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DIGITAL TECHNOLOGIES AND WOMEN'S EMPOWERMENT – CASTING THE BRIDGES

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1.1 Introduction

Societies and economies are not digitally neutral. Digital technologies are widely acknowledged as the key drivers for knowledge and information acquiring, labor and capital productivity, social, political, and economic empowerment (Graham, 2019). Digital technologies, due to the strong network effects (Katz and Shapiro, 1985) that they generate, enable the emergence of various networks reshaping the ways in which businesses are run, trading and consumption patterns, economic and social behaviors, and social norms and attitudes (Graham & Dutton, 2019). Tracing and understanding existing relationships between society-wide adoption and usage of digital technologies and economic development deserves special attention for a variety of reasons: not only to claim that it deepens our knowledge on how economies work but to state that a policy perspective that shapes institutional and economic environment is of seminal importance in this case (Stiroh, 2002; Gilbert, 2020).

Theoretical and empirical academic contributions highlight different positive effects that information and communication technologies may generate, improving the well-being of individuals and whole societies by offering them new opportunities in education and skills improvements, setting up new businesses, leaving behind the undeclared economy sector and achieving a relatively stable source of income. Arising from the gradually increasing use of information and communication technology (ICT) worldwide, a massive amount of literature documents both conceptual frameworks and empirical evidence regarding ICT's impact on social and economic development: starting from the contribution of work by Abramowitz (1986), Dosi et al. (1988), Freeman and Soete (1990), Fagerberg (1994 and 1995), Fagerberg et al. (1994) to more recent evidence like, for instance, work by Bilan et al. (2019), Loh and Chib (2019), Tchamyou et al. (2019), Adam (2020), Ali et al. (2020), Nair et al. (2020), or Vu et al. (2020).

Empirical research tracing the sensitivity of societies and economies to the introduction of digital technologies discusses a variety of channels of impact and

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interrelations between the two. Earlier studies concentrated predominantly on creating network societies and economies (Shapiro & Varian, 1998; Castells, 2000, 2011; Johansson, 2012; Van Dijk, 2020), information societies (Mossberge et al., 2007; Beniger, 2009; Lyon, 2013; Buckland, 2017; Martin, 2017) where structural changes are driven by strong network externalities (Katz & Shapiro, 1985, 1986) and unlimited access to all types of information and knowledge, usually at negligible marginal cost. Other studies emphasized the purely technical side of technological progress that changes the structure of production and, consequently, the consumption side (Joyce et al., 2019). The effects of technological progress on both the supply and the demand sides of the economy are rather direct and immediate, while changes in ways of doing business and trading patterns (Rodríguez-Crespo and Martínez-Zarzoso, 2019), education and skills (Livingstone, 2012), labor markets and the labor force (Falk and Biagi, 2017), people's economic engagement, or – more broadly – productivity shifts or poverty alleviation, seem to be more hidden, indirect, and demonstrated in the long run. Undeniably, the full potential of digital technologies can be easily unleashed when deploying them as economic development accelerators in the least-developed countries (Cheng et al., 2020) permanently lacking financial resources, good infrastructure, free and easily accessed educational and healthcare systems, and sound government (Kozma & Vota, 2014; Kaur et al., 2017). Unless a breakthrough like the explosion of ICT occurs, they will probably remain in poverty traps, being unable to take off on the development path (Hanafizadeh et al., 2019).

1.2 Digital technologies adoption and usage: global snapshot

According to ITU estimates (ITU, 2019), in 2019 slightly above 4 billion people worldwide were using the Internet, which accounts for almost 54% of the global population. In regard to mobile cellular telephony, in 2019 more than 108% of the world's population was using this type of technological tool, while 83% of individuals were using active mobile broadband networks. Figure 1.1 demonstrates ICT core indicator diffusion trajectories between 1984 and 2019 for mobile cellular telephony, between 1999 to 2019 for Internet users, and between 2007 and 2019 for active mobile broadband, and year-to-year rates of growth of the respective indicators. Additionally, Table 1.1 summarizes logistic growth estimates for examined ICT variables that report the in-time dynamics of the diffusion process. Starting from the mid-1980s we may observe the steady growth of the adoption of mobile telephony worldwide. The diffusion path between 1984 and 2000 is relatively flat, reporting slow increases in mobile telephony adoption in this period; however, since 2000 we observe that the curve takes off as annual growth rates speed up in the forthcoming years (see figure reporting year-to-year growth rates – between 2000 and 2010 the annual rates of growth range from 3% per annum to even 9% per annum, and then slow down). The results of logistic growth estimates (see Table 1.1) show that, during the examined period, the intrinsic growth rate for MCS was 31% per year (world average), which allowed it to pass from a

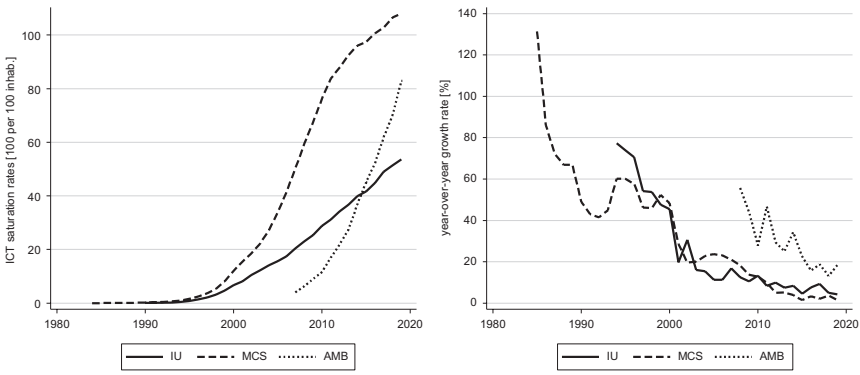

Figure 1.1 ICT core indicators diffusion trajectories and year-to-year rates of diffusion (bell curves). World (total). Period 1984–2019. Source: authors' elaboration. Note: Internet users and Mobile cellular telephony- time series: 1980–2019; active mobile broadband subscriptions - time series: 2007–2019; 3-parameter logistic growth model applied.

10% to 90% level of world average saturation in just 14.4 years, with the half-way point being reached by the year 2007.

