concerns was significantly greater for well-educated European adults (WEEA) than for both well-edu- cated young Europeans (WEYE) and less-educated Europeans living in digitally advanced countries (LEE_DAC); this effect was also significantly greater for well-educated young Europeans (WEYE) com- pared to less-educated Europeans living in digitally advanced countries (LEE_DAC), and also for less- educated Europeans living in digitally non-advanced countries (LEE_DNAC) compared to less-edu- cated Europeans living in digitally advanced countries (LEE_DAC). The effect of digital skills on infor-mation security concerns was significantly higher for less-educated Europeans living in digitally advanced countries (LEE_DAC), compared with the other three groups. For less-educated Europeans living in digitally non-advanced countries (LEE_DNAC), compared with well-educated young Eur- opeans (WEYE), this effect was also significantly higher. Finally, the effect of information security con- cerns on internet use was substantially higher for all groups, except for less-educated Europeans living in digitally advanced countries (LEE_DAC).

[Table 3. Internet uses by group about here.]

To check whether the four social mechanisms culminate in an internet use divide, we also pro- vided evidence regarding internet use by the individuals classified in each group. Results are pre- sented in Table 4. For each internet use indicator, we describe the frequencies observed in each group, and also report global percentages for comparison purposes.

Table 4 shows that the less-educated Europeans living in digitally non-advanced countries (LM1-LEE_DNAC) are characterized, as expected, by the lowest use of the internet in all activities, but especially in making appointments, watching video on demand, selling goods/services, and using payment accounts (active uses), while the principal benefits are derived from emailing (74.9%), par- ticipating in social media (61.6%), reading online (66.2%), and finding information (64.5%) (passive uses). As for the less-educated Europeans living in digitally advanced countries (LEE_DAC), we see a similar pattern of internet use, although slightly more intense; interestingly, this group presents the highest use of the internet for gaming. Regarding the well-educated young Europeans (WEYE), this group makes the highest use of the internet for communication (emails, online meet- ings, social media, self-created content), and also all other activities except for gaming. Finally, the pattern for the well-educated European adults (WEEA) is similar to that for the well-educated young Europeans, although use intensity is less; for a few indicators, internet use is as low as or even lower than that of the less-educated Europeans, specifically, telephoning over the internet/ video calls, using social media, uploading self-created content, watching videos on demand, gaming, selling goods/services, and using payment accounts.

[Table 4. Social mechanisms of internet appropriation: a comparison about here.]

We can infer, therefore: (1) that intensity of internet use is patterned by education, i.e. better edu- cated individuals make more intense use of the internet for all kind of activities; (2) that living in a more digitally developed country fosters use of the internet; and (3) that use of the internet is pat- terned by age, i.e. younger Europeans use the internet more for communication and entertainment. To sum up, in testing for the effects of social indicators on the extended model, we found that: (1) four categories of Europeans are defined according to education, country digital development, and age; (2) education is the most significant factor in discriminating Europeans' internet use; (3) the relationship between information security concerns and the other constructs in the different groups varies, suggesting that social indicators identify different social mechanisms of internet appropriation; and (4), the four social mechanisms reflect different internet uses.

5. Discussion

5.1. Main findings

This research, in extending the sequential model of the digital divide proposed by van Dijk (2005, 2020), contributes to knowledge of the social appropriation of the internet in several ways. First, we have generalized the sequential model to all the EU countries.

Second, in contrast with van Deursen and van Dijk (2015), who estimated a single global model of the social distribution of indi- viduals' scores between the theoretical constructs, we developed a global model and also explored and tested for the existence of different social mechanisms culminating in the digital divide. That is, we did not assume the existence of a single social mechanism but assumed that the various digital divides (motivations/attitudes, physical access, and digital skills) influence the ultimate divide (inter-net use) in terms of conferring different benefits depending on the social group. Third, we identified the main social groups linked to the different social mechanisms operating on the digital divide. Finally, we extended the original sequential model by including a new sequential divide, namely, information security concerns.

Our findings indicate that our extended social internet appropriation model better explains the digital divide in Europe. They also provide further evidence of the sequential path leading to the digital divide, i.e. the production of the first divide (physical access), second divide (digital skills), and third divide (internet uses and outcomes), as proposed by van Dijk (van Dijk, 2005, 2012, 2020) and other researchers (Hargittai, 2002; Scheerder et al., 2017). Finally, our model also takes into account the impact of including information security concerns in the causality chain (van Deursen & van Dijk, 2015) and further explains the social process of internet appropriation in the EU by identifying the different social mechanisms leading to the digital divide as it affects different groups.

The model extended to include information security concerns suggests that having advanced digital skills enhances internet uses and outcomes and reduces information security concerns. As the latter is negatively related to trust (Pavlou et al., 2007), reducing information security concerns fosters trust between online parties (Dutton & Shepherd, 2006; Steedman et al., 2020). The influence of digital skills on information security concerns suggests that successful online risk assessment depends on possessing better digital skills, in turn resulting in more accurate risk assessment, greater online trust, and more sharing of personal data online. Our findings provide evidence that individuals with better digital skills have fewer information security concerns, and consequently, trust digital partners more (Giantari et al., 2013; Monforti & Marichal, 2014; van Dijk, 2020), andare more willing to enter into transactions and share private data; a similar relationship has beenfound between e-government use and trust in government (Pérez-Morote et al., 2020), in online banking (Benamati & Serva, 2007), and between trust and presumption (Shah et al., 2021). The effect of information security concerns on internet use further suggests that trust results from having physical access to the internet and developing the necessary digital skills to assess and avoid risk.

