



Spatiotemporal investigation of the digital divide, the case study of Iranian Provinces

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Abstract

Many communities and territories in developing countries experience significant gaps in access to and use of information and communication technology (ICT), which is viewed as a major impediment to socioeconomic and health-related vulnerabilities. Geographic considerations, on the other hand, as well as variations in motivation for ICT usage and technology adoption within and across nations, as well as between cultures, have exacerbated the digital divide. This paper investigates disparities in access to and utilization of ICT in 31 Iranian provinces from 2011 to 2020. The research discovers evidence that family income and the number of R&D centers affected the formation of the digital divide, albeit the degree of the split has fluctuated through time and space. This study discovered that digital inequality is associated with social exclusion throughout Iranian regions, and it went on to try to better understand the underlying issues and potential solutions. In this regard, some policy avenues are suggested for government action, particularly for marginalized socioeconomic groups, such as the provision of infrastructure, training and skill augmentation, and the easing of digital services supplied by the government or private sector.

Keywords Digital access · Digital divide · ICT development Index · Spatiotemporal analysis · Spatial inequality

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1 Introduction

The world is rapidly approaching the information era, and ICT are the primary drivers of this historical shift, in recent years, digital technologies have become the main driver of improvements in the internal processes, communication, products and services, and the business model (Van Veldhoven & Vanthienen, 2021). During this historical transition, digital inequalities have emerged as a growing concern in developing societies (Pradhan et al., 2018). These inequalities relate to disparities in access, actual use and use efficacy of digital resources. (Vassilakopoulou & Hustad, 2021) This is known as the “digital divide,” and its origins may be traced back to economic, social, and other factors. (Longoria et al., 2022).

The early research on the digital divide mostly examined people’ access to information (Heponiemi et al., 2020) and were confined to discriminating between having and not having access to ICT. Although this knowledge was useful for recalling social and technical inequities, it was a reductive and imperfect categorization. This resulted in the second level of analysis based on the types of use (Ferreira et al., 2021), which, according to the EU’s most recent definition, takes into account not only the population with access to the Internet and other digital technologies, but also groups without digital access that are lagging and missing out on opportunities (European Commission, 2010). We are now discussing the third level of digital divide analysis, which focuses on the positive outcomes of Internet use (Ferreira et al., 2021) and establishes that inequalities exist when, despite access to frequent and widespread use of ICT, this does not result in beneficial socioeconomic outcomes (Aleksejeva et al., 2021).

According to the EU’s most recent definition, the digital divide not only covers the population’s access to the Internet and other digital technologies, but also reflects worries about their usage of commercial and government services, and emphasizes groups without digital access that are lagging and missing opportunities (European Commission, 2010).

The digital divide analysis focuses on the positive consequences of Internet use and demonstrates that disparities develop when, despite repeated and extensive access to ICT, it does not result in positive socioeconomic outcomes (Aleksejeva et al., 2021).

In recent years, Iran has made strides in telecommunications development. Telecommunications, Iran Semi-Private Telecommunication Company, MTN (Mobile Telecommunication Company), and IRANCELL are among the operators that have introduced 3G and 4G services and LTE facilities to improve the ICT infrastructure (ITU, 2017).

The purpose of this research is to provide a spatial–temporal analysis of the digital divide for Iran’s provinces. This includes determining the major commutators of digital divide based on uneven social, economic, and educational factors. By examining whether the disparity in development indicators will result in ICT disparities across various regions of Iran from 2011 to 2020, this research adds to the body of knowledge through answering the following questions:

- What is the regional and provincial ICT development trend in Iran?
- Is there a connection between geographical inequality and the digital divide?
- What are the key reasons contributing to the digital gap between Iranian provinces?
- Does the influence of these factors differ throughout Iran?

The paper structure is as follows. A review of theoretical framework on digital divide based on IDI (The ICT Development Index) and spatial inequity and its multiple causes of digital divide is presented, then the relationship of IDI with variety of social, economic and physical variables is analyzed. Finally, some policy implications for government intervention and directions for future research are provided.

2 Theoretical framework

2.1 Background

The phrase “digital divide” was used to describe the discrepancy in Internet access between rural and urban parts of the USA at the time (Longoria et al., 2022). This issue gradually spread to other nations. The disparity in access to or utilization of ICT devices, as measured by the number of telephone lines per person, Internet users, or mobile phone users, deepens the gap between emerging and developing nations, particularly when new aspects of technology arise (Adam et al., 2021). In this regard, cases of lack of access to online resources for minorities, the elderly, low-income people, people with low levels of education, and people with disabilities have been identified.

The digital divide can also refer to social differences in Internet access, educational opportunities, and, as a result, disparities in online information access. Because early research concentrated largely on the Internet and the deployment of new technologies, the entire capability of persons to access the Internet is at the forefront of its relevance’s (Pérez-Castro et al., 2021). The purpose of this technique was to investigate the distribution of disparity in Internet access, which may be analyzed using the number of computers, cell phones, Internet service providers, and Internet users (Graves et al., 2021).

