DOI: 10.1111/ecaf.12471

ORIGINAL ARTICLE

ECONOMIC AFFAIRS WILEY

Changes in Italy's education-related digital divide

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Abstract

This article examines differences in home computer and internet access among Italian households between 2005 and 2016. The results indicate that while computer and internet penetration has increased across all educational levels and geographical areas, digital inequalities related to education still persist and are substantial, especially in the South. Additionally, the findings suggest that the digital gap at the bottom of the education distribution is widening over time. Access among households whose reference person has primary education or less lags behind that of households with lower secondary education. Policy measures to promote and support the adoption of digital technologies among the most educationally disadvantaged households may need to be strengthened.

KEYWORDS

computer, digital divide, education, ICT, internet, Italy

JEL CLASSIFICATION

I24; O33

The views expressed are purely those of the author and may not in any circumstances be regarded as stating an official position of the European Commission.

1 | INTRODUCTION

Although in many industrialised countries the number of households with computer and internet access at home is growing rapidly, there is still a large fraction of the population without such access. More disadvantaged households (poorer, less educated households, households located in remote/rural areas) are more likely to be digitally excluded. Inequality in access to computer and internet technology is known as 'first order digital divide' (Dewan & Riggins, 2005).

Computer ownership and internet home access are practically essential in today's society, and they will be even more so in the future. Their uses and advantages include: (*a*) increasing the capacity to search and store a huge quantity of information on various issues, (*b*) improving access to public services, (*c*) making it easier to contact people and companies, (*d*) expanding access to education, job search and business transactions, and (*e*) enhancing employability (White & Selwyn, 2013; Wodajo & Kimmel, 2013).

Reducing the digital divide is an important policy objective. The United Nations has stated that digital technology can help achieve Sustainable Development Goals and has launched a 'Declaration of Digital Independence' that asserts digital inclusion as a human right (UN Secretary General's High-Level Panel on Digital Cooperation, 2019). At European Union (EU) level, one of the flagship initiatives under the Europe 2020 strategy is the 'Digital Agenda for Europe'. Its scope is to speed up the roll-out of high-speed internet and reap the benefits of a digital single market for households and firms (European Commission, 2010). Most recently, the European Commission (2020) has adopted an updated version of the Digital Education Action Plan (2021–2027) that lays out its vision for high-quality, inclusive and accessible digital education in Europe.

The COVID-19 pandemic has heightened these concerns. The disadvantages associated with digital exclusion have been particularly marked during lockdowns. For instance, children who do not have a computer or an internet connection at home have been unable to gain access to virtual teaching sessions and could not submit their homework online. Similarly, teachers living in remote areas without internet connection have been unable to provide online support to their students. There is therefore the risk that the pandemic could further aggravate educational inequality between children from different socio-economic backgrounds.

This article examines differential household access to a computer and internet at home by education of the reference person in Italy, using annual data during the period 2005–16. The study focuses on education because, as noted earlier, this is a key predictor of access to digital technologies.[1] Three different educational gaps are considered: (*a*) tertiary versus non-tertiary education, (*b*) upper secondary versus non-upper secondary education, and (*c*) lower secondary versus primary education or less.[2]

This work adds to the existing literature in three ways. First, the majority of studies provide a one-off snapshot of the digital divide whereas much less attention is given to the analysis of how digital inequalities change over time. Having a clear understanding of the evolution of the digital gap is especially important in assessing the impact of existing policy initiatives, and helps design new ones (Grishchenko, 2020). As argued by Firebaugh (1999), observing a wide digital divide is not the same thing as observing a *widening* digital divide.

Second, while most education-related digital divide analyses focus on gaps between the top and the rest of the education distribution, few studies[3] analyse gaps at the bottom of the distribution. For instance, in investigating the relationship between education and internet access in the US, Savage and Waldman (2005) consider several higher education categories (i.e. graduate degree, college, some college) but only a lower education category (i.e. less than high school). The same applies to a study by Moller (2000) that looks at the association between

the education of the head of the family and home computer and internet access in California. Important insights about the digital divide may be lost by aggregating all lower-educated individuals/households into a single class. This does not allow us to detect whether there are relevant differences between individuals/households with poor education and those with a slightly higher education level. Achieving a reduction in the digital divide requires a detailed and exact knowledge of who should be targeted (Novo-Corti & Barreiro-Gen, 2015; Subirats, Knoepfel, Larrue, & Varone, 2008).

Third, this article looks at the geographical dimension of the dynamics of the educated-related digital divide. While it is well known that households in the Italian South are less likely to have a computer and an internet connection at home than those living in the Centre or North (Gualerzi, 2016; Serrecchia, Martinelli, & Serrecchia, 2009), little is known about how these geographical differences have varied over time.

Italy is characterised by relatively poor quality of digital infrastructure, relatively low internet and computer penetration, and relatively large territorial and social disparities in the take up of information and communications technology (ICT). The country has consistently scored low in the Digital Economy and Society Index. Between 2015 and 2020, Italy ranked between 23rd and 25th out of 28 EU Member States. In Italy, in December 2013 only 21 per cent of households had fast internet (the worst coverage in the EU) and the proportion of households subscribing to fixed broadband services was just 51 per cent, the lowest percentage in the EU (European Commission, 2015).

The remainder of the article is set out as follows. First, some background information is provided on the drivers of the digital divide and their relationship with education, as well as some observations about the pattern of the digital divide over time. Next, the data and methodology employed in the analysis are described, followed by a presentation of the empirical results. Finally, some conclusions and a discussion are presented.