Even more interesting is the fact that the relationship between information security concerns andthe other model constructs is not homogenous. Instead, heterogeneity in the model's causal relationships points to social mechanisms operating on internet appropriation that are reflected in four clusters defined according to education, digital country development, and age, with edu- cation (a proxy of Bourdieu's cultural capital) best explaining the existence of different social mech- anisms that culminate in the digital divide.

The MGA test of differences between the social mechanisms underlying internet appropriation suggests that, while the configuration, composition, and meanings of the theoretical constructs are the same for all the social mechanisms in all the EU countries, the mean scores for each social mechanism differ, indicating that their distribution across the EU differs. That the mean score differed for each social mechanism was to be expected according to the RA theory (van Dijk, 2005, 2012, 2020), even though that theory did not propose the existence of four social mechanisms affecting internet use in different ways, as indicated by our findings. Thus, the division between less-and well-educated Europeans is positively associated with the intensity of internet use; living in a more digitally developed country fosters greater internet use among less-educated Europeans (but not among well-educated Europeans); and age differentiates the type of internet use (younger Europeans use the internet more for communication and entertainment). Overall, the fact that better educated younger individuals living in more digitally developed countries make greatest use of the internet corroborates findings reported elsewhere (Ayanso et al., 2010, 2014; Pick & Azari, 2008).

Identifying social indicators that best explain heterogeneity concurs with previous findings regarding the original causal model (Lamberti et al., 2021). Additionally, our MGA test of the extended model identified three different linking patterns across groups. Thus, considering edu-cation level, country digital development, and age: (1) the effect of physical access on information security concerns is significantly high for well-educated older Europeans; (2) the effect of digital skills on information security concerns is significantly high for less well-educated Europeans pro- vided they live in more digitally developed countries; and (3) the effect of information security concerns on internet use is significantly low for less well-educated Europeans living in more digitally developed countries.

Although our measurement of the theoretical constructs differs from that of van Deursen and van Dijk (2015), our estimates, similar in strength, point in the same direction as findings by van Dijk (2005, 2020). With information security concerns included in the model, perceived barriers to use remain statistically meaningful in influencing all other constructs in the model (van Deursen & Helsper, 2015; van Dijk, 2020; World Economic Forum, 2016), but not information security concerns. Adding support to the qualitative research reported elsewhere (Steedman et al., 2020), we show that unmotivated Europeans perceiving barriers to internet use will physically access the internet less, will not develop the required digital skills, will have greater information security concerns (i.e. will not trust the internet), and so will not benefit from using the internet. Our findings are therefore consist- ent with previous research that suggests that greater physical access reduces online privacy con- cerns and increases trust (Chang et al., 2016; Køien, 2011; Mahatanankoon et al., 2006).

5.2. Theoretical implications

This study makes three main theoretical contributions. First, the inclusion of information security concerns in the social internet appropriation model (van Deursen & van Dijk, 2015; van Dijk, 2005, 2020) reveals that this construct is another significant determiner affecting internet use. Second, in identifying four social mechanisms (less-educated Europeans living in digitally non-advanced countries (LEE_DNAC), less-educated Europeans living in digitally advanced countries (LEE_DAC),well-educated young Europeans (WEYE), and well-educated European adults (WEEA)) culminating in the digital divide for which the social indicators differ, we contribute to digital divide measurement and international distribution analyzes (Sciadas, 2005); moreover, we show that even though the configuration and composition of the theoretical constructs for the four social mechanisms are the same, the scores and effects vary. Third, we identify the main social axes under-lying the four social mechanisms. Together, these contributions further throw further light on ourunderstanding of social internet appropriation and its culmination in not just one, but several, digital divides.

5.3. Implications for society

Digital skills remain the most significant explanation of a digital divide. Hence, public policies thatimprove the security of digital devices could also reduce both the production costs (due to scaleeconomies) and purchase costs of more sophisticated equipment, i.e. devices with better embeddedtechnologies that are more secure and easier to use. More trustworthy devices, e.g. with better anti-intrusion protection, are crucial to enhancing trust and increasing internet use (Maple, 2017). Enhanced trust in digital devices and the internet can mitigate perceived risks and privacy concerns, with the result that individuals are more likely to have fewer information security concerns and to share personal data online. The finding that perceived barriers to internet use are negatively related to online trust is consistent with the view that attitudes to technology affect information security concerns (Blank & Dutton, 2012; Joinson et al., 2010). A negative attitude is likely to have negative repercussions for trust in technologies and for data disclosure, while a more positive atti- tude is likely to build greater trust in online non-social and social interactions in terms of providing and sharing personal data and not restricting data provided in personal profiles, etc.

Digital skills need time to develop, so public policies to reduce the digital divide in Europe could focus on fostering institutional and organizational innovations aimed at reducing information secur- ity concerns and facilitating the interpretation of the corresponding indicators. Skills, trust, techno- logical devices, and organizational innovations can all be seen as complementary or configurational, as has been argued by other researchers (Cajaiba-Santana, 2014; Rodrigo & Palacios, 2021; Shakina et al., 2021). Improving the quality of digital devices and fostering organizational innovations in systems and infrastructures (Lamberti et al., 2021) may, at least partially, compensate for a lack of the more advanced digital skills needed to be able to benefit from the internet. There will always be some individuals who are likely to remain at a disadvantage in relation to particular steps in the sequential model (physical access, digital skills, information security concerns). Nonetheless, while individuals ultimately need at least basic digital skills to be able to decode the meaning of secure technological and organizational signals and to enjoy the benefits of the internet, insti- tutional and organizational innovations may partially compensate for a digital skills deficit (Lamberti et al., 2021).