The ITU’s Digital Inequality Index considers issues such as Internet users per 100 people, computers per 100 people, mobile phone subscribers per 100 people, per capita Internet bandwidth, and broadband Internet subscribers (ITU, 2017) whereas some research suggested that social factors such as education, income, gender, and ethnicity, as well as geographical proximity, have influenced the digital divide in urban areas (Haefner & Sternberg, 2020).

2.2 Spatial inequality and the digital divide

Spatial inequality is concerned with the distribution of attainments such as income, health, education, poverty, and human development; its predominance is a severe hindrance to a region’s socioeconomic and political concord (Niranjan, 2020). It is likely that access to the Internet improve service quality for located and distant from the central areas. As a result, geographical restrictions are no longer an issue. Some argue that the Internet is altering the social environment and overcoming the (Sallar Salam Murad, 2022).

Unequal access to telecommunications infrastructure and services is one of the digital divide problems, and addressing it should be the goal of all stakeholders in developing countries.

As a result, the digital divide measurement based on Internet connection has been bridged, bandwidth and digital device concerns have expanded, and high-bandwidth is regarded as a boost to economic growth and social development (European Commission,

2010). In rural and less economically developed areas, ICT infrastructure is scarce, and associated activities are dependent on the access to infrastructure and the quality of the Internet connections (Freeman et al., 2016). Early ICT specialists saw the Internet as a facilitator of economic (Martins & Veiga, 2022) and social progress, and one of the key reasons for this forward-thinking philosophy was the Internet's perceived role as a geographical unifier (Khatiwada, 2010). The fact that the Internet exacerbates spatial inequality complicates efforts to bridge the digital divide (Ferreira et al., 2021).

The extent to which technology users may access digital space is influenced by existing geographical arrangements of resource allocation (Soltani et al., 2021). The regional agglomerations or, at the micro-spatial level, the spatial-economic status of each place is a driver of ICT access and (Reynolds et al., 2021). On the other hand, the specific areas with a large population of socially disadvantaged individuals are normally associated with higher digital divide, implying that policies must be space-based as well target the spatial distribution of minorities (Lucendo-Monedero et al., 2019).

2.3 Causes of digital divide

Several elements, including supply and demand for communication activities, as well as institutional restrictions, can be effective in the occurrence of the impact of institutional factors on technology adoption (Sanga & Aziakpono, 2022).

The adoption and usage of ICT is influenced by demographic characteristics (Nishida et al., 2014). In recent years, ICT have been a top priority in the development of the working, e-commerce, and e-recreation. As a result, there is a link between population indices qualities such as income ethnicity (Davis et al., 2020), age cohort (Niehaves and Plattfaut, 2010) and home ownership with the access to ICT (Song et al., 2019). (Azhdari et al., 2018). A range of factors, including urban–rural divisions, impact technology utilization. There is evidence of decreasing access to ICT in provinces with insufficient infrastructure. As a result of this, rural infrastructure, particularly in hilly regions, has limited access to ICT. In contrast, ICT has risen rapidly in metropolitan areas, particularly in urban core districts (Fong, 2009).

Education is critical in using technology, since university education was one of the most important factors of personal computer use in the early twenty-first century (Greve & Tan, 2021). Educating people, especially training them in the skills required for ICT usage, particularly during the Covid-19 outbreak (Natalia, 2022) will improve the readiness of individuals and organizations to adopt and use ICT (Nishida et al., 2014). Education is one of the most essential types of social development since it generates skills and experiences that are very likely to contribute significantly to the usage of ICT. ICT will be connected with higher education level, literacy rates and gross enrollment ratios in various courses (Song et al., 2019). It is expected that people with higher education level benefit from higher level of skills, therefore, have higher capabilities in using ICT facilities (Burtch & Chan, 2019). Human capital inequality exacerbates unequal Internet access. Uneven human capital development, which involves investing in digital skills and capacities via education, training, and lifelong learning, is one of the most important parts of boosting Internet access. These are about behavioral factors (Soltani et al., 2019).

Economic implications on ICT, notably rising income levels, will make ICT more affordable. Income level is one of the most important determinants of Internet penetration (Loo & Ngan, 2012), and per capita income is associated to personal computer ownership (Wei et al., 2011). And consequently, in online activities engagement. Individuals with

greater incomes may afford to pay for ICT expenditures more easily (Nishida et al., 2014; Song et al., 2019). The availability of personal computers and broadband internet (Zhao et al., 2014) is directly related to ICT usage.

Innovation is defined as any technical development in the manufacturing process that improves efficiency by utilizing fewer resources or producing more innovative goods (Castro et al., 2021). While governments in poor countries now encourage innovation, encouraging patent applications can boost both direct and indirect regional economies. The frequency of publishing in scientific and technical journals demonstrates the costs of computer and, in particular, bandwidth Internet usage for research and development (Shin et al., 2021). It is anticipated that higher usage of ICT leads to increased R&D contributions and patent applications (Song et al., 2019). Innovative techniques to utilize digital resources can help to reduce digital divides and expand digital service coverage (Vassilakopoulou & Hustad, 2021).

2.4 Conceptual model

The extent of the development divide between affluent and developing nations can be linked to advancements in ICT that encourage and strengthen socioeconomic growth. Mokyr contends that scientific progress is inextricably linked to economic progress.