2 | BACKGROUND INFORMATION

2.1 | Why does the digital divide exist?

Three main arguments are often put forward to explain the digital divide.

First, not all households/individuals can afford internet access and/or a computer. Using data from the European Social Survey, Demoussis and Giannakopoulos (2006) show that access costs have a detrimental impact on the decision to use the internet. Goldfarb and Prince (2008) argue that the cost may act as a significant barrier to computer and internet access among low-income individuals. A recent study of the UK (Kearns & Whitley, 2019) concludes that internet-access costs are a relevant consideration for low-income households living in deprived communities. Kiiski and Pohjola (2002) show that a 50 per cent decline in internet access costs would increase the number of computer hosts per capita by 25 per cent in 23 OECD countries over a five-year period.

Second, many households are located in remote rural communities where infrastructure for internet access is absent or inadequately developed. This means that internet connectivity is unavailable, very slow or unreliable. Using data from Australia, Park (2017) concludes that remoteness strongly predicts digital exclusion. Similarly, Vehovar et al. (2006) find that in Slovenia individuals from rural areas are less likely to use the internet than those from urban districts. Private companies have little incentive to provide rural areas with the needed infrastructure given that this investment is not sufficiently profitable (Whitacre, 2010). The cost

of developing such infrastructure is quite high in these areas while the number of potential consumers is quite small because of the low population density, and so costs cannot be passed directly on to the customers, most of whom are also likely to have lower incomes.

Third, a proportion of households/individuals is not interested in having access to computers and the internet as they possess poor digital skills. Fong (2009) shows than in China literacy in technology is a major determinant of technology availability and utilisation. Allmann (2020) argues that many individuals in Britain are still not connected to the internet because they lack digital literacy. This issue is especially relevant among older individuals who may be vulnerable and disadvantaged in the digital age (Blažič & Blažič, 2020).

2.2 | Education and the digital divide

In view of these three drivers of the digital divide, it is unsurprising that more educated households/individuals are more likely to have a computer and be connected to the internet than less educated ones. The former group of individuals/households are more likely to earn higher incomes, are more likely to live in urban areas (where internet access is reliable and fast because of better infrastructure), and are more likely to be digital literate than the latter group. Even across older people, the more educated and wealthier tend to have higher levels of digital skills. The theory of innovation diffusion suggests that, as complexity is an important barrier to technology adoption, people with a higher level of education are expected to be more inclined to overcome this type of problem (Rogers, 2005; Zhao, Kim, Suh, & Du, 2007). Not only do more educated individuals find it easier to cope with technological complexity, but they are also more likely to be exposed to ICT in their professional and personal life (Cruz-Jesus, Vicente, Bacao, & Oliveira, 2016). People using a computer at work are found to be more likely to have a computer at home (Dolton & Makepeace, 2002).

2.3 | The digital divide over time

Van Dijk and Hacker (2003) predict that the socio-economic gap in access to digital technology eventually closes if only because of the saturation effect of the 'higher' categories. However, market forces and government policies also work in the direction of narrowing the divide.

These factors are expected to make internet and computer penetration rates grow faster among individuals/households from lower socio-economic groups than those from higher socio-economic groups. To begin with, internet and computer access costs are declining. This has been stimulated by telecommunication deregulation policies that have resulted in greater competition among firms. For instance, Koenig et al. (2002) document declining internet access charges following the 1998 liberalisation of the telecommunication market in Germany. The OECD (2013) shows that France experienced a sharp drop in internet access costs between 2005 and 2011.

Additionally, technical solutions (such as satellite communication technologies), regulations and incentives have been employed to fill the gaps where communication markets would not alone have provided internet access, particularly in remote areas (Howard, Busch, & Sheets, 2010). Philip and Williams (2019) argue that connectivity in many rural areas has improved because of publicly funded investments in infrastructure upgrades. In the EU, the European Commission has strongly encouraged Member States to use public funding for the deployment of new network infrastructure (Polykalas, 2014). In Italy in 2008, the Ministry

of Economic Development launched the 'Digital Italy Plan'. Its goal was to digitalise the country's communication infrastructure. In 2015, the Italian government approved a proposal to provide broadband internet services to areas that do not have access to it. Finally, many public policy and education initiatives have been undertaken to encourage vulnerable segments of the population to become familiar with the internet and computers. European digital policies have been aimed at providing digital skills to disadvantaged social groups (van Deursen & van Dijk, 2014), together with national digital inclusion policies. For example, funded by the UK Government Department for Education, the Future Digital Inclusion programme has taught basic digital skills to over 1.4 million people since 2014 (Good Things Foundation, 2021). Outside the EU, Community Technology Centers promote the use of technologies among US disadvantaged adults and children (Miller, 2013).

3 | DATA AND METHODOLOGY

The data used in this study come from the Italian Multipurpose Survey on Households: Aspects of Daily Life.[4] This is a large-scale nationally representative survey conducted annually and administered by the Italian National Statistical Institute (ISTAT). It collects comparable information across time periods for repeated cross sections of households, with a new sample being drawn each year. The survey provides micro-level information on different aspects of household economic well-being, including whether households have access to a computer (desktop PC, tablet, laptop, but excluding mobile phones) and the internet at home. Data between 2005 and 2016 are used.