5.4. Study limitations and further research

The main limitation of our study is how the model's theoretical constructs were measured, as the EUICT survey data were not designed specifically to test the sequential model of internet appropriation (van Deursen & van Dijk, 2015; van Dijk, 2005, 2020). Thus, rather than measure motivations/attitudes as in the original sequential model, we measured, as the antecedent, perceived barriers to internet use. The fact that we did not use the same indicators as van Deursen and van Dijk (2015) makes direct comparison between findings a challenge. As for information security concerns, a more comprehen-sive set of indicators would certainly have helped obtain a better estimate of the construct, providing more robust evidence to uphold our results.

Another limitation is that the data available to us are six years old. Note, however, that according to Eurostat, the diffusion of internet access in the EU was already 85% in 2016 (households with inter- net access and a broadband connection). An indication that that diffusion was beginning to taper off is that the 7-point increase to 92% in 2021 was only half that of the previous five -year period (a 13- point difference between 2011 and 2016).

Interestingly, the COVID-19 pandemic and lockdowns may have relaxed precautions regarding online risk and information security concerns. However, any study of the impact of COVID-19 on the social process of internet appropriation would clearly require data for before 2020, for 2020–2021, and from 2022, so this is left for a future study. Also left for the future is testing the model adopting a longitudinal perspective, using a more comprehensive and more recent dataset to inves-tigate the sequential model's causal relationships.

Regarding the statistical model, while a causal model does not allow causal effects to be esti-mated in the strictest of senses (according to Bollen & Pearl, 2013), it is nonetheless a helpful instru- ment for evaluating the plausibility of causal chains. While our results suggest that organizational and institutional innovations that ensure more trustworthy technologies, systems, and infrastruc- tures could be crucial in reducing the digital divide, further research is needed to quantify the impact of such innovations.

6. Conclusion

We have found that including information security concerns in the causal model that explains the social process of internet appropriation better represents the sequential production of several digital divides, with our evidence suggesting that this construct is the third most impor- tant generator of the digital divide after digital skills and physical access. Furthermore, we have uncovered the existence of heterogeneity in the sequential generation of the digital divide, identifying several unequally distributed social mechanisms that produce that divide. The primary social indicator explaining heterogeneity was education, followed by well-educated younger and older Europeans (age) versus less-educated Europeans living in more and less digi- tally developed countries (country digital development). Our findings have implications for public policies to reduce the digital divide in Europe, as innovations in more secure technol- ogies, devices, systems, and infrastructures can potentially compensate for a possible individual lack of digital skills.

Notes

1. Data collection details are available at: https://circabc.europa.eu/ui/group/4f80b004-7f0a-4e5a-ba91-a7bb40cc0304/library/8bc71641-bd53-4039-b9f0-71d87822749d/details.
2. When variables are categorical, the identification of factors describing the interdependence between indicators cannot be assessed by applying principal component analysis (PCA) or factor analysis (FA). A better choice is MCA, a multivariate method of analysis used to describe, explore, summarize, and visualize the interdependence among a set of indicators contained within a data table of n individuals described by q categorical variables. It can be seen as an analogue of PCA for categorical variables (rather than quantitative variables). MCA reduces the dimensionality of a table and the new dimensions can be understood as 'latent' characteristics. The coordinates (scores) are linear combinations of the categorical indicators. The dimensions are defined to maximize the varia- bility of the original indicators. Therefore, with few dimensions it is

possible to retain the original variation, with the principal benefit of reducing dimensionality. From a practical point of view, MCA dimension coordinates can be interpreted as an optimal numeric scale where each coordinate represents individual scores. For MCA, Green- acre (1993) has shown that the scores of individuals form an optimal scale when those scores are far apart, thereby maximizing differences between individuals.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by AGAUR (Catalan research funding agency) under grant [SGR-1056-2017] and by the EU H2020 programme [870691-INVENT]

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Tables

Table 1. EU countries sample size.

Country	N before filtering	N after filtering
Austria	4875	3943
Belgium	5055	4252
Bulgaria	9444	5331
Cyprus	4264	3017
Czech Republic	7508	5619
Germany	19086	17424
Denmark	4271	4035
Estonia	4220	3632
Greece	4774	2810
Spain	14250	10330
Finland	2255	2088
France	12171	10407
Croatia	3232	2113
Hungary	6018	4731
Ireland	7567	5628
Italy	32085	21691
Lithuania	7067	5022
Luxembourg	1528	1494
Latvia	6955	5440
Malta	1146	860
Netherlands	4561	4163
Poland	10348	7000
Portugal	7642	4827
Romania	15561	8445
Sweden	1353	1258
Slovenia	1568	1138
Slovakia	3608	2412
United Kingdom	2775	2550
Total	205187	151660

Table 2. Construct comparison for the Eurostat and the van Deursen and van Dijk (2015) Netherlands surveys.

