Type of paper: Original scientific paper
Received: 23.12 2021.
Accepted: 29.12.2021.
DOI: https://doi.org/10.18485/edtech.2021.1.1.3
UDC: 004.7(497.11)

The development of a dimensional model for the analysis of information and communications technology use in Serbia

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Abstract: Modern information and communications technology (ICT) affects not only the digital transformation of business, but that of society in general. The impact of ICT on economic development has been recognised by the European Union through its Digital Decade strategy that highlights the development of a digital society by 2030, while the European Commission has launched the Digital Agenda for Europe, aimed at creating a unique digital market. In order to fully use the potential of ICT, the Government of the Republic of Serbia has adopted a series of strategies in the past few years with the end goal of improving employment opportunities and the quality of life. Using the publicly available data provided by the Statistical Office of the Republic of Serbia and the information provided by oecd.stat. at https://stats.oecd.org, this paper focuses on the development of a dimensional model for the analysis of information and communications technology use in Serbia and the comparison with data from EU countries.

Key words: Dimensional model, information and communications technology, multidimensional data analysis, e-business, web, digital society

1. Introduction

In the late 20th and early 21st century, ICT accelerated technological development in all segments of the economy. One struggles to think of a business aspect or field in which ICT has no application. The use of ICT facilitates everyday life and work and makes business more efficient. It is used in medicine, industry, agriculture, transport, public administration, etc.

The development of the Internet – a global computer network – has broadened the possibilities for global computer connections and data exchange, which has initiated the globalisation process. The Internet also enables instant distribution of information to people and organisations [11]. The overall evolution of the Internet and ICT has contributed to the development of new business models and the digital economy in general.

The impact of ICT on economic development has been recognised by the European Union through its Digital Decade strategy that highlights the development of a digital society by 2030, while the European Commission has launched the Digital Agenda for Europe, aimed at creating a unique digital market. In order to fully use the potential of ICT, the Government of the Republic of Serbia has adopted a series of strategies in the past few years with the end goal of improving employment opportunities and the quality of life (Strategy for the Development of an Information Society in the Republic of Serbia by 2020, Strategy on Development of Electronic Communications in the Republic of Serbia for period 2010-2020, and Digital Skills Strategy (2020-2024).

2. Materials and methods

The topic of this paper is the use of ICT in Serbia and related data comparison with EU countries. The paper aims to illustrate the extent to which ICT is used by analysing different trends and indicators. The paper uses publicly available data of the Statistical Office of the Republic of Serbia, as well as data available at *OECD.Stat*. The following data was taken from the Statistical Office of the Republic of Serbia website: information regarding households that have "a computer, internet connection, and broadband, in relation to the region in Serbia, earnings, and type of settlement in which they live"[1], "individuals – computer and internet use frequency in relation to education level, employment status, gender, age, and use"[1]. The following data was taken from the *OECD.Stat* website: information regarding households that have "internet connection and a computer"[2], and information regarding "individuals who have internet connection in relation to age (16–74)"[2]. The data collected refers to the period 2011–2020. Microsoft Excel and Microsoft Power BI were used to develop and implement the dimensional model.

The first part of the paper describes the development of information technology, specifically Web 1.0, Web 2.0 and Web 3.0. The second part of the paper highlights how information technology changed working methods, business processes and business models. It describes Web 1.0 e-business, Web 2.0 which involves end users in creating services, and Web 3.0 smart technology and smart business. The third part of the paper illustrates the process of collecting and modifying data, the process of creating dimension tables and fact tables, as well as the development of the dimensional model for ICT use in Serbia and data comparison with EU countries.

The final part of the paper includes the conclusion regarding the comparative analysis of Serbia and EU countries, specifically Slovenia, using the same indicators.

3. The development of information technology

The 21st century is an age of radical change in nearly all business areas. Managing a company differs when viewed from the perspective of the Industrial Age and the Information Age. In the Information Age, intellectual resources are more important than material resources, while in the Industrial Age it is the other way round. Given that we live in an age of data, information, wisdom, and knowledge, we can conclude that organisations will be successful only if they invest sufficiently in intellectual resources and manage them accordingly. The value of an organisation used to be determined solely by measurable financial and material resources; today, non-material values and the quality of human resources also contribute to this. The economy has changed over time due to the emergence of the Internet. We refer to today's economy as a 24-hour economy, given that it provides constant communication with business partners, i.e. suppliers, banks, buyers, etc. [7].

The Internet has contributed not only to a different and more diverse economy, but to the creation and development of **electronic business (e-business)**. E-business refers to conducting business transactions electronically, usually over the Internet, and it includes sales, purchases, customer support, and organisation.

Due to the fact that the economy has improved and that the emergence of the Internet has accelerated e-business, which is today one of the best-known types of business, **information technology (IT)** has emerged as a new discipline. IT entails the application of computers for storing, analysing, downloading and transferring data or information, and usually refers to company business operations, given that it was created as a consequence of company requirements. A comprehensive definition defines IT as a set of tools, processes, and equipment used for collecting, processing, and presenting data and information [7].

In addition to the main definition, the term "information technology" can also acquire a broader meaning to include all the activities of IT professionals, which include a wide range of options, from application instalment to information system and computer network design.

The ability to use information technology entails:

- all the necessary skills for the efficient use of these tools;
- proficiency in all tools used in computing;
- identifying situations in which information technology can be used in order to solve a problem.

Modern information technology practically revolves around networking processes due to the rapid development of web technology, which has paved the way for new forms of electronic communication, such as online discussions, email, chat, forums, etc. This has created entirely new and innovative forms of social relations which are more and more used in everyday life [7].