The survey keeps track of the highest level of educational attainment of the household's reference person. Education levels are split into tertiary education, upper secondary education, lower secondary education, and primary education or less. Based on these categories, three different indicators of educational inequality in access to home computer and internet can be constructed: first, the gap between households with a reference person with tertiary education and those with a reference person with less than tertiary education (I_1); second, the gap between households with a reference person with upper secondary education and those with a reference person with less than upper secondary education (I_2); and third, the gap between households whose reference person has lower secondary education and those whose reference person has primary education or less (I_3).

Suppose that Y^* is the continuous latent variable associated with the decision to have a computer (the internet) at home. If $Y^* > 0$ the household chooses to have a computer (the internet) at home, whereas the opposite occurs if $Y^* \leq 0$. Although Y^* is unobservable, it relates to an observable binary variable, Y, that takes the value of 1 if the household has a computer (the internet) at home, and 0 otherwise. To measure the difference in the propensity to have computer and internet access at home between more and less educated households, the following three specifications are outlined, each allowing us to estimate one of the three indicators of digital educational inequality:

$$Y_{it} = \delta_1 + \beta_1 ED_{1it} + \delta_1' X_{it} + \alpha_t + \alpha_t * ED_{1it} + \varepsilon_{1it} \quad (1)$$

$$Y_{it} = \delta_2 + \beta_2 ED_{2it} + \delta_2' X_{it} + \alpha_t + \alpha_t * ED_{2it} + \varepsilon_{2it} \quad (2)$$

$$Y_{it} = \delta_3 + \beta_3 ED_{3it} + \delta_3' X_{it} + \alpha_t + \alpha_t * ED_{3it} + \varepsilon_{3it} \quad (3)$$

TABLE 1 Mean proportion of households by level of education of household's reference person in 2005 and 2016, Italy

Educational level of the household's reference person	2005	2016
Tertiary education	0.086	0.126
Upper secondary education	0.293	0.334
Lower secondary education	0.302	0.293
Primary education or less	0.319	0.243

Source: ISTAT, Indagine Multiscopo sulle Famiglie, Aspetti della Vita Quotidiana

Here the subscript i indicates the household and the subscript t represents the survey year; ED_1, ED_2 and ED_3 refer to households whose reference person has tertiary education, upper secondary education and lower secondary education, respectively; X is a vector of control variables that includes additional characteristics of the household reference person (i.e. gender and age) as well as household characteristics (i.e. geographical area of residence and size of household); α is the fixed effects for survey year[5]; ε is the regression disturbance term. Equation 1 is estimated using the whole sample, Equation 2 is estimated only for households whose reference person has upper secondary education or less, and Equation 3 is estimated only for households whose reference person has lower secondary education or less. While the estimated βs give an indication of the extent of the digital educational inequality in the reference survey year (β_1, β_2 and β_3 capture the extent of I_1, I_2 and I_3, respectively, in 2005), the coefficients on the interactions suggest how inequality has changed between 2005 and 2016.

The three equations are estimated using a linear probability model. While this model has some limitations, such as the assumption that errors are normally distributed, an important advantage is that the interpretation of the parameters of interest (i.e. those associated with interactions) is similar to that of a linear regression model. In a seminal paper, Ai and Norton (2003) show, in fact, that in non-linear models (such as probit, logit) involving dichotomous or limited variables the coefficient of the interaction term between two variables does not capture the effect of a change in both variables, given that the real effect comprises some cross-derivatives or differences. Another benefit associated with using linear probability models, as observed by Mood (2010), is that coefficients are comparable over models, groups, time and so forth.

After removing observations with missing values on our variables of interest, we are left with a sample size of 503,053 households. As shown in Table 1, in line with expectations, the proportion of more highly-educated households (i.e. those with a reference person with tertiary education or upper secondary education) increased over time, whereas the opposite trend is observed for lower-educated households (i.e. those with a reference person with lower secondary education or less).[6] However, one should note that the latter still account for a large proportion of households. Looking at the very bottom of the education distribution shows that in 2016 households whose reference person had primary education or less accounted for just under a quarter of the sample.

4 | EMPIRICAL RESULTS

Tables 2, 3 and 4 present estimates of Equations (1), (2) and (3), respectively. Results are presented for two different specifications. While in the baseline specification the household

TABLE 2 Linear probability estimates of the probability of having a home computer and internet access, 2005–2016: all households

	Presence of a computer at home				Internet access at home			
	(1) Coeff.	(2) S.E.	(3) Coeff.	(4) S.E.	(5) Coeff.	(6) S.E.	(7) Coeff.	(8) S.E.
Constant	0.515***	0.003	0.697***	0.006	0.400***	0.003	0.555***	0.006
Characteristics of the household reference person								
Male			0.013***	0.001			0.012***	0.002
Aged 65 or above			−0.300***	0.002			−0.261***	0.002
Tertiary education	0.311***	0.008	0.283***	0.007	0.337***	0.009	0.312***	0.008
Characteristics of the household								
Geographical area of residence (reference is North)								
Centre			−0.011***	0.002			−0.001	0.002
South			−0.121***	0.002			−0.128***	0.002
Size (reference is 6 or more members)								
1 member			−0.369***	0.006			−0.333***	0.006
2 members			−0.248***	0.005			−0.220***	0.006
3 members			−0.025***	0.005			−0.003	0.006
4 members			0.065***	0.005			0.077***	0.006
5 members			0.059***	0.006			0.061***	0.006
Year (reference is 2005)								
2006	0.030***	0.004	0.030***	0.004	0.019***	0.004	0.019***	0.004
2007	0.036***	0.004	0.041***	0.004	0.049***	0.004	0.053***	0.004
2008	0.061***	0.004	0.069***	0.003	0.082***	0.004	0.089***	0.004
2009	0.108***	0.004	0.117***	0.003	0.141***	0.004	0.148***	0.004
2010	0.134***	0.004	0.147***	0.003	0.195***	0.004	0.206***	0.004
2011	0.145***	0.004	0.159***	0.003	0.218***	0.004	0.231***	0.003
2012	0.151***	0.004	0.169***	0.003	0.228***	0.004	0.244***	0.004
2013	0.192***	0.005	0.206***	0.005	0.285***	0.005	0.298***	0.005
2014	0.190***	0.004	0.208***	0.003	0.316***	0.004	0.332***	0.003
2015	0.194***	0.004	0.215***	0.003	0.339***	0.004	0.358***	0.003
2016	0.195***	0.004	0.219***	0.003	0.364***	0.004	0.386***	0.003
Year*tertiary education (Reference is 2005*tertiary education)								
2006*tertiary education	−0.026**	0.011	−0.027***	0.010	−0.012	0.012	−0.013	0.011
2007*tertiary education	−0.008	0.010	−0.016	0.010	−0.009	0.012	−0.016	0.011
2008*tertiary education	−0.026***	0.010	−0.029***	0.010	−0.036***	0.012	−0.039***	0.011