Construct	Definition	Items	Operationalization	Reference	van Deursen and van Dijk', model
Barriers	Perceived barriers to internet use are socio-structural (infrastructure, awareness, cultural acceptance) and psychological (affordability, skills).	*What are the reasons for not accessing internet at home?* (1) Have internet access elsewhere, (2) Do not need internet (because not useful, not interesting, etc.), (3) Equipment costs too high, (4) Access costs too high (telephone, DSL subscription, etc), (6) Perceived lack of skills, (7) Privacy or security concerns, (8) Broadband internet not available in our area, (9) Other	First dimension of multiple correspondence analysis (MCA)	Durndell & Haag 2002; Meuter et al. 2003	Internet attitude (5-point Likert scale), measured by the 8 highest loading items of the Internet Attitude Scale (Durndell and Haag, 2002).
Physical access	Opportunity to access the internet	*Which of the following devices have you used to access internet?* (1) Desktop computer, (2)Laptop or netbook, (3) Tablet computer, (4) Mobile phone or smartphone, (5) Other mobile device (e.g., e-reader, smartwatch), (6) Smart TV (directly connected to the internet)	First dimension of multiple correspondence analysis (MCA)	van Deursen & van Dijk, 2015	Material Internet Access (single-item scale), measured dichotomously using 7 questions regarding devices used to access the internet: desktop PC, laptop PC, tablet PC, smartphone, game console, TV, e-reader.
Digital skills	Ability to use the internet	*Please indicate level of the following skills:* (1) Obtain information, (2) Communicate information, (3) Solve software and hardware problems, (4) Solve substantive problems	Eurostat Likert scale, ranging from 1 (no skills) to 4 (highest skills)	Ferrari 2012; Hargittai, Piper, & Morris 2018; van Deursen & Mossberger 2018; van Deursen & van Dijk, 2009, 2010, 2015; van Dijk & Hacker, 2003	Medium- and Content-related Internet Skills (single-item scale)

Internet usage	Number and variety of different internet activities participated in online	*For which of the following activities have you used internet?* (1) **Social interaction**: 1 – Sending/receiving e-mails; 2 - Telephoning over the internet/video calls (via webcam) over the internet (e.g., Skype or Facetime); 3 - Participating in social networks (creating user profiles, posting messages or other contributions to Facebook, etc); 4 - Uploading self-created content (text, photos, music, videos, software, etc) to any website for sharing (2) **Information-seeking**: 5 - Reading online news/newspapers/news magazines; 6 - Finding information about goods or services; 7 - Seeking health-related information (e.g., injury, disease, nutrition, health, etc); 8 - Making an appointment with a practitioner via the website (e.g., hospital or healthcare centre) (3) **Leisure**: 9 - Listening to music (e.g., web radio, music streaming) 10 - Watching internet-streamed TV (live or catch-up) from broadcasters; 11 - Watching video on demand from commercial services (Netflix, HBO, etc); 12 - Playing video games (4) **Commercial transactions**: 13 - Using services related to travel or travel-related accommodation; 14 - Selling goods or services, e.g., via auctions (e.g. eBay); 15 - Internet banking; 16 - Using payment accounts (e.g. PayPal) to pay for goods or services purchased online	16 dichotomous items reflecting a broad range of internet activities, grouped and summed in 4 categories: social interaction, information-seeking, leisure, commercial transaction	Blank & Groselj, 2014; van Deursen & van Dijk, 2014; van Deursen & van Dijk, 2015	Internet Usage (single-item scale), measuring frequency of engagement in 21 activities., with items summed into a single scale that reflected diversity of usage activities (0 to 21)
Information Security Concerns	Personal data disclosure online	What type of personal information have you provided over the internet? (1) Personal details (e.g. name, date of birth, ID number) (2) Contact details (e.g. home address, phone number, e-mail) (3) Payment details (e.g. credit/debit card number, bank account number) (4) Other personal information (e.g. photos, current location, health/employment/income information)	First dimension of multiple correspondence analysis (MCA)	Pavlou et al., 2007; Vishwamitra et al., 2017	

Table 3. Internet uses by group.

	GLOBAL	LM1 LEE_DNAC	LM2 LEE_DAC	LM3 WEYE	LM4 WEEA
Sample size (N)	151660	55085	44645	44645	4872
Internet use *For which of the following activities have you used internet?*					
Social interaction					
1 – Sending/receiving e-mails	83.6%	74.9%*	82.7%*	96.1%**	92.4%*
2 - Telephoning over the internet/video calls (via webcam) over the internet (e.g., Skype or Facetime)	40.9%	41.3%	33.6%	52.7%**	41.90%
3 - Participating in social media (creating user profiles, posting messages, other contributions, etc)	62.1%	61.6%*	62.6%*	77.5%**	46.1%
4 - Uploading self-created content (text, photos, music, videos, software, etc) to any website for sharing	32.6%	31.7%	30.3%	44.4%*	27.1%
Information-seeking					
5 - Reading online news/newspapers/news magazines	71.9%	66.2%*	67.2%*	85.3%**	80.2%*
6 - Finding information about goods or services	77.1%	64.5%*	81.9%*	89.1%**	84.7%*
7 - Seeking health-related information (e.g., injury, disease, nutrition, health, etc)	57.8%	47.9%	59.7%	68.2%**	66.4%
8 - Making an appointment with a practitioner via the website (e.g., hospital or healthcare centre)	14.8%	8.1%	15.7%	22.7%**	20.4%*
Leisure					
9 - Listening to music (e.g., web radio, music streaming)	46.9%	45.3%	45%	62.5%**	37.6%
10 - Watching internet-streamed TV (live or catch-up) from broadcasters	31.1%	22.1%	33.5%	44.2%	33.9%
11 - Watching video on demand from commercial services (Netflix, HBO, etc)	15.9%	9.7%	19.6%	25%	13.6%
12 - Playing video games	31.3%	33.40%	34.1%**	33.1%	19.3%
Commercial transactions					
13 - Using services related to travel or travel-related accommodation	43.9%	29.5%	44.2%*	61.2%**	58.2%*
14 - Selling goods or services, e.g., via auctions (e.g. eBay)	17.2%	11.1%	20.2%	24.9%	17.1%
15 - Internet banking	55.1%	39.9%	55.5%	76.3%**	67.4%*
16 - Using payment accounts (e.g. PayPal) to pay for goods or services purchased online	28.6%	17.8%	31.3%	42.9%	33.3%

Table 4. Social mechanisms of internet appropriation: a comparison.