The ICT Development Index measures the “degree of ICT advancement.” This index enables comparing different advances in ICT development over time and aims to show the progress of society during the various stages of ICT development and the convergence of technology and innovation of new technologies. IDI is a technical term for a collection of 11 indicators divided into three categories Access, Use, and Skill (ITU, 2017).

Figure 1 and Table 1 illustrate that each of these objects contains some sub-items. The International Telecommunication Union (ITU) used IDI to investigate the global digital divide, comparing IDI scores across nations in its annual report and emphasizing differences between developed and developing countries. The conceptual framework connected to the interaction between geographical inequality and digital divides may be described in the following diagram (Fig. 1).

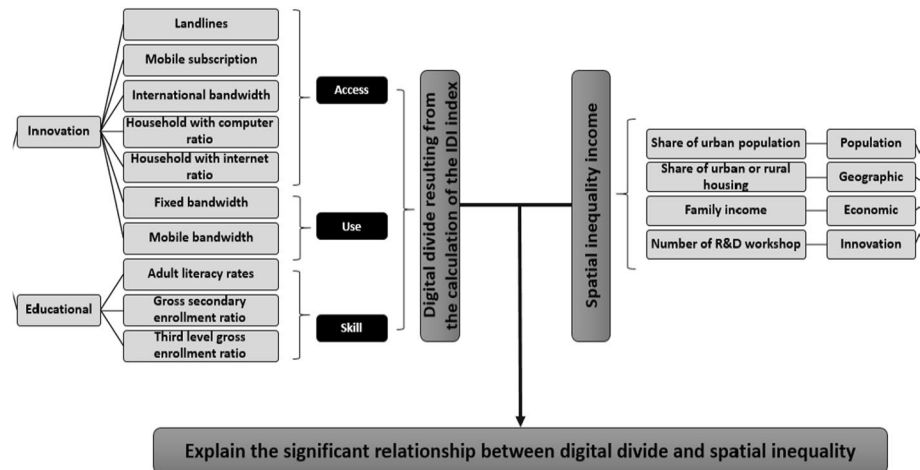


Fig. 1 The conceptual framework

Table 1 Components and its associated socioeconomic indicators

Data classification	Variable	Variable abbreviation	Source
Access	Fixed-telephones	Tlph_Sbt	Radio Regulations and Communications Organization
	Mobile subscriptions	Mobile	
	Ratio of households with computers	Cmptr	Statistics Center of Iran and Communication Technology Organization
	Ratio of households with internet	Intrnt	
Use	Fixed-telephones broadband subscribers	User_Inter	Radio Regulations and Communications Organization
	Mobile bandwidth subscription	Broad_B	
Skill	Adult literacy rate	Literacy	Statistical Center of Iran
	Gross guidance registration ratio	Guidance	
	Gross Tertiary enrollment ratio	Tertiary	
Economic	Family income	Income_Month	Statistical Center of Iran
Population	Urban population	Pop_Urban	
Physical	Share of residential areas	Resd_Area	
Innovation	Share of R&D activities, innovation districts, Startups and Science/Technology parks	R_D_Mnf	Ministry of Cooperatives, Labor and Social Welfare

Years of data collection: 2011, 2013, 2015, 2017, 2020

3 Methods and materials

3.1 Data

In Iran, official entities such as the Statistics Centre of Iran (SCI), the Statistics and Information Group, and the Radio Regulatory Authority of the Ministry of Communications and Information Technology are in responsibility of collecting and disseminating ICT data.

The supplemental data came from a variety of sources, including an open-access platform, a government study, and a consultant report. Data for 31 Iranian provinces are taken from several secondary sources between 2011 and 2020.

3.2 Methods

Various indexes have been used to measure the impact of ICT on socioeconomic development. Those that collect data from many different countries and are used throughout the world are the following: (i) Global Innovation Index (ii) E-government Development Index (EGDI); (iii) Networked Readiness Index (NRI); (iv) Global Competitiveness Index (GCI); (v) Technology Achievement Index (TAI); (vi) Digitalization Index (DI); and (vii) (GII). (Pérez-Castro et al., 2021) But in this article, we discuss about IDI. Because it is integrated index for showing the digital divide. It is a composite index based on variety of components: infrastructure investment, network access, accessibility, capacity, usage, and human capital, all of which mark the path toward a digital society.

Based on these, the ITU develops and publishes the ICT Development Index, which is used to gauge the level of ICT development. The ICT Development Index is a tool that allows governments, operators, development organizations, and researchers to assess and evaluate each country's ICT engagement (Ziamba & Becker, 2019).

The combined indicators include the ICT Development Index, which is based on 11 criteria that identify ICT and are organized into three clusters: access information, usage, and skills (ITU, 2017). The following indicators are included in the index (W_i = Weight for item i and V_i = Variable for item i).

Access indicators (ICT access, $W_1 = 0.4$).

- Fixed-telephone subscriptions per 100 inhabitants ($W_{11} = 0.25$)
- Mobile-cellular subscriptions per 100 inhabitants ($W_{12} = 0.25$)
- Percentage of households with computer ($W_{13} = 0.25$)
- Percentage of households with Internet ($W_{14} = 0.25$)

Use indicators (ICT use, $W_2 = 0.4$).