TABLE 2 *(continued)*

	Presence of a computer at home				Internet access at home			
	(1) Coeff.	(2) S.E.	(3) Coeff.	(4) S.E.	(5) Coeff.	(6) S.E.	(7) Coeff.	(8) S.E.
2009*tertiary education	−0.033***	0.010	−0.037***	0.009	−0.033***	0.011	−0.036***	0.011
2010*tertiary education	−0.069***	0.010	−0.070***	0.009	−0.077***	0.011	−0.078***	0.010
2011*tertiary education	−0.062***	0.009	−0.069***	0.009	−0.083***	0.011	−0.091***	0.010
2012*tertiary education	−0.072***	0.009	−0.070***	0.009	−0.093***	0.011	−0.091***	0.010
2013*tertiary education	−0.077***	0.011	−0.081***	0.011	−0.100***	0.012	−0.105***	0.012
2014*tertiary education	−0.085***	0.009	−0.080***	0.009	−0.123***	0.010	−0.118***	0.010
2015*tertiary education	−0.094***	0.009	−0.095***	0.009	−0.143***	0.010	−0.145***	0.010
2016*tertiary education	−0.079***	0.009	−0.081***	0.009	−0.152***	0.010	−0.154***	0.009
R–squared	0.045		0.296		0.070		0.270	
Obs.	503,053		503,053		503,053		503,053	

Notes: ***denotes statistical significance at 1% level; **denotes statistical significance at 5% level; *denotes statistical significance at 10% level.
Source: ISTAT, Indagine Multiscopo sulle Famiglie, Aspetti della Vita Quotidiana

reference person's educational level, year dummies and interactions between these variables are included, in the full specification we add gender and age of the household reference person, geographical area of residence, and household size. Odd-numbered columns report results for the baseline specification, and even-numbered columns report results for the full specification. In all the regressions, the coefficients on the year dummies are all highly statistically significant, thus suggesting that their inclusion in the model is appropriate.[7] Additionally, given that the size of these coefficients tends to increase with each successive year, this indicates that there has been an increasing secular trend in computer and internet penetration rate.

In line with expectations, the results in Tables 2, 3 and 4 consistently show that access to a computer and the internet at home increases with the educational level of the household's reference person. Similarly, household reference person's age and gender are also relevant predictors of the presence of digital technologies. Households whose reference person is aged 65 or above are consistently significantly less likely to have a computer and an internet connection at home than those whose reference person is younger than 65. While in Tables 2 and 3 households with a male reference person are more likely to have a home computer and an internet connection than those with a female reference person, the opposite result is shown in Table 4. Furthermore, households located in the South are generally found to be less likely to have access to a computer and the internet than those in the North and Centre. This finding is

TABLE 3 Linear probability estimates of the probability of having a home computer and internet access, 2005–2016: households whose reference person has upper secondary education or less

	Presence of a computer at home				Internet access at home			
	(1) Coeff.	(2) S.E.	(3) Coeff.	(4) S.E.	(5) Coeff.	(6) S.E.	(7) Coeff.	(8) S.E.
Constant	0.429***	0.003	0.655***	0.006	0.316***	0.003	0.512***	0.006
Characteristics of the household reference person								
Male			0.007***	0.002			0.007***	0.002
Aged 65 or above			−0.238***	0.002			−0.198***	0.002
Upper secondary education	0.270***	0.006	0.195***	0.005	0.261***	0.006	0.195***	0.006
Characteristics of the household								
Geographical area of residence (reference is North)								
Centre			−0.018***	0.002			−0.007***	0.002
South			−0.123***	0.002			−0.130***	0.002
Size (reference is 6 or more members)								
1 member			−0.430***	0.006			−0.386***	0.006
2 members			−0.298***	0.006			−0.267***	0.006
3 members			−0.054***	0.005			−0.033***	0.006
4 members			0.054***	0.005			0.063***	0.006
5 members			0.055***	0.006			0.055***	0.006
Year (reference is 2005)								
2006	0.031***	0.005	0.034***	0.004	0.016***	0.005	0.018***	0.004
2007	0.031***	0.005	0.039***	0.004	0.042***	0.005	0.049***	0.004
2008	0.058***	0.005	0.067***	0.004	0.077***	0.005	0.085***	0.004
2009	0.104***	0.005	0.114***	0.004	0.133***	0.005	0.141***	0.004
2010	0.129***	0.005	0.145***	0.004	0.187***	0.005	0.202***	0.004
2011	0.142***	0.005	0.159***	0.004	0.212***	0.005	0.227***	0.004
2012	0.149***	0.005	0.169***	0.004	0.223***	0.005	0.240***	0.004
2013	0.193***	0.007	0.208***	0.006	0.281***	0.007	0.295***	0.006
2014	0.187***	0.005	0.206***	0.004	0.311***	0.005	0.328***	0.004
2015	0.194***	0.005	0.215***	0.004	0.339***	0.005	0.358***	0.004
2016	0.194***	0.005	0.218***	0.004	0.366***	0.005	0.387***	0.004
Year*upper secondary education (Reference is 2005*upper secondary education)								
2006*upper secondary education	−0.006	0.008	−0.013*	0.007	0.007	0.008	0.001	0.008
2007*upper secondary education	0.008	0.008	0.002	0.007	0.014*	0.008	0.009	0.008