Path	**LM1 LEE_DNAC**	**LM2 LEE_DAC**	**LM3 WEYE**	**LM4 WEEA**	**LM1 vs. LM2**	**LM1 vs. LM3**	**LM1 vs. LM4**	**LM2 vs. LM3**	**LM2 vs. LM4**	**LM3 vs. LM4**
Sample size (N)	55085	44645	44645	4872						
Perceived barriers to internet use → Information Security Concerns	-0.008^{NS}	-0.009^{NS}	-0.001^{NS}	-0.007^{NS}	0.914	0.248	0.896	0.182	0.810	0.380
Physical access → Information Security Concerns	0.153	0.115	0.145	0.181	**<0.001**	0.446	0.002	**<0.001**	**<0.001**	**<0.001**
Digital skills → Information Security Concerns	0.367	0.420	0.332	0.346	**<0.001**	**<0.001**	0.002	**<0.001**	**<0.001**	0.146
Information Security Concerns → Internet use	0.162	0.125	0.182	0.158	**<0.001**	0.002	0.608	**<0.001**	**<0.001**	0.002

Note. *p=<0.001.

Appendix

Table A1. Indicators of theoretical constructs.

Scales	% yes	M	SD		% yes
Sample Size (N) = 151 660				**Physical access**	
Perceived barriers to internet use					
What are the reasons for not accessing internet at home?				*Which of the following devices have you used to access internet?*	
1- Have internet access elsewhere	1.26%			1 - Desktop computer	53.63%
2 - Do not need internet (because not useful, not interesting, etc.)	0.42%			2 - Laptop or netbook	59.92%
3 - Equipment costs too high	0.70%			3 - Tablet computer	36.77%
4 - Access costs too high (telephone, DSL subscription, etc)	0.66%			4 - Mobile phone or smart phone	73.92%
5 - Perceived lack of skills	0.23%			5 - Other mobile devices (e.g., e-reader, smartwatch)	7.10%
6 - Privacy or security concerns	0.17%			6 - Smart TV (directly connected to the internet)	11.70%
7 - Broadband internet not available in our area	0.15%				
8 - Other	0.31%				
Digital skills				**Information Security Concerns**	
Please indicate level of the following skills (minimum 1, maximum 4)				*What type of personal information have you provided over the internet?*	
1 - Information skills		2.74	0.57	1 - Personal details (e.g. name, date of birth, ID number)	46.20%
2 - Problem-solving skills		2.13	0.86	2 - Contact details (e.g. home address, phone number, e-mail)	55%
3 - Communication skill		2.62	0.61	3 - Payment details (e.g. credit/debit card number, bank account number)	32.61%

4 - Software skills	2.47	0.71	4 - Other personal information (e.g. photos, current location, health/employment/income information)	19.73%
Internet use				
For which of the following activities have you used internet?				
Social interaction				
1 – Sending/receiving e-mails				83.66%
2 - Telephoning over the internet/video calls (via webcam) over the internet (e.g., Skype or Facetime)				40.97%
3 - Participating in social networks (creating user profiles, posting messages or other contributions to Facebook, etc)				62.14%
4 - Uploading self-created content (text, photos, music, videos, software, etc) to any website for sharing				32.60%
Information-seeking				
5 - Reading online news/newspapers/news magazines				71.92%
6 - Finding information about goods or services				77.11%
7 - Seeking health-related information (e.g., injury, disease, nutrition, health, etc)				57.85%
8 - Making an appointment with a practitioner via the website (e.g., hospital or healthcare centre)				14.81%
Leisure				
9 - Listening to music (e.g., web radio, music streaming)				46.99%
10 - Watching internet-streamed TV (live or catch-up) from broadcasters				31.10%
11 - Watching video on demand from commercial services (Netflix, HBO, etc)				15.91%
12 - Playing video games				31.34%
Commercial transactions				
13 - Using services related to travel or travel-related accommodation				43.93%
14 - Selling goods or services, e.g., via auctions (e.g. eBay)				17.24%
15 - Internet banking				55.11%
16 - Using payment accounts (e.g. PayPal) to pay for goods or services purchased online				28.60%

Table A2. MICOM results (steps 2 and 3).

MICOM procedure (Henseler et al., 2016)	LM1 vs. LM2	LM1 vs. LM3	LM1 vs. LM4	LM2 vs. LM3	LM2 vs. LM4	LM3 vs. LM4
Sample Size (N) = 55085 (LM1) 44645 (LM2) 44645 (LM3) 4872 (LM4)						
Step 2: Compositional invariance						
H0: Compositional measurement invariance of the constructs	**Score correlation p-value**					
Perceived barriers to internet use	1.000*	1.000*	1.000*	1.000*	1.000*	1.000*
Physical access	1.000*	1.000*	1.000*	1.000*	1.000*	1.000*
Digital skills	1.000*	1.000*	1.000*	1.000*	1.000*	1.000*
Information Security Concerns	1.000*	1.000*	1.000*	1.000*	1.000*	1.000*
Internet use	1.000*	0.998*	0.999*	0.998*	0.999*	1.000*
Step 3: Equality of the means and variances						
H0: Difference between group means is zero	**Score mean difference p-value**					
Perceived barriers to internet use	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Physical access	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Digital skills	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Information Security Concerns	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Internet use	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
H0: Log of the ratio of the group variances is zero	**Score log-ratio variance p-value**					
Perceived barriers to internet use	<0.001	<0.001	0.7776*	<0.001	<0.001	<0.001
Physical access	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Digital skills	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Information Security Concerns	<0.001	<0.001	<0.001	<0.001	0.3347*	<0.001
Internet use	<0.001	<0.001	0.3868*	<0.001	<0.001	<0.001

Note. *Verified (p>0.05).