- Percentage of individuals using the Internet (IU, $W_{21} = 0.5$)
- Fixed-broadband subscriptions per 100 inhabitants (FBB, $W_{22} = 0.5$)

Skills indicators (ICT skills, $W_3 = 0.2$).

- Secondary gross enrollment ratio ($W_{31} = 0.33$)
- Tertiary gross enrollment ratio ($W_{32} = 0.33$)
- Adult literacy rate ($W_{33} = 0.33$)

The values of the subindices were first calculated by normalizing the indices in each subindex as below:

$$z = \frac{x - \text{Min}(x)}{\text{Max}(x) - \text{Min}(x)} \quad (1)$$

To calculate the final index, the sub-branches of access to ICT and the use of ICT each weighted 40%, and a subindex of skills weighted 20%. Then, the final value of the index was calculated by adding the weight of sub-categories.

$$IDI = (W1 * V1) + (W2 * V2) + \dots + (W33 * V33) \quad (2)$$

3.3 Study area

Iran's urban population, which now makes up 75% of the country's population, is growing at an average yearly pace of roughly 3% and is anticipated to do so for the foreseeable future. Tehran, the nation's capital, is the only megacity in the nation. The other eight major cities with populations of one million or more are referred to locally as "metropolitan areas": Mashhad, Isfahan, Shiraz, Karaj, Tabriz, Ahwaz, and (Soltani, 2017a) while attaining sustainability targets has proven particularly difficult in a nation with relatively significant oil reserves, urban transportation has become a big issue in major Iranian cities. Iranian cities see significant levels of traffic congestion, air and noise pollution, and

accidents even though the general rate of automobile ownership is lower than in wealthy countries (Soltani, 2017b). The development of ICT is crucial for minimizing traffic congestion and the negative effects it has on the environment and the economy especially in metropolitan regions.

Thirty-one provinces were studied, and their human development indexes, as well as their abbreviated names, are displayed in the figure below. The Human Development Index is depicted in this graphic as a factor that may indicate various social and economic divisions. Despite efforts by national and local authorities especially in remote and socially disadvantaged areas (Zali et al., 2016; Zali et al., 2014).

The HDI remains low in several Iranian regions, with substantial differences across them (Fig. 2). More information on the socioeconomic characteristics of 31 provinces are provided in Appendix 1.

Following the entrance of MTN, Iran's mobile market expanded. Only 1% of the population had a cellphone subscription when MTN began. By 2016, mobile phone subscribers exceeded the general population, with 93% of homes possessing a phone (94% in urban areas and 88% in rural areas) (ITU, 2017).

4 Analysis and findings

Examining the state of the digital divide as determined by the IDI index shows that in 2011, Tehran (T1) and its bordering provinces had the highest IDI index (Fig. 3). Following 2011, the concentrated distribution of the provinces with the highest amount decreased proportionally and linearly, from north to south of the country, including Khorasan Razavi (K2), Semnan (S1), Mazandaran (M1), Tehran (T1), Isfahan (I1), Yazd (Y1), and Fars (F1).

The pattern of changes in the digital divide based on the IDI index from 2011 to 2020 is as below:

- Provinces with high incremental change during the period 2011–2020: Tehran (T1) (1.83), Khorasan Razavi (K2) (0.69), Isfahan (I1) (0.61)
- Provinces without change or near-zero change: Hormozgan (H1) (0.01), Sistan and Baluchestan (S2) (0.03).
- Provinces with decreasing change during the period 2011 to 2020: Bushehr (B1) (− 0.06) and Kurdistan (k5) (− 0.09).

According to the calculations above, the 31 provinces can be categorized in four clusters based on their ranks in two main attributes: IDI and HDI (Fig. 4).

The linear regression model (Table 2) is used to study the link between changes in the digital divide index and independent factors. Population density, the proportion of R&D workshops, the percentage of urban housing, and monthly income are among the factors impacting changes in the digital divide index from 2011 to 2020, according to the regression research. Second, family income and the proportion of R&D workshops in the provinces are among the factors impacting changes in the digital divide, and they have shown to be successful as important independent variables each year.

ArcGIS is used to do a cluster analysis. Based on a set of weight parameters, Anselin Local Moran's I statistic is used to find hotspots (high cluster auto correlation), cold spots (low cluster auto correlation), and geographical outliers (no cluster correlations). Semnan (S1), Mazandaran (M1), Tehran (T1), Qom (Q2), and Isfahan (I1) are among those that can