According to logistic growth estimates (compare Table 1.1) the upper ceiling for MCS diffusion is at about 110 per 100 inhabitants, and it seems, on average, the world population has reached this level of ICT saturation. Still, these results differ by world regions if we discriminate between developed countries, developing countries, and least-developed countries (LDCs).[2] Figure A in the Appendix draws MCS diffusion curves for the respective regions for the period 2005–2019.[3] Needless to state that the MCS saturation results are highest in developed countries – in 2019 saturation reached almost 130 per 100 inhabitants, while in LDCs it was only 75 per 100 inhabitants. Interestingly, regardless of the country group, annual growth rates (see also Figure A in the Appendix), as well as the in-time shape of the MCS development path, do not differ significantly, which may speak in support of the hypothesis that ICT diffusion process is strongly endogenously driven by emerging network externalities (Katz & Shapiro, 1986; Lechman, 2015; Aguilar et al., 2020; Hoernig & Monteiro, 2020). Still, what shall be noted, according to the ICT statistics cited, is that even the most economically deprived countries, with the lowest gross per capita income, may benefit from the global spread of digital technologies. There is abundant empirical literature reporting the massive spread and increasingly fast adoption of ICT in economically poor countries, despite the fact that neither its diffusion determinants nor its effects are well recognized. See, for instance, the most recent research by Cheng et al. (2020) modeling ICT effects for financial and economic development in MENA economies; Maneejuk and Yamaka (2020) examining ICT impact on economic growth, through the channels of fixed and mobile telephony as well as R&D; Çetin et al.

Table 1.1 ICT core indicators logistic growth estimates.[1] World (total). Period 1984–2019

Region and time period	κ *[per 100 inhab.]*	T_m *[year]*	α *[% per year]*	Δt *[# of years]*	*r-sq.*	*Root MSE*	*Res. Dev.*	*# obs.*
MCS_world_1984–2019	109.5	2007.5	0.31	14.4	0.99	1.02	100.8	36
	[0.96]	[0.08]	[0.00]					
IU_world_1990–2019	63.6	2011.1	0.19	22.5	0.99	1.17	85.4	28
	[2.35]	[0.43]	[0.00]					
AMB_world_2007–2019	120.9	2016.8	0.32	13.7	0.99	1.25	39.4	13
	[10.3]	[0.54]	[0.01]					

Source: authors' estimates. Note: estimation method – NLS. In parenthesis (robust SE). MCS – mobile cellular subscriptions; IU – Internet users; AMB – active mobile broadband subscriptions.

(2020) tracing the impact of digital technologies on women's empowerment; or, more specifically, for example, inter alia, the work of Hasbi and Dubus (2020) tracing mobile broadband diffusion determinants in sub-Saharan African regions or that of Venkatesh et al. (2020) using the context of social networks to examine the effects of ICT adoption on women's health in rural India.

If we turn to the global data on Internet usage, we also observe rapid shifts since the 1990s. However, in this case the annual rates of growth are more moderate (only accidentally exceeding 3% per annum – see Figure 1.1) and the diffusion curve demonstrates relatively stable growth, reaching 54% of the global population in 2019 that uses the World Wide Web through different ICT devices. Respective logistic growth estimates (Table 1.1) report that the global speed of diffusion in this case is relatively lower, as intrinsic growth rates returned to 19% per annum, which means that 22.5 years were needed to pass from a 10% to 90% level of the world average saturation in IU (between 1990 and 2019). Again, if we discriminate by world regions, in 2019 in developed countries the IU saturation reached almost 87%; in developing countries, 47%; but in LDCs it stuck at the low level of only 19% of the population using the Internet (compare also the respective diffusion trajectories and annual diffusion rates in Figure B in the Appendix). Slightly more optimistic data are revealed in regard to the third ICT indicators considered – active mobile broadband. Respective data trace back to 2007, as the spread of this type of ICT is reported only from this year. Compared to other examined ICT indicators, in respect of average world data, the dynamics of diffusion of AMB is the highest figure – estimated intrinsic growth rate is 32% per annum (see Table 1.1) – while the reported upper ceiling is of 120.9 per 100 inhabitants. Interestingly the AMB diffusion trajectory seems to take off immediately once active mobile broadband networks are introduced to the market; hence no early diffusion phase characterized by slow growth is observed. Analogous observations may be claimed in regard to the reported active mobile broadband spreading process in developed, developing, and least-developed countries. Obviously, for 2019 the highest saturation rates are for developed countries – almost 122 per 100 inhabitants – while for developing and LDCs, the figures are 75 and 33 per 100 inhabitants, respectively. Still, reported annual growth rates in the least-developed economies are high between 2015 and 2019 (varying between 4% and 6% per year), which may potentially result in dynamic shifts in active mobile broadband networks usage even in the most economically backward countries if high rates of growth are maintained in forthcoming years.

1.3 Digital technologies for women's empowerment

Globally, we observe a growing interest in providing valuable and conclusive evidence on the role of ICT in fostering women's empowerment. Female economic participation is recognized as one of the most serious issues that economically backward countries are currently facing. Female populations in developing countries are usually deprived of access to educational, health, and financial systems;

due to social norms and attitudes or religious regimes, women are prevented from entering the formal labor market but, instead, are recognized as "hidden and usually unpaid" labor, exposed to poverty. Female poverty and feminization of vulnerability is often a direct effect of women's poor education, low professional skills and competences, high illiteracy, and lack of permanent income from stable, contracted work. In developing countries women usually run informal, home-based, and small-scale businesses, mostly in traditional sectors that bring relatively low returns and benefits. In the developing world, the female population remains unused in formal economic activities, which impedes both the social and the economic progress of a country. Over time, the statistical landscape regarding female labor-force participation has been changing. These changes are neither fast nor massive, but draw our attention to the fact that women are gradually gaining in economic power. According to the World Development Indicators database (2020), since the 1990s, female labor-force participation rates[4] are changing slightly in different parts of the world. Between 1990 and 2019 in regions like Europe and Central Asia, Latin America and the Caribbean, the Middle East and North Africa, female (aged 15+) labor participation has increased by 1.4pp, 10.5pp, and 2.8pp respectively. During the analogous period in regions like East Asia and the Pacific and sub-Saharan Africa we observe slight falls in female labor-force participation rates, such as 7.3pp and 1.2pp respectively. Still, these elementary statistics reporting on general global tendencies regarding women's engagement in the labor market will be interpreted jointly with data on female labor-force participation rates, but for ages 15 to 24, to provide a broader scope for drawing conclusions. Notably, during past decades, global efforts to enhance girls' education, especially in underdeveloped economies, brought visible effects (Khoja-Moolji, 2018; Paul, 2019; Ullrich, 2019; Asadullah et al., 2020). The positive outcomes of attracting young women to going to school instead of going to work are unveiled in the data for female labor-force participation rate for ages 15 to 24.