Table A3. Full comparison of social mechanisms of internet appropriation.

Path	**LM1 LEE_DNAC**	**LM2 LEE_DAC**	**LM3 WEYE**	**LM4 WEEA**	**LM1 vs. LM2**	**LM1 vs. LM3**	**LM1 vs. LM4**	**LM2 vs. LM3**	**LM2 vs. LM4**	**LM3 vs. LM4**
Sample size (N)	55085	47058	44645	4872						
Perceived barriers to internet use → Physical access	-0.095	-0.120	-0.080	-0.106	< **0.001**	0.058	0.180	< **0.001**	0.070	0.006
Perceived barriers to internet use → Digital skills	-0.037	-0.064	-0.069	-0.074	< **0.001**	< **0.001**	< **0.001**	0.544	0.164	0.538
Perceived barriers to internet use → Information Security Concerns	-0.008[NS]	-0.009[NS]	-0.001[NS]	-0.007[NS]	0.914	0.248	0.896	0.182	0.810	0.380
Perceived barriers to internet use → Internet use	-0.021	-0.015	-0.014[NS]	-0.029	0.080	0.114	0.122	0.790	0.002	0.002
Physical access → Digital skills	0.625	0.620	0.416	0.542	0.202	< **0.001**	**0.000**	< **0.001**	< **0.001**	< **0.001**
Physical access → Information Security Concerns	0.153	0.115	0.145	0.181	< **0.001**	0.446	0.002	< **0.001**	< **0.001**	< **0.001**
Physical access → Internet use	0.209	0.225	0.279	0.257	0.004	< **0.001**	**0.000**	< **0.001**	< **0.001**	0.004
Digital skills → Information Security Concerns	0.367	0.420	0.332	0.346	< **0.001**	< **0.001**	0.002	< **0.001**	< **0.001**	0.146
Digital skills → Internet use	0.544	0.564	0.409	0.475	< **0.001**	< **0.001**	**0.000**	< **0.001**	< **0.001**	< **0.001**
Information Security Concerns → Internet use	0.162	0.125	0.182	0.158	< **0.001**	0.002	0.608	< **0.001**	< **0.001**	0.002

Note. *p=<0.001. [NS] non-significant

Figure captions

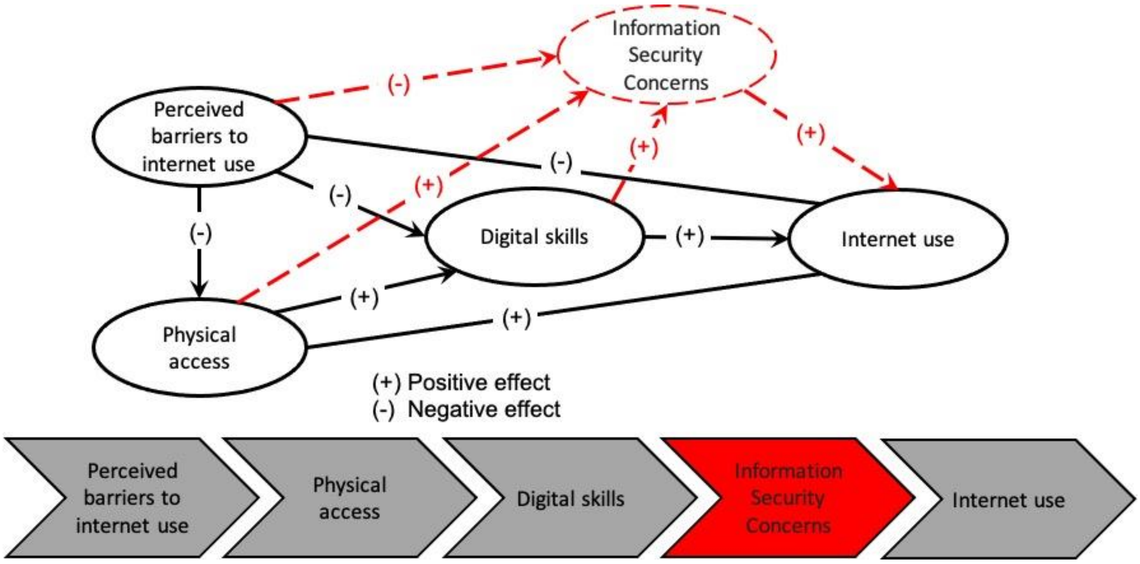
Figure 1. The role of trust in the social process of internet appropriation.

