

FROM DIGITAL ACCESS TO SOCIO-ECONOMIC INCLUSION: A NETWORK ANALYSIS OF EUROPEAN COUNTRIES

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Abstract

Digitalization is increasingly invoked as a vector of socio-economic inclusion, but most studies deal with the relationships between digital infrastructure, innovation, employment and poverty through linear models that assume pre-established causal directions and ignore the interdependence structure of the system. This paper proposes a complementary approach, based on network analysis, which allows the simultaneous estimation of the associations between all variables and the identification of their latent configuration. The study capitalizes on data for the member states of the European Union and a Network Analysis was carried out, in which the edges express partial correlations, i.e. associations remaining after controlling for all other variables in the network. The strongest positive associations arise between individual internet use and household access to the internet, respectively between innovation performance and internet use, confirming that digital adoption and innovation capacity form a coherent core. The occupancy rate functions as a connecting node between the two communities, being connected to both digital variables and innovation. In contrast, the poverty rate behaves as a peripheral node, maintaining only negative relationships with employment, internet use, internet access and innovation, suggesting that socio-economic exclusion manifests itself simultaneously as digital exclusion. The conclusions support the idea that digital access does not lead to inclusion directly, but through effective use, innovation capacity and employment. From a public policy perspective, the results call for interventions that go beyond the expansion of infrastructure and target digital skills and the absorption of innovation, as levers to reduce poverty.

Keywords: digital divide; socio-economic inclusion; network analysis; partial correlation network; innovation; employment; European Union

JEL Classification: O33, J21, O31, I32

1. Introduction

Digitalization has become one of the major axes of European policies. Through the *Digital Decade* programme, the European Union has set ambitious targets for 2030 on high-speed network coverage and the level of digital skills of the population (European Commission, 2021). The premise of these commitments is that expanding digital access generates, over time, positive effects on employment and poverty reduction.

This premise is only partially confirmed by existing research. Studies on the digital divide show that access to the internet is a necessary, but not sufficient, condition for economic and social participation: as connectivity becomes widespread, inequalities shift from access to the mode of use and the benefits actually obtained (Hargittai, 2002; van Dijk, 2020; Robinson et al., 2015). From this perspective, inclusion does not mean simply connecting, but the real ability of individuals to transform digital resources into valued outcomes (Sen, 1999; Helsper, 2012).

At the macroeconomic level, the literature confirms the existence of a positive relationship between digital infrastructure and economic performance (Röller & Waverman, 2001; Czernich et al., 2011), but at the same time stresses that these effects depend on the context in which the technology is adopted, in particular on national innovation capacity (Fagerberg and Srholec, 2008). In other words, the same levels of connectivity can produce very different social outcomes from one country to another.

This paper looks at how digital access, internet use, the ICT sector, innovation, employment and poverty are interlinked across European countries. Unlike approaches that isolate a single explained variable, here the seven indicators are treated as a system of interdependent relationships, represented in the form of a network (Epskamp and Fried, 2018). The objective is to identify the groups of indicators that behave coherently and the links through which connectivity translates, or not, into socio-economic inclusion.

The paper is structured as follows: section 2 reviews the relevant literature; Section 3 presents the data and methodology; Section 4 discusses the results; Section 5 sets out the conclusions and public policy implications.

2. Literature review

Early research on the digital divide looked at the problem in simple terms: who has and who doesn't have access to the internet (Norris, 2001). As the connection expanded, this perspective proved insufficient. Hargittai (2002) showed that, between people who have the same access, there are important differences in skills and how they are used, what the author called the "second-level digital divide". Subsequently, van Deursen and van Dijk (2014) confirmed that, in societies with almost universal access, inequalities do not disappear, but move in the way the internet is used.

A third level of analysis refers to the concrete results that people obtain from the use of the internet: higher incomes, access to jobs, public services or education (van Deursen and Helsper, 2015). The synthesis by Scheerder, van Deursen and van Dijk (2017) shows that the advantages are also concentrated in people with a high level of education and income, so digitalization can amplify already existing inequalities. The same conclusion appears in Robinson et al. (2015), who argue that digital inequalities should be treated as a dimension of social inequality in general, not as a separate technical issue.

A second research strand looks at the economic effects of digital infrastructure. Röller and Waverman (2001) identified a positive link between the development of telecommunications networks and economic growth in OECD countries. Similar results have been obtained for broadband by Koutroumpis (2009) and Czernich et al. (2011), who estimate that expanding high-speed internet coverage contributes significantly to GDP growth per capita.

However, these effects are not automatic. Brynjolfsson and Hitt (2000) showed that investment in technology only produces results when it is accompanied by organizational changes and complementary investments. The theoretical explanation comes from the literature on general-purpose technologies: information technologies are widespread in all sectors of the economy, but their effects occur late and unevenly (Bresnahan and Trajtenberg, 1995). Vu (2011) empirically confirms that the benefits of digitalization strongly depend on the institutional and economic context of each country.