The body of both theoretical and empirical literature tracing the relationship between economic development and women's economic participation is significant: starting from several stylized facts, as, for instance, the "feminization U hypothesis"[5] in the development literature strand; to the massive body of evidence focusing on, e.g., gender-gap elimination in education and then employment (Seguino, 2000; Blecker & Seguino, 2002; Klasen, 2002; Klasen & Lamanna, 2009); elimination of social stigma; institutional restrictions against female industrial workers; restrictive cultural values and religious beliefs that keep women away from the formal economy (Jensen, 2012; Dildar, 2015; Ucal & Günay, 2019); and issues related to fertility, child-rearing, and in-house undeclared activities (Di Porto and Elia, 2015; Bucher-Koenen et al., 2020; Kato, 2020). Another massive strand of the literature broadly studies the nexuses between economic growth and female labor-force participation; see, for instance, the work of Tam (2011), Yakita (2018), Klasen (2019), or Petrongolo and Ronchi (2020), examining potential channels of uni-, or bi-directional impact.

As societies and economies gradually become more saturated with digital technologies, fast deployment and shifts in the usage of ICT bring to life new products and services. Digital technologies – by reshaping global trading and consumption patterns, fostering growths of ICT sectors, restructuring labor markets making it more flexible, on the one hand, while, on the other, introducing changes to the structure of labor demand and supply – may constitute an important factor for enhancement of female labor-force participation. The fast digitalization of all processes and artificial intelligence solutions, by changing the way that different types of jobs get done, may effectively contribute to growing female labor engagement in formal (registered) economic activities as well as to overall social, economic, and political women's empowerment. The female labor force may benefit from the growing deployment of digital technologies if their professional skills and competence allow them to perform the abstract and non-routine tasks (Autor et al., 2003) that gradually gain dominance in highly digitalized economies. In this sense, efforts toward gender equality and female economic empowerment in this rapidly changing technological and socioeconomic landscape gain in importance, not only in developing countries but also in high-income, digitally advanced economies. In UNDP (2008) it is claimed that "women's economic empowerment can be achieved by targeting initiatives to expanding women's economic opportunity; strengthen their legal status and rights; and ensure their voice, inclusion and participation in economic decision-making" (UNDP, 2008, p. 9), while in the OECD-DAC Network on Gender Equality we read that women's economic empowerment may be defined as women's "capacity to participate in, contribute to and benefit from growth processes in ways that recognise the value of their contributions, respect their dignity and make it possible to negotiate a fairer distribution of the benefits of growth" (OECD, 2011 p. 6). The roots of the concept of women's empowerment may be initially traced in influential works of, inter alia, Amartya Sen (1985, 1999), Kabeer (1999), or Narayan-Parker (2005). Broadly perceived, women's empowerment[6] may be achieved through various channels of impact that, in the end, allow the elimination of the barriers and constraints that prevent the female population from participating in economic activities, finding paid work, benefiting equally to men from access to, and control over, financial resources. As claimed by Alsop and Heinsohn (2005) or Duflo (2012), from a long-term perspective growing female economic empowerment will translate into the capacity to make the desired choices, but will also generate shifts in the distribution of economic power between the genders. Analogous claims are traced in Tornqvist and Schmitz (2009) who argue that increasing female empowerment is achievable mainly by eliminating gender inequalities in the labor market, which offers both genders equal access to economic opportunities to achieve income.

Despite the fact that gender issues have long been neglected in economic literature, we finally observe a growing body of evidence in this matter that combines a broad array of aspects. Empirical studies focusing on gender inclusion both in developed and developing countries concentrate on aspects ranging from the creation of gender networks, through facilitating access to finance

and mobile money, including inclusive aspects of finance or microfinance, ICT-based agriculture, health and educational solutions, promoting higher female engagement in the formal economy sectors, production and service sectors, to promoting female's engagement in the scientific field, and political and institutional empowerment (Çetin et al., 2020; Asongu and Odhiambo, 2020). ITU (2020) statistics report that the gender-based digital divide is persistent, and in some countries the female population benefits from technologies to a lesser extent than the male population. ICT is not equally distributed. Gaps and divides exist leaving unfavorable groups outside the digital revolution. According to OECD (2018),

> Worldwide roughly 327 million fewer women than men have a smartphone and can access mobile Internet. Women are on average 26% less likely than men to have a smartphone. In South Asia and Africa these proportions stand at 70% and 34%, respectively. While the global digital gender divide in Internet usage remained almost unchanged between 2013 and 2017, at about 11%, the gap between developed and developing countries increased, driven by an increase in the gender Internet usage gap of by 3 percentage points in least-developed countries and 4 percentage points in Africa.

In 2018, out of 101 cases classified by ITU, in 74[7] cases women were deprived of equal access to ICT tools and services; for men, ICT access and use of ICT rates are higher than for the female population (see Figure D in Appendix). Digital gender gaps are especially visible in Arab states and less-developed economies. The largest digital gender gaps (in 2018) were reported in Côte d'Ivoire (−20.2pp), Algeria (−12.2pp), Turkey (−12.8pp), Egypt (−11.0pp), and Uzbekistan (−10.4pp). Persistent gender gaps are recognized as one of the obstacles impeding women's economic impact and engagement. Needless to stress that compulsory schooling is a critical factor enabling women to gain basic skills and competences, but also skills to use digital tools effectively; ensuring affordable access to ICT is essential and should be one of the priorities in state-policy interventions. Directing policy efforts toward eradicating digital gender divides includes, inter alia, actions to ensure access to the Internet, mobile phones, digital-based finances, and ICT platforms and services, which, from a longer-term perspective, may help to increase job opportunities and enable women to join global trading markets (even through micro-trading initiatives), to leave the informal economy, and fight economic vulnerability.

1.4 ICT for households/inclusive technologies

The importance of households in the adoption of information and communication technologies, without doubt, affects women's empowerment. In other words, it could be argued that the empowerment of women can happen only

through the empowerment of households. Most women belong to households that are not single-member households, but even if they live alone, they still form a household. The formation of a household is not unaffected by the socio-economic status of its members. Thus, the household's structure and economic well-being should be taken into account when discussing ICTs and women empowerment.