Table 2 Summary of models

Model Index	B					t-statistics				
Year	2011	2013	2015	2017	2020	2011	2013	2015	2017	2020
Pop_2020	-1.30E-07	-1.60E-07	-1.15E-07	-9.86E-08	-1.50E-07	-1.368	-1.823	-1.374	-1.412	-1.782
GDP_total2020	0.026	0.041	0.02	0.011	0.023	1.421	1.551	0.942	0.585	0.987
R_D_mnl2020	0.006	0.004	0.002	0.002	0.002	3.22	2.363	2.528	3.527	3.081
Econ_participation2020	0.004	0.008	0.023	0.006	0.004	0.412	0.702	1.537	0.578	0.442
Urb_pop_prop_2020	0.015	0.001	0.002	3.28E-06	7.81E-06	2.761	0.394	0.206	0.014	0.030
Income_2020	7.36E-06	3.88E-06	3.56E-06	3.36E-06	9.50E-07	2.226	1.552	2.115	3.765	1.853
Resd_area	0.001	0.002	0.002	0.002	0.003	1.237	1.821	1.626	1.638	1.765
Constant	1.118	-0.241	-1.163	-0.452	-0.015	2.452	-0.333	-0.973	-0.953	-0.03
R2						0.61	0.88	0.83	0.89	0.82
Anova F						4.41	21.6	19.3	22.2	12.5
Std. Error of the Estimate						0.17	0.2	0.2	0.19	0.25

Bold= Significant at 95% interval.

form a significant cluster based on adjacent features between 2011 and 2020 in order to depict the necessary relationships that emerge from this cluster (Fig. 5). The constant pattern of these provinces in a cluster throughout time demonstrates the influence of technical progress and communication index concentration on neighboring provinces.

Thus, using linear regression analysis, the distance from the center (Tehran (T1) as a province with an index of ICT development and a high index compared to other provinces) and the effect of clusters formed by the digital divide index are examined. According to the data, the distance from Tehran (T1) and the cluster formed by the aforementioned provinces showed no significant link with the IDI score ($R^2 = 0.65$).

In geographically weighted regression (GWR), a local variation of linear regression is utilized to describe numerous spatially related interactions. These correlations' findings from 2013 to 2020 demonstrate that the geographical association between these two variables (the proportion of R&D workshops and monthly income) has developed over this time period until 2020. Correlations have changed with time, so that in 2013, fewer provinces (Semnan, Yazd, and Fars) had a highly significant correlation in line with the link between R&D workshops and monthly income and the IDI index. However, this trend has extended over time, and by 2020, it will have reached additional provinces (Fig. 6).

5 Discussion

This work created a conceptual model that linked access to ICT with geographical inequality, which was subsequently validated using a variety of spatial statistics methods such as OLS and GWR. Among the significant findings are:

Province	Sistan and Baluchistan	Kurdistan	Kohgiluyeh and Boyer-Ahmad	Kurdistan	North Khrosan	East Azarbaijan	Chaharmahal and Bakhtiari	Ilam	Southern Khrosan	Golestan	Kermanshah	Qom	Khuzestan	Gilan	Bouahehr	Mhrosan Razavi	Hamedan	Zanjan	Ardabil	Hormozgan	Western Azerbaijan	Kerman	Fars	Qazvin	Semnan	Mazandaran	Makazi	Ilahan	Alborz	Yazd	Tehran		
	S2	K3	K8	K5	K2	A1	C1	I2	K1	G1	K7	Q2	K4	G2	B1	K2	H2	Z1	A3	H1	A2	K6	F1	Q1	S1	M1	M2	I1	A4	Y1	T1		
2006	0.60	0.64	0.63	0.62	0.65	0.64	0.65	0.64	0.65	0.68	0.64	0.69	0.66	0.70	0.68	0.66	0.68	0.69	0.67	0.66	0.70	0.68	0.69	0.69	0.69	0.69	0.71	0.71	0.71	0.70	0.70	0.73	
2011	0.64	0.67	0.66	0.66	0.66	0.68	0.68	0.68	0.67	0.68	0.70	0.67	0.71	0.69	0.71	0.68	0.70	0.70	0.71	0.70	0.69	0.71	0.70	0.71	0.72	0.72	0.72	0.72	0.73	0.73	0.70	0.73	0.75
2016	0.63	0.65	0.66	0.66	0.67	0.67	0.67	0.68	0.68	0.68	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.70	0.70	0.70	0.70	0.70	0.70	0.72	0.72	0.72	0.72	0.73	0.74	0.74	0.74	0.77	

Fig. 2 Human Development Index of province (Askari Pour Lahiji & Otofah shamsi, 2020)