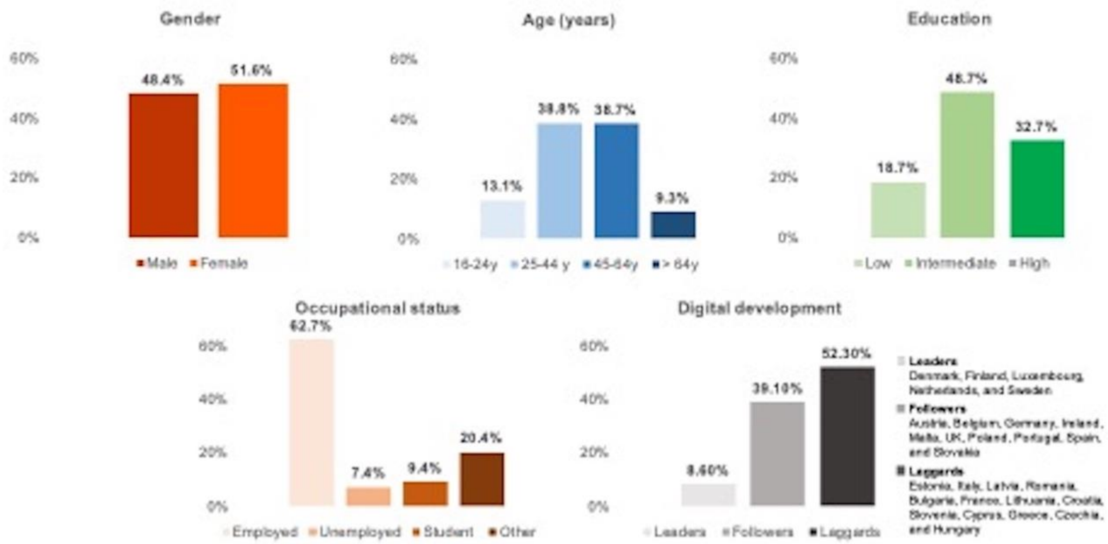
Figure 2. Social indicator details.

Figure 3. Digital skills and internet use validation.

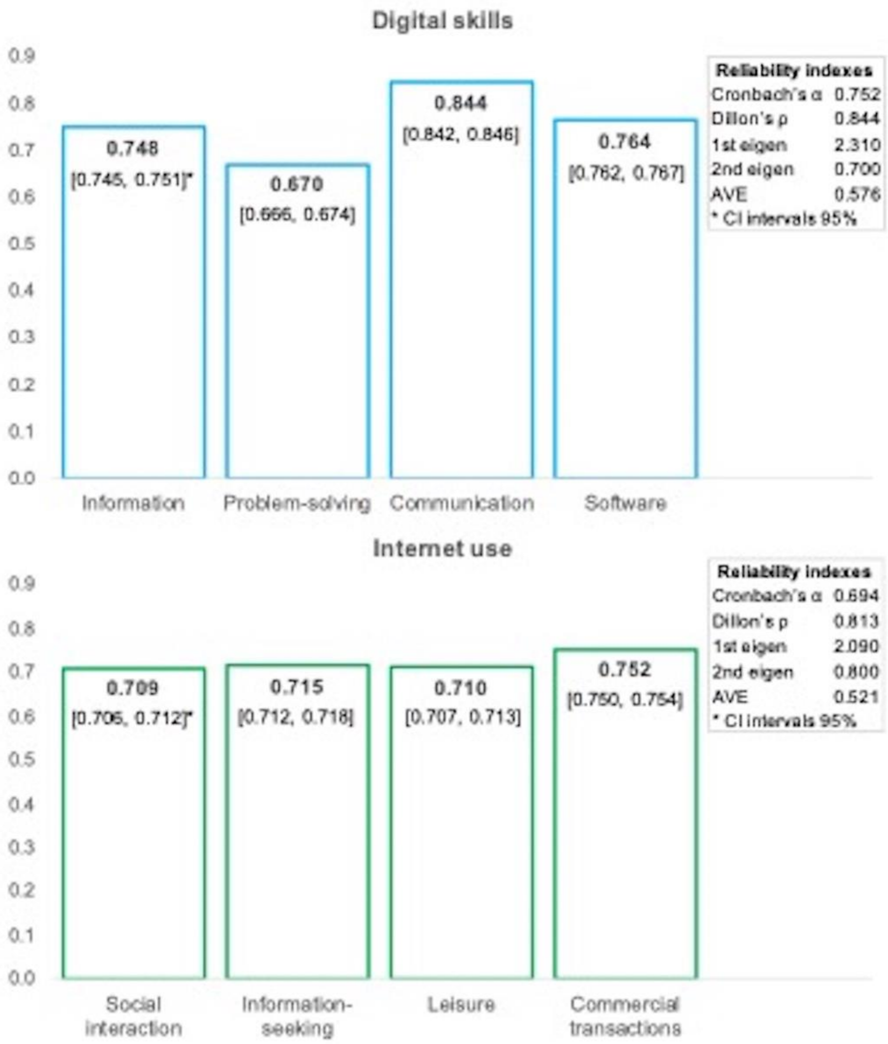
Figure 4. Path coefficients (95% CI) in the sequential model of inequality production.

Figure 5. Uncovering the social mechanisms underlying internet appropriation.