The vast majority of the literature suggests the positive impact of ICT adoption on many aspects of household economic and social well-being. On the economic side, households' unincorporated businesses benefit from ICT adoption (McNamara, 2003; Irvine & Anderson, 2008; Cramer & Krueger, 2016; Mbuyisa & Leonard, 2017). The widespread adoption of inclusive technologies for production, marketing, and pricing in household-run businesses definitely contributes to an increase in household income.

The adoption of ICT is also crucial for household consumption and wealth accumulation. Better household consumption practices constitute the other benefit of ICT adoption (Kim, 2018), leading to more considerable savings. Access to information in general, and specific information in particular, allows household income to increase and be more equally distributed (Patria and Erumban, 2020). Further, the welfare of households in terms of income and wealth increases due to better information on financial products (online credit, financial savings, investments) and services (money transfers), and market access (Monga et al., 2014; Pellegrina et al. 2017; Tchamyou et al., 2019). Growing ICT adoption has impacted the economic quality of the life of households. With regard to well-being, household members have better access to social networking (Hübler & Hartje, 2016), education, and health (Cecchini & Scott, 2003), or even diagnosis of tropical diseases (Priscilla Elias Ferreira da Silva, 2020).

Nevertheless, this is not to say that ICT development has reached all households. Specifically, some households still do not have access to the Internet because the service is not available in the area, or it does not correspond to households needs, or it is beyond the social acceptance of the household (fear of being exposed to harmful content on the Internet), or the cost of the service and the equipment is too high. The inequality in access to ICT and its usage is persistent, specifically among households with low income or which are located in areas of limited access. The first group of households is economically poor, so financial restrictions can limit ICT use. Additionally, this group of households could also have no access to ICT services (e.g., no telecommunication infrastructure in the area). In other words, the supply of services and the demand of households for ICT create constraints and inequalities among the population of households.

So far, we have identified that ICT adoption helps households in many aspects of the economic and social realm, be it household income or even social networking. There is no doubt that there is still a need for ICT adoption for households in developing countries. Thus, the question remains of what public policies should be implemented to account for the best possible solutions in ICT

adoption, so that the broadly defined well-being of households is achieved. For instance, government policies in reducing the poverty of households that usually refer to cash or near-cash benefits might also need public policy intervention that adopts inclusive technologies available for the disadvantaged or vulnerable households. This is specifically valid for developing countries, but also some instances in the developed world exist. For instance, recent research emphasizes the advantages of ICT adoption for rural households in China and points out the importance of infrastructure for rural areas (Leng et al., 2020). When discussing ICT adoption and its effect on well-being in general and income in particular, it is essential to consider the differences between households living in rural areas and those in urban areas. The issue of poverty reduction for rural households has been on the agenda of many scholars and policymakers (World Bank, 2007; European Commission, 2008; Liu et al., 2019). The impact of ICT on poverty reduction in developing countries has also been well researched (Alimi & Okunade, 2020; Tiwari, 2008, Urquhart et al., 2008), but the conclusions are still debatable in terms of the impact of ICT on household poverty reduction (Torero & von Braun, 2006; The ICT/Poverty Nexus, United Nations). The relevant issue in this research is a reverse causality problem where poverty reduction is necessary for the affordability of information and communication technologies. Thus, the digital divide still exists despite the efforts associated with its reduction.

Public policies should be implemented to account for various types of households when adopting ICTs. Moreover, the empowerment of women with ICT depends also on the policies implemented for various social-cultural types of households. Specifically, women living in refugee or immigrant households could be less prone to ICT adoption than non-immigrant households. Besides the economic importance, immigrant households' empowerment has a crucial role in subjective well-being, as it relates to the complex family relations for both those who immigrated and those who stayed at home. A similar situation where family relations are essential is relevant for elderly households whose needs can be better managed with ICT usage (Khvorostianov, 2016).

Household access to ICTs might also be associated with the other type of household structure, namely the household's internal structure, where a woman might or might not be the household head. This is a specifically important issue with regard to the decision-making process within the household. Even though a recent study of South African households reveals that the gender of the household head does not always determine household access to ICTs, but rather available income (Pashapa & Rivett, 2017), it could be still argued that women's empowerment might be limited due to the partner taking over the task of ICT in households. Therefore, intra-household relationships seem crucial for women's empowerment. More research is needed in this respect, which can borrow from research on family/household relations.

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Notes

1 Model applied: $N_x(t) = \frac{k}{1+e^{-\alpha(t-\beta)}}$ where $Nx(t)$ stands for the value of variable x in time period t. The parameters show the following (Lechman, 2015): κ – upper asymptote determining the limit of growth ($N(t) \rightarrow \kappa$); α – growth rate determining the rate of diffusion; β specifies the time (T_m) when the logistic pattern reaches 0.5κ. To facilitate interpretation of these parameters we replace α with a "specific duration" defined as $\Delta t = \frac{\ln(81)}{\alpha}$ approximating time needed for x to grow from 10%k to 90%k.

2 Country classification according to United Nations standard: UN M49 used by the United Nations for statistical purposes, see: http://unstats.un.org/unsd/methods/m49/m49regin.htm. Taiwan is not listed separately in the UN M49 but included in China.

3 For earlier periods, ICT data by region are not available.

4 Share of female population ages 15+; according to modeled ILO estimate.

5 "Feminization U hypothesis" or "U-shaped relationship" between female labor-force participation and economic development (expressed by GDP per capita) suggests that moving from an agriculture-based economy to an industrial- and services-based economy implies falling rates of female labor-force participation. However, further structural changes, including, inter alia, progress in education and healthcare, determine falls in fertility rates, which drives an increase in female engagement in the labor market (some examples of work include Bloom et al, 2009; Rees and Riezman, 2012; Verick, 2018).