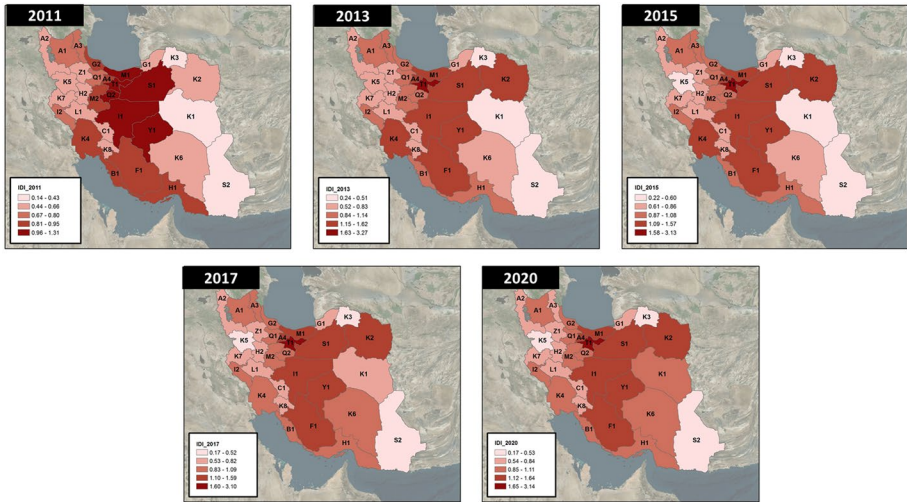


Fig. 3 Temporal changes of IDI

While the overall level of ICT in Iran increased significantly between 2011 and 2020, the level of provincial IDI in Iran has shown sharp differences over time and gradually from the central zone with high IDI index (including Khorasan Razavi (K2), Semnan (S1), Mazandaran (M1), Tehran (T1), Isfahan (I1), Yazd (Y1), and Fars (F1). It descends to the west and east above, in the center of Iran. The eastern half of this zone (especially Sistan and Baluchestan (S2) and South Khorasan (K1)) has more adverse conditions than the western part.