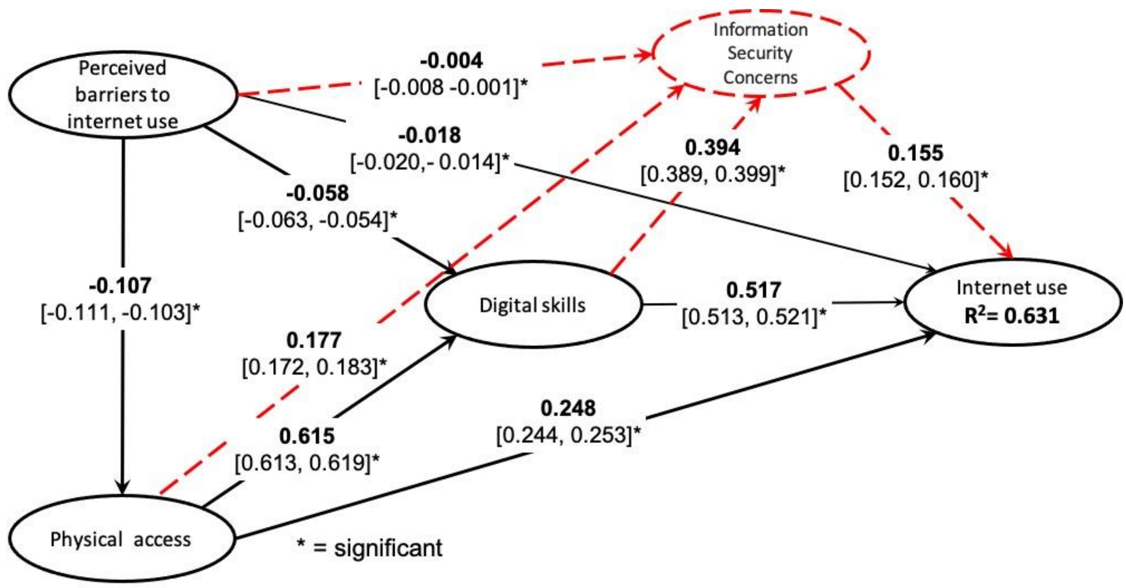

Information Security Concerns
Perceived barriers to internet use
Digital skills
Internet use
Physical access
(-)
(+)
(+) Positive effect
(-) Negative effect
Perceived barriers to internet use
Physical access
Digital skills
Information Security Concerns
Internet use



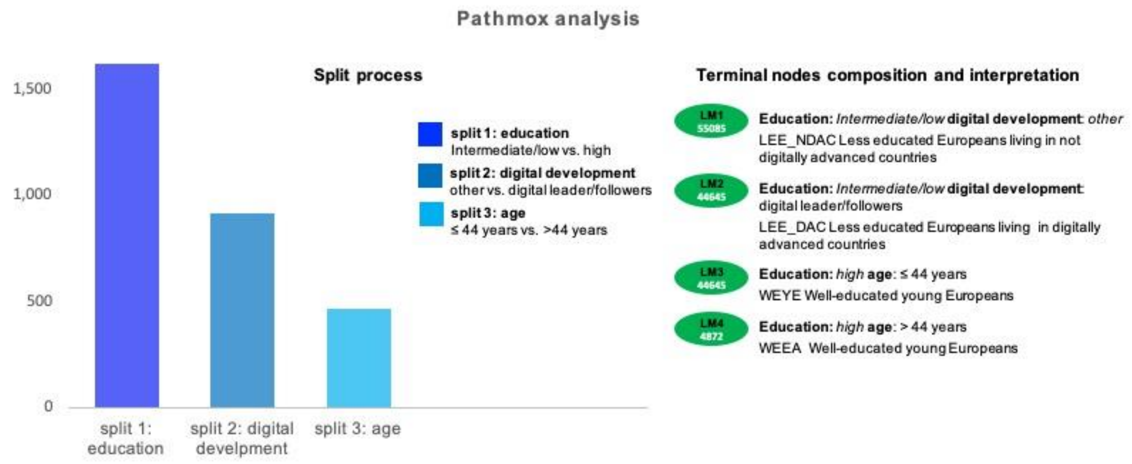
Gender
60%
40%
20%
0%
48.4%
51.6%
Male
Female
Age (years)
60%
40%
20%
0%
13.1%
38.8%
38.7%
9.3%
16-24y
25-44 y
45-64y
> 64y
Education
60%
40%
20%
0%
18.7%
48.7%
32.7%
Low
Intermediate
High
Occupational status
60%
40%
20%
0%
62.7%
7.4%
9.4%
20.4%
Employed
Unemployed
Student
Other
Digital development
60%
40%
20%
0%
8.60%
39.10%
52.30%
Leaders
Followers
Laggards
Leaders
Denmark, Finland, Luxembourg, Netherlands, and Sweden
Followers
Austria, Belgium, Germany, Ireland, Malta, UK, Poland, Portugal, Spain, and Slovakia
Laggards
Estonia, Italy, Latvia, Romania, Bulgaria, France, Lithuania, Croatia, Slovenia, Cyprus, Greece, Czechia, and Hungary



Digital skills
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.748
[0.745, 0.751]*
0.670
[0.666, 0.674]
0.844
[0.842, 0.846]
0.764
[0.762, 0.767]
Information
Problem-solving
Communication
Software
Reliability indexes
Cronbach's α 0.752
Dillon's ρ 0.844
1st eigen 2.310
2nd eigen 0.700
AVE 0.576
* CI intervals 95%
Internet use
0.709
[0.706, 0.712]*
0.715
[0.712, 0.718]
0.710
[0.707, 0.713]
0.752
[0.750, 0.754]
Social interaction
Information-seeking
Leisure
Commercial transactions
Reliability indexes
Cronbach's α 0.694
Dillon's ρ 0.813
1st eigen 2.090
2nd eigen 0.800
AVE 0.521
* CI intervals 95%



Sample size (N) = 151660



Pathmox analysis
Split process
1,500
1,000
500
0
split 1: education
split 2: digital develpment
split 3: age
split 1: education
Intermediate/low vs. high
split 2: digital development
other vs. digital leader/followers
split 3: age
≤ 44 years vs. >44 years
Terminal nodes composition and interpretation
LM1 55085
Education: Intermediate/low digital development: other
LEE_NDAC Less educated Europeans living in not digitally advanced countries
LM2 44645
Education: Intermediate/low digital development: digital leader/followers
LEE_DAC Less educated Europeans living in digitally advanced countries
LM3 44645
Education: high age: ≤ 44 years
WEYE Well-educated young Europeans
LM4 4872
Education: high age: > 44 years
WEEA Well-educated young Europeans