6 As women's economic empowerment is a broad and complex phenomenon, various approaches to its measurement have been proposed. Some examples may be traced in, for instance, the work of Buvinic et al. (2013) who claim that women empowerment is associated with ownership and control over assets, Bandiera et al. (2013) who argue that they perceive women's empowerment through changes in household task allocation between women and men, while, for instance, Valdivia (2015) states that women's economic empowerment is associated with life satisfaction and the general development of social capital. Fox and Romero (2017) suggest that formulating composed indices may help to understand the complexity and multidimensionality of women's economic empowerment, while some aspects associated with women's economic mobility, the difference in wages between women and men, women's role in labor markets, savings behaviors, or even reproductive health behaviors and attitude or women belonging to public organizations, may approximate the state of women's economic empowerment. Ferrant and Thim (2019) claim that women's economic empowerment may be perceived through the lens of women's engagement in unpaid care work. Next, in Richardson's (2018) complex study we find extensive discussion dealing with a variety of concepts and approaches to women's empowerment.

7 The number indicates the difference (in absolute terms) in ICT access (individuals using the Internet) between women and men. The negative value indicates that men have better access to ICT than women.

References

Abramowitz, M. (1986). Catching up, forging ahead, and falling behind. *Journal of Economic History*, *46*(2), 385–406.

Adam, I. O. (2020). ICT development, E-government development and economic development. Does institutional quality matter? *Information Technologies and International Development*, *16*, 19.

Aguilar, D., Agüero, A., & Barrantes, R. (2020). Network effects in mobile telecommunications markets: A comparative analysis of consumers' preferences in five Latin American countries. *Telecommunications Policy*, *44*(5), 101972.

Ali, M. A., Alam, K., Taylor, B., & Rafiq, S. (2020). Does ICT maturity catalyse economic development? Evidence from a panel data estimation approach in OECD countries. *Economic Analysis and Policy*, https://doi.org/10.1016/j.eap.2020.09.003.

Alimi, A. S., & Okunade, S. O. (2020). Financial inclusion, ICT diffusion and poverty reduction: Evidence from Sub-Sahara African countries. *Asian Journal of Economics and Business*, *1*(2), 139–152.

Alsop, R., & Heinsohn, N. (2005). *Measuring Empowerment in Practice: Structuring Analysis and Framing Indicators*. Policy Research Working Paper; No. 3510. World Bank, Washington, DC. https://openknowledge.worldbank.org/handle/10986/8856 License: CC BY 3.0 IGO.

Asadullah, M. N., Savoia, A., & Sen, K. (2020). Will South Asia achieve the sustainable development goals by 2030? Learning from the MDGs experience. *Social Indicators Research*, *150*(1), 1–25.

Asongu, S. A., & Odhiambo, N. M. (2020). Inequality and gender inclusion: Minimum ICT policy thresholds for promoting female employment in Sub-Saharan Africa. *Telecommunications Policy*, *44*(4), 101900.

Autor, D. H., Levy, F., & Murnane, R. J. (2003). The skill content of recent technological change: An empirical exploration. *The Quarterly Journal of Economics*, *118*(4), 1279–1333.

Beniger, J. (2009). *The Control Revolution: Technological and Economic Origins of the Information Society*. Cambridge: Harvard University Press.

Bilan, Y., Mishchuk, H., Samoliuk, N., & Grishnova, O. (2019). ICT and economic growth: Links and possibilities of engaging. *Intellectual Economics*, *13*(1), 93–104.

Blecker, R. A., & Seguino, S. (2002). Macroeconomic effects of reducing gender wage inequality in an export-oriented, semi-industrialized economy. *Review of Development Economics*, *6*(1), 103–119.

Bloom, D. E., Canning, D., Fink, G., & Finlay, J. E. (2009). Fertility, female labor force participation, and the demographic dividend. *Journal of Economic Growth*, *14*(2), 79–101.

Bucher-Koenen, T., Farbmacher, H., Guber, R., & Vikström, J. (2020). Double trouble: The burden of child-rearing and working on maternal mortality. *Demography*, *57*, 1–18.

Buckland, M. K. (1991). Information as thing. *Journal of the American Society for Information Science*, *42*(5), 351–360.

Buvinic, M., Furst-Nichols, R., & Pryor, E. C. (2013). *A Roadmap for Promoting Women's Economic Empowerment*. United Nations Foundation and ExxonMobil Foundation. http://www.womeneconroadmap.org/sites/default/files/WEE_Roadmap_Report_Final.pdf.

Castells, M. (2000). Toward a sociology of the network society. *Contemporary Sociology*, *29*(5), 693–699.

Castells, M. (2011). *The Rise of the Network Society*, Vol. 12. United Kingdom: John Wiley & Sons.

Cecchini, S., & Scott, C. (2003). Can information and communications technology applications contribute to poverty reduction? Lessons from rural India. *Information Technology for Development*, *10*(2), 73–84.

Çetin, F., Urich, T., Paliszkiewicz, J., Mądra-Sawicka, M., & Nord, J. H. (2020). ICTs, empowerment, and success: Women's perceptions across eight countries. *Journal of Computer Information Systems*, *61*, 1–10.

Cheng, C. Y., Chien, M. S., & Lee, C. C. (2020). ICT diffusion, financial development, and economic growth: An international cross-country analysis. *Economic Modelling, 94*, 662–671.

Cramer, J., & Krueger, A. B. (2016). Disruptive change in the taxi business: The case of Uber. *American Economic Review*, *106*(5), 177–182, https://doi.org/10.1257/aer.p20161002.

Da Silva, P. E. F., dos Santos Fonseca Junior, G., Ambrozio, R. B. et al. (2020). Development of a software for mobile devices designed to help with the management of individuals with neglected tropical diseases. *Research on Biomedical Engineering*, https://doi.org/10.1007/s42600-020-00090-8.

Di Porto, E., & Elia, L. (2015). *Estimating Labor Demand Function in the Presence of Undeclared Labour: A Look Behind the Curtain (No. 389)*. Italy: Centre for Studies in Economics and Finance (CSEF), University of Naples.

Dildar, Y. (2015). Patriarchal norms, religion, and female labor supply: Evidence from Turkey. *World Development*, *76*, 40–61.

Dosi, G., Freeman, C., Nelson, R., Silverberg, G., & Soete, L. (1988). *Technical Change and Economic Theory*. Pisa: Laboratory of Economics and Management (LEM), Sant'Anna School of Advanced Studies.

Duflo, E. (2012). Women empowerment and economic development. *Journal of Economic Literature*, *50*(4), 1051–1079.

European Commission (2008). Poverty and social exclusion in rural areas. *European Commission Directorate-General for Employment, Social Affairs and Equal Opportunities Unit, E2*.