TABLE 3 *(continued)*

	Presence of a computer at home				Internet access at home			
	(1) Coeff.	(2) S.E.	(3) Coeff.	(4) S.E.	(5) Coeff.	(6) S.E.	(7) Coeff.	(8) S.E.
2008*upper secondary education	−0.001	0.008	0.000	0.007	0.004	0.008	0.004	0.008
2009*upper secondary education	−0.003	0.008	−0.001	0.007	0.010	0.008	0.012	0.008
2010*upper secondary education	−0.010	0.008	−0.011	0.007	−0.004	0.008	−0.006	0.007
2011*upper secondary education	−0.017**	0.008	−0.015**	0.007	−0.007	0.008	−0.005	0.007
2012*upper secondary education	−0.023***	0.008	−0.017**	0.007	−0.011	0.008	−0.007	0.007
2013*upper secondary education	−0.033***	0.010	−0.028***	0.009	−0.018*	0.011	−0.015	0.010
2014*upper secondary education	−0.025***	0.008	−0.018***	0.007	−0.020***	0.008	−0.013**	0.007
2015*upper secondary education	−0.040***	0.008	−0.029***	0.007	−0.040***	0.008	−0.031***	0.007
2016*upper secondary education	−0.040***	0.008	−0.026***	0.007	−0.047***	0.008	−0.035***	0.007
R-squared	0.080		0.319		0.101		0.289	
Obs.	451,207		451,207		451,207		451,207	

Notes: Households whose reference person has tertiary education have been excluded. ***denotes statistical significance at 1% level; **denotes statistical significance at 5% level; *denotes statistical significance at 10% level.
Source: ISTAT, Indagine Multiscopo sulle Famiglie, Aspetti della Vita Quotidiana

in line with the conclusion of Chinn and Fairlie (2007) that regional differentials in income explain differences in technology diffusion while controlling for several factors including human capital. Household size is also an important determinant, and it appears to have a non-linear relationship with the dependent variables of our models. While households with up to three members are more likely to possess a computer and be connected to the internet than those with six or more members, the opposite conclusion holds when the latter are compared with households of four or five members. One should also observe that, as expected, the R-squared of the full specification is systematically higher than that of the baseline specification.

TABLE 4 Linear probability estimates of the probability of having a home computer and internet access, 2005–2016: households whose reference person has lower secondary education or less

	Presence of a computer at home				Internet access at home			
	(1) Coeff.	(2) S.E.	(3) Coeff.	(4) S.E.	(5) Coeff.	(6) S.E.	(7) Coeff.	(8) S.E.
Constant	0.339***	0.005	0.657***	0.007	0.246***	0.004	0.518***	0.008
Characteristics of the household reference person								
Male			−0.011***	0.002			−0.011***	0.002
Aged 65 or above			−0.170***	0.003			−0.136***	0.003
Lower secondary education	0.184***	0.007	0.041***	0.006	0.144***	0.006	0.022***	0.006
Characteristics of the household								
Geographical area of residence (reference is North)								
Centre			−0.020***	0.003			−0.009***	0.003
South			−0.143***	0.002			−0.147***	0.002
Size (reference is 6 or more members)								
1 member			−0.506***	0.007			−0.438***	0.007
2 members			−0.378***	0.007			−0.328***	0.007
3 members			−0.064***	0.007			−0.041***	0.007
4 members			0.071***	0.007			0.075***	0.007
5 members			0.063***	0.007			0.058***	0.007
Year (reference is 2005)								
2006	0.017***	0.006	0.025***	0.005	0.004	0.006	0.010*	0.005
2007	0.022***	0.006	0.036***	0.005	0.030***	0.006	0.041***	0.005
2008	0.034***	0.007	0.048***	0.005	0.054***	0.006	0.065***	0.005
2009	0.079***	0.007	0.092***	0.005	0.098***	0.006	0.109***	0.005
2010	0.092***	0.007	0.112***	0.005	0.140***	0.006	0.157***	0.005
2011	0.109***	0.007	0.127***	0.005	0.164***	0.007	0.179***	0.005
2012	0.117***	0.007	0.136***	0.005	0.177***	0.007	0.193***	0.005
2013	0.157***	0.010	0.175***	0.008	0.233***	0.010	0.247***	0.008
2014	0.150***	0.007	0.168***	0.005	0.251***	0.007	0.265***	0.005
2015	0.161***	0.007	0.176***	0.006	0.280***	0.007	0.293***	0.005
2016	0.162***	0.007	0.180***	0.006	0.306***	0.007	0.322***	0.006
Year*lower secondary education (Reference is 2005*lower secondary education)								
2006*lower secondary education	0.025***	0.010	0.018**	0.008	0.022**	0.009	0.015*	0.008
2007*lower secondary education	0.017*	0.010	0.009	0.008	0.024***	0.009	0.018**	0.008
2008*lower secondary education	0.041***	0.010	0.037***	0.008	0.041***	0.009	0.038***	0.008