The link between digitalization and employment is mediated by the capacity for innovation. Literature on National Innovation Systems (Freeman, 1987; Lundvall, 1992; Nelson, 1993) argues that a country's technological performance depends on the network of institutions, firms, and public policies that support innovation. Fagerberg and Srholec (2008) empirically demonstrate that countries with stronger innovation capacities succeed in transforming technology into economic development, while others remain mere users of imported technology.

On the labor market, the effects of digitalization are differentiated. Autor, Levy and Murnane (2003) showed that technology primarily replaces routine tasks, favoring occupations that involve analytical and interpersonal skills. Goos, Manning and Salomons (2014) document, for European countries, a process of employment polarization: highly skilled and low-skilled jobs are increasing, while the middle zone is eroding. Acemoglu and Restrepo (2019) nuance this image, showing that technology eliminates certain activities, but simultaneously creates new ones, and the net effect depends on the balance between the two processes.

3. Data and Methodology

The analysis is based on a panel dataset, covering the Member States of the European Union in the period 2020-2023, resulting in a total of 108 observations. The data come from the Eurostat database, except for the Global Innovation Index.

Seven indicators covering three dimensions have been selected: infrastructure and digital access, innovation capacity and socio-economic outcomes. Operational definitions, units of measurement and sources are presented in Table 1.

Table 1. Variables used in the analysis

Variable	abbrev.	Operational Definition	Unit	Source
Employment rate	er	Employment rate of the population aged 20-64 years	%	Eurostat
Internet access	hiac	Share of households with internet access at home	%	Eurostat
High-speed internet coverage	hsico	Share of households covered by Next Generation Access (NGA) broadband networks	%	Eurostat
Individual internet use	iius	Share of individuals who used the internet during the last 12 months	%	Eurostat
Global Innovation Index	gin	Aggregate score of the Global Innovation Index	0-100	WIPO
ICT sector	ictc	Value added of the ICT sector as a share of GDP	%	Eurostat
Poverty rate	pv	Share of the population experiencing poverty	%	Eurostat

Source: Author contribution

Table 2 presents the main characteristics of the variables included in the analysis. The data show a high level of convergence in terms of basic digital access: the share of households with internet access averages 91.6% and individual internet use 90.3%, with low standard deviations. In contrast, high-speed network coverage shows the greatest dispersion among all variables (standard deviation of 19.6 percentage points, with values between 10.2% and 100%), which indicates important differences in infrastructure between states. Socio-economic outcomes also remain heterogeneous: the poverty rate ranges from 10.8% to 35.6%, and the employment rate from 58.3% to 83.5%. The global innovation index stands at an average of 47.3 points, with a gap of almost 30 points between the weakest and the best-ranked state.

Table 2. Summary statistics of variables used in the econometric analysis, 2020-2023

	pv	er	hiac	iius	ictc	hsico	gin
Valid	102	102	106	107	46	108	105
Missing	6	6	2	1	62	0	3
Mean	20.459	75.082	91.622	90.256	5.090	73.222	47.293
Std. Deviation	5.302	5.277	4.004	5.614	1.451	19.567	7.655
Minimum	10.800	58.300	78.850	74.270	3.040	10.200	34.700
Maximum	35.600	83.500	99.180	99.350	10.140	100.000	64.200

Source: Author contribution in JASP19

For the analysis, a network of partial correlations, Network Analysis, was estimated. In this representation, each variable is a node, and the bond between two nodes expresses the remaining association between them after the influence of all the other variables in the model is eliminated (Epskamp and Fried, 2018).

The structure of the network has been analysed from two perspectives. The first concerns the position of each variable in the system, evaluated by centrality indicators. The second concerns

the internal organization of the network, i.e. the identification of groups of variables that relate more strongly to each other than to the rest of the system, through community detection algorithms (Golino and Epskamp, 2017).

4. Results and discussions

Figure 1 shows the estimated network of partial correlations for the seven indicators. Each line represents the link between two variables after eliminating the influence of the other five; The thickness of the line indicates the intensity of the association, and the color indicates its sign (green for positive associations, red for negative associations).