Fagerberg, J. (1994). Technology and international differences in growth rates. *Journal of Economic Literature*, *32*(3), 1147–1175.

Fagerberg, J. (1995). Convergence or divergence? The impact of technology on "why growth rates differ". *Journal of Evolutionary Economics*, *5*(3), 269–284.

Fagerberg, J., Verspagen, B., & von Tunzelmann, G. N. (1994). *The Dynamics of Technology, Trade and Growth*. United Kingdom: Edward Elgar Publishing.

Falk, M., & Biagi, F. (2017). Relative demand for highly skilled workers and use of different ICT technologies. *Applied Economics*, *49*(9), 903–914.

Ferrant, G., & Thim, A. (2019). *Measuring Women's Economic Empowerment: Time Use Data and Gender Inequality*. OECD Development Policy Papers, No. 16. OECD Publishing, Paris, https://doi.org/10.1787/02e538fc-en.

Fox, L., & Romero, C. (2017). *In the Mind, the Household, or the Market? : Concepts and Measurement of Women's Economic Empowerment*. Policy Research Working Paper No. 8079. World Bank, Washington, DC. https://openknowledge.worldbank.org/handle/10986/26951 License: CC BY 3.0 IGO.

Freeman, C., & Soete, L. (1990). Information technology, and the global economy. In: Berleur J., et al. (Eds.), *The Information Society: Evolving Landscapes* (pp. 278–294). New York: Springer.

ITU (2020). World Telecommunication/ICT Indicators Database 2020 (24th Edition/December 2020), ITU, Geneve

Gilbert, R. J. (2020). *Innovation Matters: Competition Policy for the High-Technology Economy*. Cambridge: MIT Press.

Graham, M. (Ed.). (2019). *Digital Economies at Global Margins*. Cambridge: MIT Press.

Graham, M., & Dutton, W. H. (Eds.) (2019). *Society and the Internet: How Networks of Information and Communication Are Changing Our Lives*. Oxford: Oxford University Press.

Hanafizadeh, P., Khosravi, B., & Badie, K. (2019). Global discourse on ICT and the shaping of ICT policy in developing countries. *Telecommunications Policy*, *43*(4), 324–338.

Hasbi, M., & Dubus, A. (2020). Determinants of mobile broadband use in developing economies: Evidence from Sub-Saharan Africa. *Telecommunications Policy*, *44*(5), 101944.

Hoernig, S., & Monteiro, F. (2020). Zero-rating and network effects. *Economics Letters*, *186*, 108813.

Hübler, M., & Hartje, R. (2016). Are smartphones smart for economic development? *Economics Letters*, *141*, 130–133, https://doi.org/10.1016/j.econlet.2016.02.001.

International Telecommunication Union (2019). *Measuring Digital Development: Facts and Figures 2019*, ITU, Geneve, Switzerland

Irvine, W., & Anderson, A. R. (2008). ICT (information communication technology), peripherality and smaller hospitality business in Scotland. *International Journal of Entrepreneurial Behaviour & Research*, *14*(4), 200–218.

Jensen, R. (2012). Do labor market opportunities affect young women's work and family decisions? Experimental evidence from India. *The Quarterly Journal of Economics*, *127*(2), 753–792.

Johansson, B., Karlsson, C., & Westin, L. (Eds.). (2012). *Patterns of a Network Economy*. Cham: Springer Science & Business Media.

Joyce, P. J., Finnveden, G., Håkansson, C., & Wood, R. (2019). A multi-impact analysis of changing ICT consumption patterns for Sweden and the EU: Indirect rebound effects and evidence of decoupling. *Journal of Cleaner Production*, *211*, 1154–1161.

Kabeer, N. (1999). Resources, agency, achievements: Reflections on the measurement of women's empowerment. *Development and Change*, *30*(3), 435–464.

Kato, H. (2020). Does a relationship between fertility and labor participation of women really exist? Perspectives from time series analysis. *International Journal of Economic Policy Studies*, *14*(1), 3–23.

Katz, M. L., & Shapiro, C. (1985). Network externalities, competition, and compatibility. *The American Economic Review*, *75*(3), 424–440.

Katz, M. L., & Shapiro, C. (1986). Technology adoption in the presence of network externalities. *Journal of Political Economy*, *94*(4), 822–841.

Kaur, H., Lechman, E., & Marszk, A. (Eds.) (2017). *Catalyzing Development through ICT Adoption: The Developing World Experience*. Cham: Springer.

Khoja-Moolji, S. (2018). *Forging the Ideal Educated Girl: The Production of Desirable Subjects in Muslim South Asia* (p. 218). Oakland: University of California Press.

Khvorostianov, N. (2016). "Thanks to the Internet, We Remain a Family": ICT domestication by elderly immigrants and their families in Israel. *Journal of Family Communication*, *16*(4), 355–368, https://doi.org/10.1080/15267431.2016.1211131.

Kim, D. (2018). Consumer welfare of informative messages via mobile instant messenger: A case of KakaoTalk's info-talk. *Telematics and Informatics*, *35*(6), 1643–1655, https ://doi.org/10.1016/j.tele.2018.04.010.

Klasen, S. (2002). Low schooling for girls, slower growth for all? Cross-country evidence on the effect of gender inequality in education on economic development. *The World Bank Economic Review*, *16*(3), 345–373.

Klasen, S. (2019). What explains uneven female labor force participation levels and trends in developing countries? *The World Bank Research Observer*, *34*(2), 161–197.

Klasen, S., & Lamanna, F. (2009). The impact of gender inequality in education and employment on economic growth: New evidence for a panel of countries. *Feminist Economics*, *15*(3), 91–132.

Kozma, R. B., & Vota, W. S. (2014). ICT in developing countries: Policies, implementation, and impact. In:Spector, J.M. et al. (Eds.), *Handbook of Research on Educational Communications and Technology* (pp. 885–894). New York: Springer.

Lechman, E. (2015). *ICT Diffusion in Developing Countries: Towards a New Concept of Technological Takeoff*. Cham: Springer.

Leng, C., Ma, W., Tang, J., & Zhu, Zhongkun (2020). ICT adoption and income diversification among rural households in China. *Applied Economics*, *52*(33), 3614–3628, https://doi.org/10.1080/00036846.2020.1715338.