TABLE 4 *(continued)*

	Presence of a computer at home				Internet access at home			
	(1) Coeff.	(2) S.E.	(3) Coeff.	(4) S.E.	(5) Coeff.	(6) S.E.	(7) Coeff.	(8) S.E.
2009*lower secondary education	0.042***	0.010	0.042***	0.008	0.061***	0.009	0.063***	0.008
2010*lower secondary education	0.059***	0.010	0.062***	0.008	0.083***	0.009	0.086***	0.008
2011*lower secondary education	0.050***	0.010	0.060***	0.008	0.081***	0.009	0.090***	0.008
2012*lower secondary education	0.050***	0.010	0.064***	0.008	0.079***	0.010	0.091***	0.008
2013*lower secondary education	0.047***	0.014	0.059***	0.011	0.074***	0.014	0.086***	0.012
2014*lower secondary education	0.052***	0.010	0.069***	0.008	0.100***	0.009	0.116***	0.008
2015*lower secondary education	0.041***	0.010	0.068***	0.008	0.092***	0.009	0.116***	0.008
2016*lower secondary education	0.038***	0.010	0.065***	0.009	0.093***	0.009	0.116***	0.008
R–squared	0.063		0.336		0.080		0.294	
Obs.	296,232		296,232		296,232		296,232	

Notes: Households whose reference person has tertiary education or upper secondary education have been excluded. ***denotes statistical significance at 1% level; **denotes statistical significance at 5% level; *denotes statistical significance at 10% level.
Source: ISTAT, Indagine Multiscopo sulle Famiglie, Aspetti della Vita Quotidiana

To move on to the primary interest of this work, Table 2 shows that the digital gap between highly educated households and those with less education (I_1) has narrowed over time. The results from the baseline specification show that, while in 2005 households whose reference person had tertiary education were 31.1 percentage points more likely to have a computer at home than those whose reference person had upper secondary education or less, in 2016 this difference was reduced to 23.2 percentage points. Not only is the same pattern seen for home internet access, but the observed gap reduction is even larger. Again, the estimates from the baseline specification show that the difference fell from 33.7 percentage points in 2005 to 18.5 percentage points in 2016 (a steady decline is observed from 2009 onwards). Similar considerations hold also when examining findings from the full specification, though the gap values are smaller.

As shown in Table 3, a narrowing of the digital gap can also be observed between households with a reference person with upper secondary education and those with a reference person with lower secondary education or less (I_2). Column 1 of Table 3 shows that, while in 2005 the former group of households were 27 percentage points more likely to have a computer at home than the latter group, in 2016 the corresponding value was 23 percentage points. As for home internet connection, as shown in column 5 of Table 3, the relevant gap was reduced by 4.7 percentage points (it fell from 26.1 percentage points in 2005 to 21.4 percentage points in 2016). A decreasing gap is also seen in the estimates reported in columns 3 and 7 of Table 3.

Based on these results, we can note that, although both I_1 and I_2 narrowed between 2005 and 2016, I_1 showed the greater reduction. While in 2005 the size of I_1 is consistently greater than that of I_2, the opposite occurs in 2016.

In contrast to the results of Tables 2 and 3, the estimates of Table 4 indicate an increase in our third measure of digital inequality (I_3). This would seem to suggest that, though home computer and internet access have improved for households with a reference person with lower secondary education as well as for those with a reference person with primary education or less, growth has been faster in the former.[8] Column 1 of Table 4 shows that the gap in home computer ownership widened from 18.4 to 22.2 percentage points between 2005 and 2016, whereas, as indicated in column 5, the disparity in home internet access increased by 9.3 percentage points during the same period (from 14.4 to 23.7 percentage points). Results from the full specification also show a trend towards increasing inequality, though the relevant gap is much smaller once the effect of the additional covariates is taken into account.

Appendices A and B depict changes over time in the three indicators of digital educational inequality by geographical area of residence. Data shown in these appendices are based on regression results from the baseline and full specifications, respectively. Consistent with the estimates depicted in Tables 2, 3 and 4, in all geographical areas while I_1 and I_2 decreased, I_3 increased.

In the first two indicators of digital educational inequality, the magnitude of the gap is larger in the South than in the Centre and North throughout the whole period under examination. As for I_1, it is interesting to observe a particularly significant gap reduction in home internet access across all the geographical areas.

I_3 increased with respect to both computer and internet access, although to a slightly greater extent in the latter. Furthermore, the size of the both gaps appears to be generally higher in the North than in the South and Centre.

5 | DISCUSSION AND CONCLUSION

This article has shown that, while household access to a computer and internet increased steadily during the 2005–16 period, it remains structured along lines of educational background. Households with a more educated reference person are less likely to be digitally excluded than those with a less educated reference person. There are also important geographical differences as households in the South are less likely to have a computer and the internet at home than those in the Centre and North across all educational levels of the reference person.