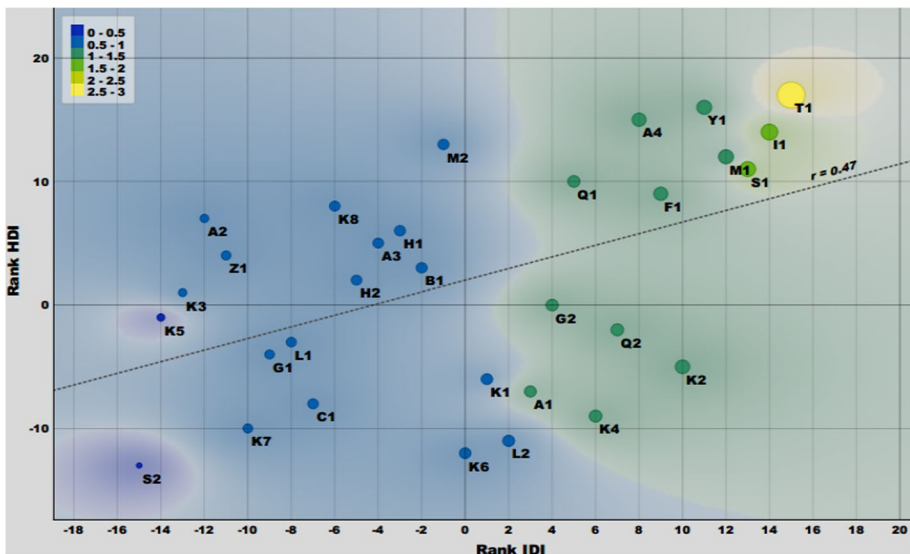


Fig. 4 Relationship between IDI and HDI

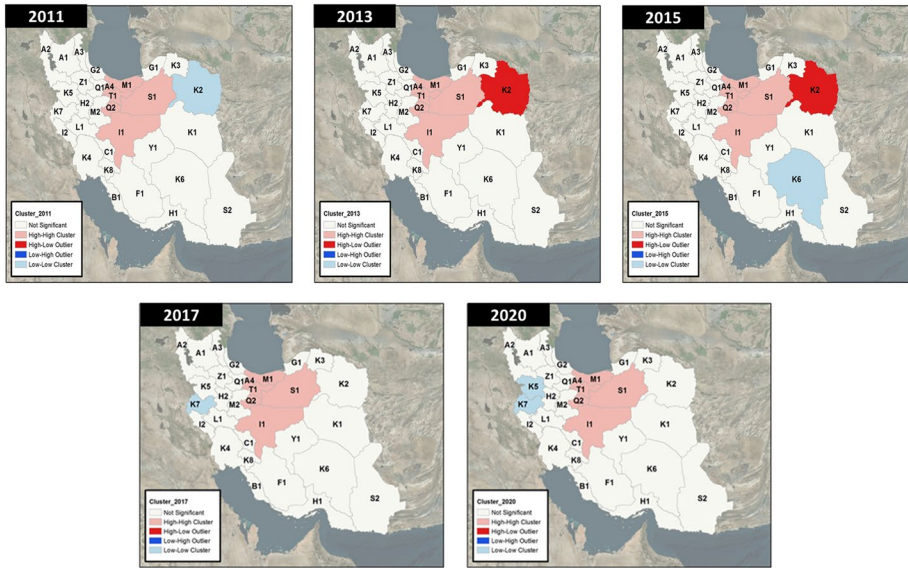


Fig. 5 Temporal changes of Cluster of IDI

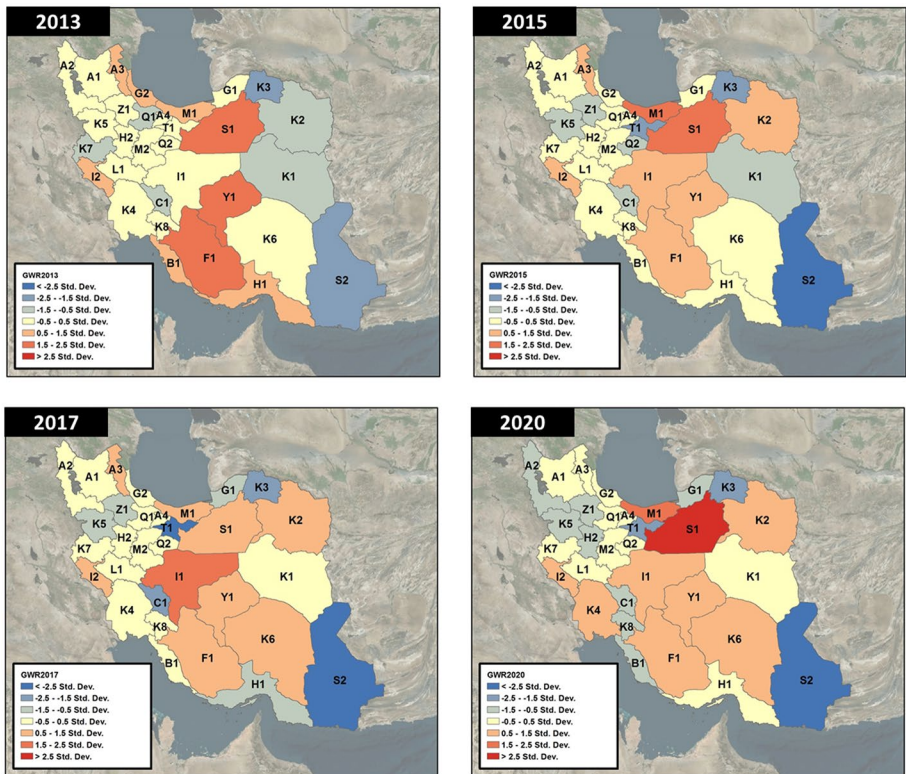


Fig. 6 Temporal changes of geographically weighted regression of IDI index

Between 2011 and 2020, ICT development shifted from the central zone to the western regions, and from the same zone to the eastern regions, despite the fact that they continue to be in worse shape than provinces in the IDI index zone. Provinces with high IDIs, on the other hand, tend to be big provinces with one or more large cities, such as Shiraz, Isfahan, Karaj, Mashhad, and so on; provinces with low IDIs, on the other hand, tend to be in areas with significant levels of poverty in the country's outlying provinces. The IDI score is strongly related to economic levels (monthly income) and technological education, according to linear and geographical regression studies.

The two most important variables related with IDI are increasing the number of research and development workshops and average household income. Infrastructure (supply of ICT goods) and inhabitants' salaries to the point where ICT is regarded one of the life support packages as a permanent expense of living for families (demand for ICT products) can be factors in the province's economy improving.

While various governmental initiatives have been adopted to support ICT growth and narrow the digital gap in the region, the results show that first, socioeconomic, educational, and R&D elements should be strengthened to increase access and usage of information technology in these areas (Guillén & Suárez, 2005). These criteria can be shown in the following zoning model to aid understanding of the interactions between variables in the macro-spatial framework (Fig. 7).

The spatial correlation of IDI index and digital divide can be presented in three distinct zones. Central zone covers the provinces of Khorasan Razavi (K2), Semnan (S1), Mazandaran (M1), Tehran (T1), Isfahan (I1), Yazd (Y1), and Fars (F1). The largest average of the digital divide in eastern zone reflects the existence of income inequalities, the develop of major cities, and the dispersion of research and development workshops as compared to other provinces. Although there are major cities with a pretty excellent distribution of development research workshops in western zone, the family income split and a lack of effective budget allocation in technology (based on population) limit this expansion in these areas.

6 Conclusion

The association between residents' family income and IDI suggests that there is an improvement in the flow of urbanization rates and residents' incomes to boost the beneficial effects of ICT. On the one hand, technical research and development workshops should be promoted in each of the activity and service centers of rural and urban communities, and on the other hand, fundamental ICT training for all age groups should be supplied. Government decision-makers can work with schools to help children from low-income families by giving home computers, therefore reducing the effect of the digital divide among students (Wei et al., 2011). Furthermore, the government may target other vulnerable parts of the population such as the elderly, unemployed, pension recipients, and socially disadvantaged groups (Vassilakopoulou & Hustad, 2021). This study found that the digital gap is more visible in those with lower education levels; so, supporting policies should involve training and upgrading IT skills among the target groups. Training older adults in particular can increase their abilities and opportunities for utilizing digital devices and taking use of their advantages (Klier et al., 2020). Of course, disparities in physical and knowledge

levels across different sectors of society, as well as geographical groupings of communities, must be recognized. E-governance services supplied by the government or commercial sector must also be changed to make them more accessible to persons with limited digital capabilities. It is projected that the availability of more collaborative services and the ease of use of digital services would result in increased adoption by a wider proportion of the population.