Liu, M., Feng, X., Wang, S., & Qiu, H. (2019). China's poverty alleviation over the last 40 years: Successes and challenges. *Australian Journal of Agricultural and Resource Economics*, *64*(1), 209–228, https://doi.org/10.1111/1467-8489.12353.

Livingstone, S. (2012). Critical reflections on the benefits of ICT in education. *Oxford Review of Education*, *38*(1), 9–24.

Loh, Y. A. C., & Chib, A. (2019). Tackling social inequality in development: Beyond access to appropriation of ICTs for employability. *Information Technology for Development*, *25*(3), 532–551.

Lyon, D. (2013). *The Information Society: Issues and Illusions*. Cambridge: John Wiley & Sons.

Maneejuk, P., & Yamaka, W. (2020). An analysis of the impacts of telecommunications technology and innovation on economic growth. *Telecommunications Policy*, *44*(10), 102038.

Martin, W. J. (2017). *The Global Information Society*. New York: Taylor & Francis.

Mbuyisa, B., & Leonard, A. (2017). The role of ICT use in SMEs towards poverty reduction: A systematic literature review. *Journal of International Development*, *29*(2), 159–197, https://doi.org/10.1002/jid.3258.

McNamara, K. S. (2003). Information and communication technologies, poverty and development: Learning from experience. *A Background Paper for the infoDev Annual Symposium December 9–10, 2003 Geneva, Switzerland*, http://documents1.worldbank.org/curated/en/741291468779079516/pdf/300760PAPER0ICT0Learning0from0Experience.pdf.

Monga, C., Lin, J. Y., Aker, J. C., & Blumenstock, J. E. (2014). The economic impacts of new technologies in Africa. In: *The Oxford Handbook of Africa and Economics, (November)* (pp. 1–15), https://doi.org/10.1093/oxfordhb/9780199687107.013.021.

Mossberger, K., Tolbert, C. J., & McNeal, R. S. (2007). *Digital Citizenship: The Internet, Society, and Participation*. Cambridge: MIT Press.

Nair, M., Pradhan, R. P., & Arvin, M. B. (2020). Endogenous dynamics between R&D, ICT and economic growth: Empirical evidence from the OECD countries. *Technology in Society*, *62*, 101315.

Narayan-Parker, D. (Ed.). (2005). *Measuring Empowerment: Cross-Disciplinary Perspectives*. Washington: World Bank Publications.

OECD (2011). *Women's Economic Empowerment*. Issues paper Paris: OECD-DAC Network on Gender Equality. http://www.oecd.org/social/gender-development/47561694.pdf.

OECD (2018). *Bridging the Digital Gender Divide: Include, Upskill, Innovate*. http://www.oecd.org/internet/bridging-the-digital-gender-divide.pdf.

Pashapa,T., & Rivett, U. (2017). Gender of household head and the digital divide in South Africa's settlements. *Gender, Technology and Development*, *21*(3), 232–249, https://doi.org/10.1080/09718524.2018.1434994.

Patria, H., & Erumban, A. (2020). Impact of ICT adoption on inequality: Evidence from Indonesian provinces. *The Journal of Indonesia Sustainable Development Planning*, *1*(2), 125–139.

Paul, P. (2019). Effects of education and poverty on the prevalence of girl child marriage in India: A district–level analysis. *Children and Youth Services Review*, *100*, 16–21.

Pellegrina, L. D., Frazzoni, S., Rotondi, Z., & Vezzulli, A. (2017). Does ICT adoption improve access to credit for small enterprises? *Small Business Economics*, *48*(3), 657–679, https://doi.org/10.1007/s11187-016-9794-x.

Petrongolo, B., & Ronchi, M. (2020). Gender gaps and the structure of local labor markets. *Labour Economics*, *64*, 101819.

Rees, R., & Riezman, R. (2012). Globalization, gender, and growth. *Review of Income and Wealth*, *58*(1), 107–117.

Richardson, R. A. (2018). Measuring women's empowerment: A critical review of current practices and recommendations for researchers. *Social Indicators Research*, *137*(2), 539–557.

Rodríguez-Crespo, E., & Martínez-Zarzoso, I. (2019). The effect of ICT on trade: Does product complexity matter? *Telematics and Informatics*, *41*, 182–196.

Seguino, S. (2000). Gender inequality and economic growth: A cross-country analysis. *World Development*, *28*(7), 1211–1230.

Sen, A. (1985). Well-being, agency and freedom: The Dewey lectures 1984. *The Journal of Philosophy*, *82*(4), 169–221.

Sen, A. (1999). *Development as Freedom*. New York: Oxford University Press.

Shapiro, C., Carl, S., & Varian, H. R. (1998). *Information Rules: A Strategic Guide to the Network Economy*. Cambridge, MA: Harvard Business Press.

Stiroh, K. J. (2002). Are ICT spillovers driving the new economy? *Review of Income and Wealth*, *48*(1), 33–57.

Tam, H. (2011). U-shaped female labor participation with economic development: Some panel data evidence. *Economics Letters*, *110*(2), 140–142.

Tchamyou, V. S., Erreygers, G., & Cassimon, D. (2019). Inequality, ICT and financial access in Africa. *Technological Forecasting and Social Change*, *139*, 169–184.

Tiwari, M. (2008). ICTs and poverty reduction: User perspective study of rural Madhya Pradesh, India. *The European Journal of Development Research*, *20*(3), 448–461, https://doi.org/10.1080/09578810802245600.

Torero, M., & von Braun, J. (2006). Impacts of ICT on low-Income rural households. In: Torero & Braun (Eds.), *Information and Communication Technologies for Development and Poverty Reduction* (pp. 234–311), Baltimore: John Hopkins University Press.

Törnqvist, A., & Schmitz, C. (2009). *Women's Economic Empowerment: Scope for Sida's Engagement*. Sida Working Paper December 30, 2009, Stockholm.

Ucal, M., & Günay, S. (2019). Female employment status: A survey analysis of selected member states of the Arab League. *Eurasian Economic Review*, *9*(3), 373–394.

Ullrich, H. E. (2019). Discussion and conclusion – reflections on the impact of education in South Asia: From Sri Lanka to Nepal. In: Urllich (Ed.), *The Impact of Education in South Asia* (pp. 287–297). Cham: Palgrave Macmillan.

UNDP (2008). *Innovative Approaches to Promoting Women's Economic Empowerment*. New York: UNDP. https://digitallibrary.un.org/record/641439.