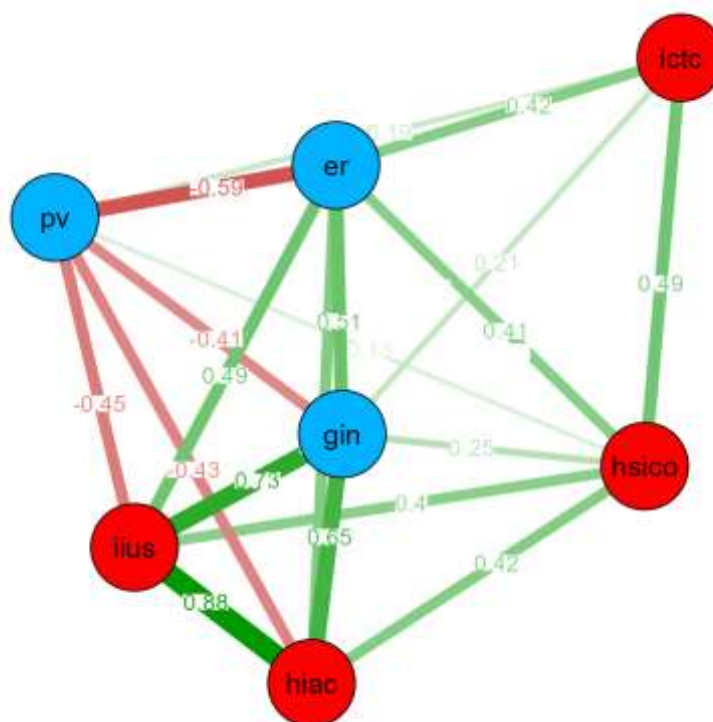


Figure 1. Network Analysis of digital access and socio-economic inclusion, EU-27, 2020-2023

Source: Author contribution in JASP19

The network is dense, which shows that the digital, economic and social dimensions do not work in isolation, but form an interconnected system. However, the community detection algorithm identified two distinct groups. The first group brings together the indicators describing internet infrastructure and use: household access to the internet, individual use, high-speed network coverage and the size of the ICT sector. The second group brings together indicators describing economic and social performance, namely the employment rate, the poverty rate and the capacity to innovate.

Within the digital group, the strongest link in the entire network occurs between households' access to the internet and individual use (0.88). The result is to be expected: where the basic infrastructure is available, it is also used. Basically, the two indicators measure mostly the same phenomenon.

High-speed network coverage is moderately linked to basic access (0.42) and usage (0.40), suggesting that advanced infrastructure follows a partially different dynamic from that of basic connectivity. The ICT sector is the weakest integrated node of the group: it has a notable connection only with high-speed coverage (0.49), otherwise being connected by very weak

associations. The economic dimension of the ICT sector thus appears to depend on specialised infrastructure rather than on the overall degree of population connectivity.

In the second group, the strongest link is the negative link between the employment rate and the poverty rate (-0.59), confirming the classic relationship between labour market participation and the risk of poverty. The employment rate is also positively linked to innovation capacity (0.51), and innovation is negatively associated with poverty (-0.41).

The occupancy rate thus appears as the best-connected node of the network: it has consistent links both within its own group and with all digital indicators. This central position suggests that the labour market functions as a focal point of the system, the place where digital and innovation resources are transformed into social outcomes.

The most important result of the analysis concerns how the two groups connect. The links are not diffuse, but focus on a few routes.

Innovation capacity is strongly associated with individual internet use (0.73), being the only socio-economic variable so closely linked to a digital indicator. Innovation therefore functions as a transitional element: it translates the use of the internet into a harnessable economic capacity.

The employment rate is directly linked to all digital indicators, household access (0.65), individual use (0.49), high-speed coverage (0.41) and the ICT sector (0.42), but with moderate intensities, relatively evenly distributed. Digitization thus contributes to employment in several ways simultaneously, without any of them being dominant.

The poverty rate, on the other hand, has no positive relationship with digital indicators. It is negatively associated with internet use (-0.45), household access (-0.43) and innovation (-0.41), but these links are weaker than employment. In other words, digitalization does not reduce poverty directly, but through employment and innovation.

5. Conclusions

The network analysis applied to the seven indicators shows that digital access and socio-economic inclusion form two distinct but connected areas of the same system. Indicators of internet access and use are largely mutually explanatory and have achieved a high level of convergence across European countries, while social outcomes remain highly differentiated.

The connection between the two areas is not direct, but is made through two bridge-nodes. The capacity for innovation turns the use of the internet into an economic resource, and the employment rate channels the effects of digitalization towards poverty reduction. Poverty occupies a peripheral position in the network, being linked to digital indicators only indirectly and with moderate intensities.

The results have a direct implication for European public policies. The connectivity targets assumed by the Digital Decade remain necessary but insufficient: in the absence of complementary measures on employment and innovation capacity, expanding access does not automatically translate into social inclusion. For countries below the European average, investment in infrastructure should be accompanied by active labour market policies and support for the national innovation system.

The work also has limits. The network describes conditional associations, not causal relationships, and the limited availability of ICT data affects the accuracy of estimates involving this indicator. Future research could extend the analysis by including digital skills and estimating separate networks by groups of countries, to test whether the identified structure is maintained at regional level.

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