More recent data than those used here show that there continue to be relevant geographical and educational background differences in Italian households' access to internet and digital devices. While between the years 2018 and 2019 in the South the share of households that did not have a computer or a tablet at home was 41.6 per cent, the corresponding figure in Italy as a whole was 33.8 per cent (ISTAT, 2020). In 2019, the proportion of households with broadband connection was 94.1 per cent across those with at least one member with tertiary education, whereas it was only 46.1 per cent across less educated households (i.e. those whose highest educational attainment was lower secondary education) (ISTAT, 2019).

We should note that the COVID-19 crisis has shed additional light on the issue of digital exclusion. Many children from less advantaged backgrounds had no computer or internet access at home and hence were unable to follow online lessons. Teachers from poor areas in the South of Italy report that approximately 60 per cent of their students could not regularly

attend virtual classes (Ferrario, 2020). In order to address this problem, the Italian government allocated 70 million euro for the purchase of computers and tablets to be loaned to students and academic staff (Valerio, 2020). At the same time, many schools and teachers set up different initiatives to distribute laptops to less privileged pupils (Jones, 2020). However, despite this, it is expected that many disadvantaged children will experience a significant learning loss during the pandemic, exacerbating existing inequality in educational outcomes (Pensiero et al., 2019). If no action is taken to repair some of the learning damage suffered by students during the lockdown,[9] this situation might have serious long-term repercussions. Current students, especially the most vulnerable ones, will be entering the labour market with a lower level of skills and thereby may be exposed to the risk of higher unemployment and lower wages.

When looking at changes in the digital divide over time, we find that the difference between the most highly educated households (i.e. those with a reference person with tertiary education) and those with lower levels of education is narrowing, though it is still quite large, especially in the South.

Perhaps the most policy-relevant result of this study is that, in contrast to what is reported above, the digital gap at the bottom of the education distribution is actually widening over time. This is an important finding, as most of the existing studies tend to focus only on the gap between the top and the rest of the education distribution, thereby providing only a partial picture of the digital divide. We find that, although computer and internet penetration is increasing among households with poor education (i.e. those with a reference person with primary education or less), such growth lags behind that of households with a basic education (i.e. those with a reference person with lower secondary education). This situation occurs in all geographical areas but appears to be slightly more pronounced in the North.

Given that, as stated above, more educated households are more likely to have digital technologies than less educated ones, growth in computer and internet penetration needs to be faster in the latter than in the former in order for the digital divide to be bridged. And this should occur when different educational levels are compared. However, the observed widening of the gap at the lower end of the education distribution clearly impedes the closing of the digital gap.

Although, as indicated earlier, market-driven changes such as lower internet access charges are improving the overall picture, there are no obvious ways in which market forces will eliminate the digital gap in a reasonable timescale. To address this problem, policies aimed at promoting and supporting the adoption of digital technologies among the most educationally disadvantaged households may need to be strengthened. In 2016, of those Italian households whose reference person had primary education or less (about a quarter of total households), about 50 per cent did not have a computer or the internet at home. Interventions specifically targeting relevant fractions of the population that appear to be digitally marginalised are therefore of great importance.

But more research needs to be conducted on poorly educated households without computer and internet access in order to find out to what extent this is due to affordability problems, lack of basic ICT skills, or place of residence issues (being in remote/rural areas).

One limitation of this study's analysis is that access to digital technologies does not automatically confer advantages to households as it depends on how computers and internet are used (Halford & Savage, 2010), and this needs to be investigated further. Similarly, another shortcoming of the study is that there is no distinction in terms of the speed and quality of internet connection at home. For instance, it would have been helpful to distinguish between broadband connectivity and the use of dial-up or digital subscriber line.

Without more information of this kind, there is potential for the implementation of expensive policies which fail to resolve the problems associated with the digital divide.

NOTES

[1] For instance, Moller (2000) argues that the education of the head of household is the most important factor in explaining access to a computer at home in California.

[2] The education system in Italy includes nursery school (age 3 to 6 years), primary education (age 6 to 11 years), lower secondary education (age 11 to 14 years), upper secondary education (age 14 to 19 years) and tertiary education.

[3] One exception is the paper by Cruz-Jesus et al. (2016), who show that in several European countries the digital gap exists not only between people with highest and lowest levels of education, but also between people with middle and lowest levels of education.

[4] In Italian, Indagine Multiscopo sulle Famiglie, Aspetti della Vita Quotidiana.

[5] Survey year fixed effects control for secular changes over time that affect all households similarly in a given year.

[6] Survey sample weights are used for all data calculations throughout this article.

[7] This is also confirmed by the results of F tests (available from the author upon request).

[8] While home access to the internet among households whose reference person has lower secondary education increased by 39.9 percentage points between 2005 and 2016, the corresponding figure for households whose reference person has primary education or less is 30.6 percentage points. The same applies to home access to a computer, 20 percentage points versus 16.2 percentage points.

[9] Small group tutoring has been proposed as an effective and relatively inexpensive method to mitigate the negative effects on education caused by COVID-19 (Burgess, 2020).