As noted previously, data availability is one of the limitations in digital divide research, therefore, future research can be based on additional disaggregated data, especially if the effort intends to analyses the phenomena using comparable methodological techniques (e.g., OLS and GWR) used in this study. While utilizing country-level data is useful for comparing nations or regions, specific online activities are not documented in such data, making the comparison skewed (Zhao et al., 2014). Furthermore, identifying digital inequality across various demographic segments within nations is difficult (Vassilopoulos & Hustad, 2021). Another avenue for future study may be policy analysis research on the effect of public policies in expanding or decreasing the digital gap, especially given the COVID-19 pandemic's greater reliance on ICTs in many societies, including Iran. It is also advised that differences in the IDI index at the urban and rural levels be investigated and the mechanisms impacting

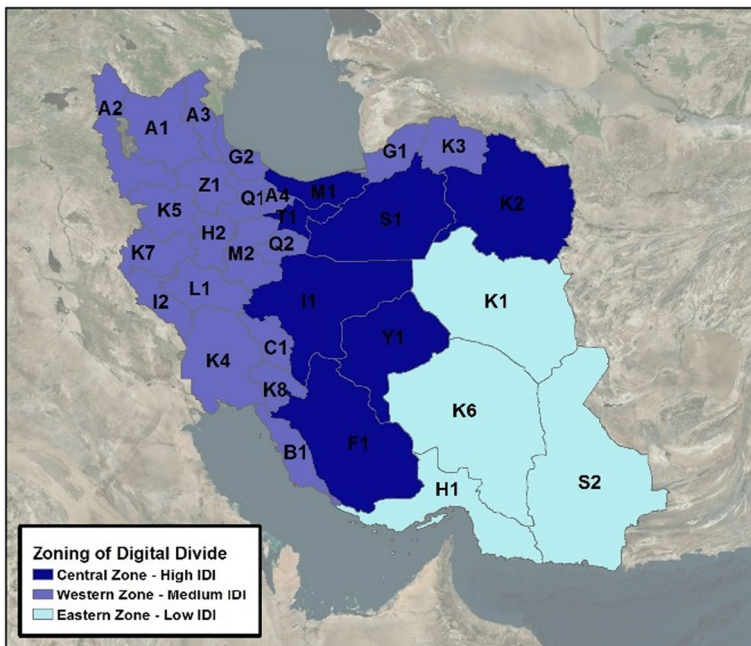


Fig. 7 Graphic of spatial distribution of IDI index

them be identified. In this way, analyzing locational factors can be integrated with some examination of motivational gaps for ICT use and technology adoption between and within provinces (regions) (Ashraf et al., 2014). Such a research will have extra benefit due to very different social, cultural and economic context of Iranian provinces.

Appendix 1. Socioeconomic profile of Iranian provinces

Province		Area share (%)	Population share (%)	Urban population (%)	Economic participation rate	Average family income (1000Rials)	GDP (%)
Sistan and Baluchestan	S2	11.2	3.5	48.5	31.1	43636	1.4
Kurdistan	K5	1.8	2.0	70.8	41.9	66203	1.0
Kohgiluyeh and Boyerahmad	K8	1.0	0.9	55.7	38.6	66476	2.0
Lorestan	L1	1.7	2.2	64.5	35.0	54999	1.2
North Khorasan	K3	1.7	1.1	56.1	42.4	52623	0.6
East Azarbaijan	A1	2.8	4.9	71.9	41.0	64094	3.5
Chaharmahal and Bakhtiari	C1	1.0	1.2	64.1	39.4	79683	0.7
Ilam	I2	1.2	0.7	68.1	36.1	46488	1.0
Southern Khorasan	K1	9.3	1.0	59.0	38.0	44022	0.5
Golestan	G1	1.3	2.3	53.3	38.2	47331	1.3
Kermanshah	K7	1.5	2.4	75.2	38.9	60636	1.6
Qom	Q2	0.7	1.6	95.2	35.8	48803	1.1
Khuzestan	K4	3.9	5.9	75.5	38.5	70363	12.9
Guilan	G2	0.9	3.2	63.3	40.8	56331	2.3
Boushehr	B1	1.4	1.5	71.9	37.0	57589	5.8
Khorasan Razavi	K2	7.3	8.1	73.1	42.1	70011	5.3
Hamedan	H2	1.2	2.2	63.1	38.6	55987	1.3
Zanjan	Z1	1.3	1.3	67.3	40.8	52504	1.0
Ardabil	A3	1.1	1.6	68.2	43.8	69407	1.0
Hormozgan	H1	4.3	2.2	54.7	38.8	55262	2.0
Western Azerbaijan	A2	2.3	4.1	65.4	40.5	64979	2.1
Kerman	K6	11.1	4.0	58.7	37.6	29673	2.9
Fars	F1	7.5	6.1	70.1	39.4	59072	4.8
Qazvin	Q1	1.0	1.6	74.8	39.3	60683	1.7
Semnan	S1	6.0	0.9	79.8	38.9	48183	1.0
Mazandaran	M1	1.5	4.1	57.8	41.0	73741	3.5
Markazi	M2	1.8	1.8	76.9	35.6	58870	1.9
Isfahan	I1	6.6	6.4	88.0	40.4	53542	5.6
Alborz	A4	0.3	3.4	92.6	37.8	55913	2.8
Yazd	Y1	4.5	1.4	85.3	40.8	56379	1.8
Tehran	T1	0.8	16.6	93.9	40.2	43296	23.2

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