Urquhart, C., Liyanage, S., & Kah, M. M. (2008). ICTs and poverty reduction: A social capital and knowledge perspective. *Journal of Information Technology*, *23*(3), 203–213, https://doi.org/10.1057/palgrave.jit.2000121.

Valdivia, M. (2015). Business training plus for female entrepreneurship? Short and medium-term experimental evidence from Peru. *Journal of Development Economics*, *113*, 33–51.

Van Dijk, J. (2020). *The Network Society*. London: SAGE Publications Limited.

Venkatesh, V., Sykes, T. A., & Zhang, X. (2020). ICT for development in Rural India: A longitudinal study of women's health outcomes. *MIS Quarterly*, *44*(2, 605–629).

Verick, S. (2018). Female labor force participation and development. *IZA World of Labor*, *2018*, 87, https://doi.org/10.15185/izawol.87.v2.

Vu, K., Hanafizadeh, P., & Bohlin, E. (2020). ICT as a driver of economic growth: A survey of the literature and directions for future research. *Telecommunications Policy*, *44*(2), 101922.

World Bank (2007). Rural households and their pathways out of poverty. *World Development Report 2008: Agriculture for Development*, 72–93, https://doi.org/10.1596/978-0-8213-6807-7_ch3

Yakita, A. (2018). Female labor supply, fertility rebounds, and economic development. *Review of Development Economics*, *22*(4), 1667–1681.

Appendix

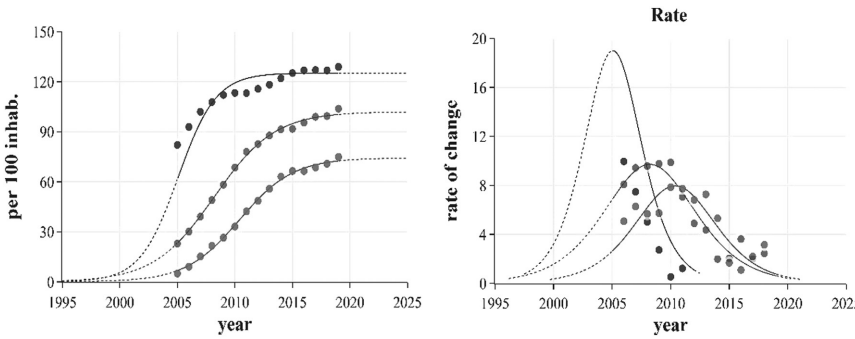

Figure A Mobile cellular telephony diffusion trajectories By region. Period 2005–2019. Source: authors' elaboration. Note3-parameter logistic growth model applied.

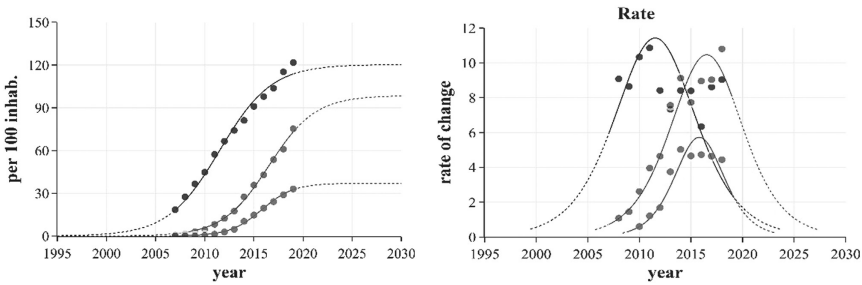

Figure B By region. Period 2007–2019. Source: authors' elaboration. Note 3-parameter logistic growth model applied.

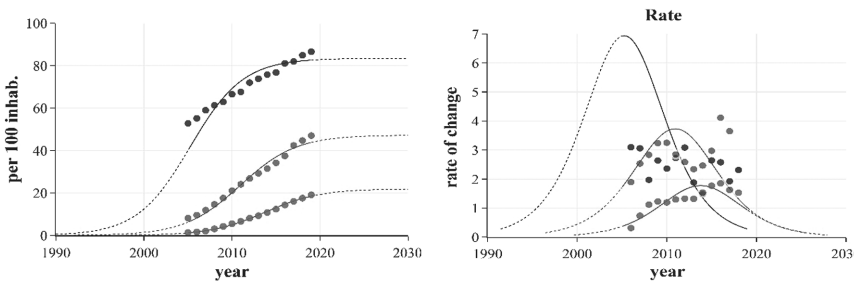

Figure C Internet users diffusion trajectories. By region. Period 2005–2019. Source: authors' elaboration. Note: 3-parameter logistic growth model applied.

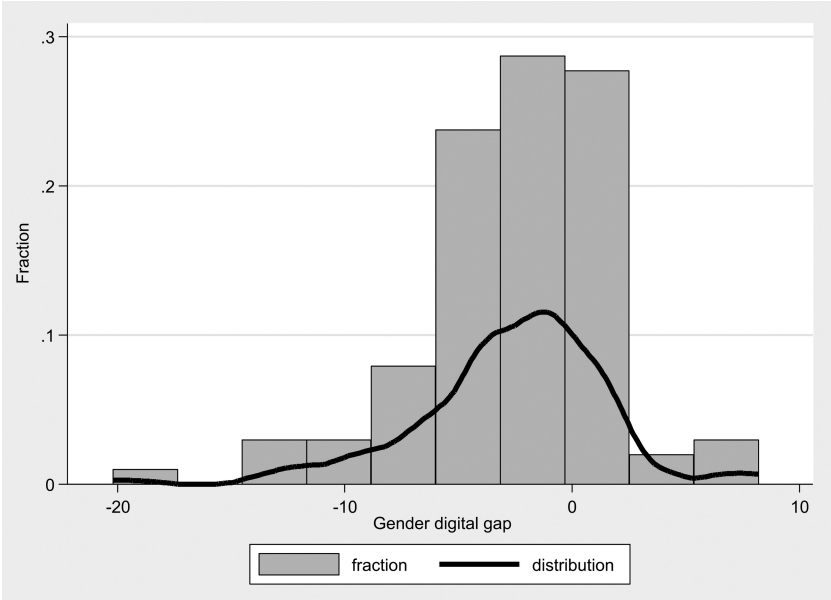

Figure D Digital gender divide. 110 world countries. Year: 2018. Source: authors' elaboration based on data extracted from ITU database 2019.