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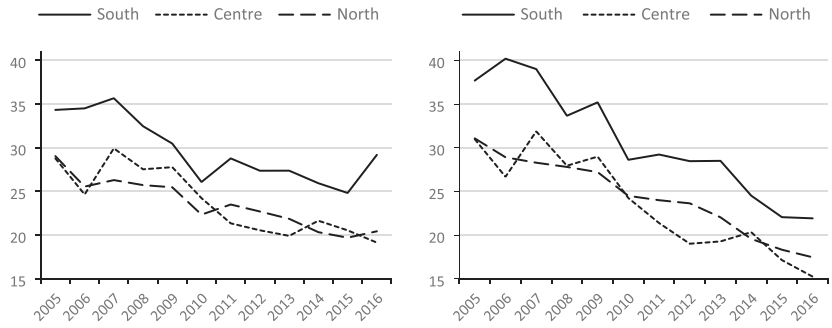
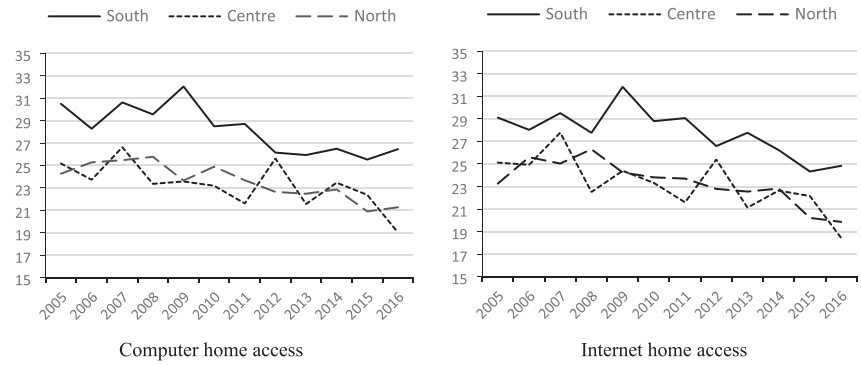
How to cite this article: Di Pietro G. Changes in Italy's education-related digital divide. *Economic Affairs*. 2021;41:252–270. https://doi.org/10.1111/ecaf.12471

APPENDIX A: Percentage point gap in computer and internet home access by level of education of household's reference person and geographical area of residence, 2005–2016 (baseline specification)

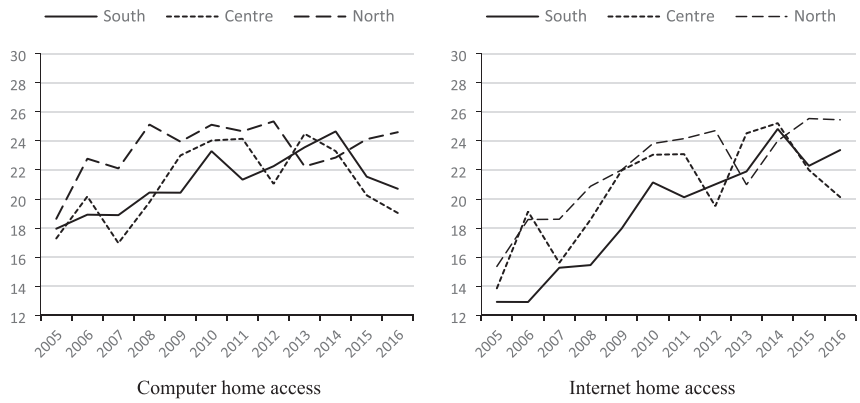
(a) Tertiary education vs. non-tertiary education (I_1)



(b) Upper secondary education vs. non-upper secondary education (I_2)

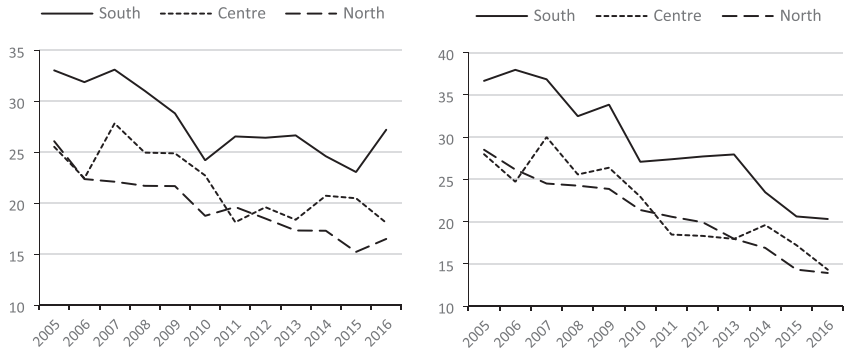


(c) Lower secondary education vs. primary education or less (I_3)

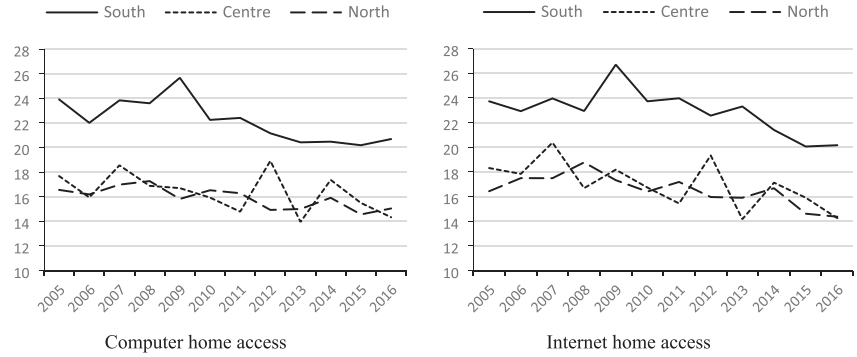


APPENDIX B: Percentage point gap in computer and internet home access by level of education of household's reference person and geographical area of residence, 2005–2016 (full specification)

(a) Tertiary education vs. non-tertiary education (I_1)



(b) Upper secondary education vs. non-upper secondary education (I_2)



(c) Lower secondary education vs. primary education or less (I_3)