In order for the "network of all networks" to be the way we know it today, scientists in the past had to implement their idea. In the 1960s, a group of American scientists came up with the idea to connect all computers in a way that would allow them to access each other's data any time and from any location. The idea was to connect two computers located at different American universities using a telephone line, i.e. a dial-up connection. This is how the first global computer network was created. When in 1991 Tim Berners-Lee from the CERN institute in Switzerland developed a project conceived as a scientific exchange medium, called World Wide Web (WWW), he could not have imagined that this seemingly small project would become so popular around the world. Initially, the web was based on a one-way display of information, and it was only later that the first Line Mode Browser was designed [10]. In 1993, Marc Andreessen presented the first graphical Web browser, Mosaic, which displayed more than ASCII text and integrated text and graphics. Mosaic was developed at NSCA (National Centre for Supercomputing Applications) at the University of Illinois in the USA.

The first version of Mosaic supported the File Transfer Protocol (FTP) and could display HTML files containing text, different format images, as well as the Postscript video format. This version could access data using Web protocols and provided users with various options, such as font selection or window size. At that time, web pages were immutable and had a simple layout, which made it difficult for creators to update them over specific intervals with new information. Given that HTML was the only web page coding language, pages were designed for functional communication and their role was to display information to the user. Later, modern dial-up models were designed to maximise reading time and accelerate data transmission, i.e. the web applied the client-server model displayed in figure 3 [10].

The model is called client–server because of the interaction between the client and the server in which the client asks the server to perform a service which the server offers. After receiving the request from the client, the server processes it and sends a response. Once the response arrives, the client can continue working [10]. After a while, nearly all users could successfully and efficiently identify how to locate information in different places. Earlier browser versions displayed no content until a page was fully loaded. However, in 1994, the founder of Silicon Graphics, Jim Clark, together with Marc Andreessen, created Mosaic Communications, later named Netscape Communications, which allowed pages to be loaded on-the-fly). This allowed for partial content to be loaded while the page itself was not fully loaded [10].

Netscape Communications provided users with the possibility to read content while loading the page. In addition, it included support for standards such as JavaScript and Cookies. JavaScript is a programming language used for defining web page functionalities on the client's side, while Cookies are small text files received from the server for identification purposes. The innovative Netscape was dominant until Microsoft created Internet Explorer, whose evolution up to version 6.0 enabled it to practically conquer the market [10].

Later, just like the Internet Explorer replaced Netscape, the next big browser, Mozilla Firefox, replaced the Internet Explorer and became one of the leading and most popular browsers on account of its quality [10].

In addition to these, some of which are still very popular today, other browsers were developed, such as Safari for the Macintosh platform, Opera, and later Google Chrome. Today, the state of web clients is such that developers can develop sections of the client part of distributed applications, and use existing functionalities for other parts [10].

4. Information technology use as a prerequisite for the development of the economy and society

Internet development has several stages, all of which can be grouped into the following four phases. The first stage began in 1991 and was mostly dominated by science, i.e. a combination of scientists and engineers who worked on the development of digital transformation. One of the most important features in this period is the IETF (Internet Engineering Task Force), which provided standards for Internet use. In other words, anyone who wanted to use the Internet could do so using the RFC (Request for Comments) document, which described different methods and standards. Also, one of the important elements that marked this stage is NSFNet (Backbone) and thousands of university (campus) networks that enabled scholars to use the Internet [8].

The second developmental phase was the period from 1992 until 1997, when the academic world was already making extensive use of the Internet. In this stage, FNC (Federal Networking Council) allowed new companies known as ISPs (Internet Service Providers) to interconnect. However, the most important feature of this stage and the most significant achievement to this day is the emergence of the World Wide Web. This stage saw the development of browsers, which now allowed apps to be displayed on the entire screen, as well as the development of hardware, which allowed smaller organisations to use computers due to a decrease in price and the significant expansion of the product. Perhaps the biggest achievement of the second stage was the fact that computers were now increasingly used at home, where modems reached a speed of up to 56 kbit/s. In other words, customers moved from a static web content search to being dynamic participants in web content creation [8].

The third stage (1998–2005) is the period in which the Internet finally expanded internationally. The features of this phase were advancement in web technology and app development, significant search engine enhancement, as well as the possibility to interact online using Flash and JavaScript technology. In addition to international expansion, this improvement also enabled users to share data and video services on a single network technology [8].

In the fourth stage, the Internet became a global "network of all networks". This phase, which began in 2006, was characterised by the emergence of the 100-Gbit transmission using Dense Wave Division Multiplexing, the Voice over Internet Protocol which enables telephone communication over the Internet, Internet use via mobile phones and other portable devices, Internet Television Protocol (IPTV), i.e. broadband transmission of digital TV signal through IP structure. Consequently, in the fourth phase, the Internet officially became a global network, while certain features became an integral part of everyday life in almost every household [8].

4.1. Web 1.0 – e-business

The key interest areas are [3,4]:

- protocols, HTTP;
- open, standardised markup languages HTML and XML;
- the first search engines;
- software platforms and web app development tools;
- web programming languages, such as Java and JavaScript;
- website development;
- web commercialisation and development of web business models.

Protocols, HTTP

HTTP (**Hypertext Transfer Protocol**) is a network protocol that is the main and most frequent information transmission method on the web. HTTP is a client–server protocol whereby the client sends requests which the server processes and sends back a response. Its main purpose is to deliver an HTML document, i.e. webpage.

The HTTP server *listens to* requests on a port (usually port 80) in order to provide the required response. Once the server has provided the response, the connection is interrupted until the next request [5,6].

HTML and XML markup languages

HTML (Hypertext Markup Language) is a markup language for defining web pages. Its main features are metadata which are clearly separated from document content. We can use it to divide text units, such as headings, paragraphs, quotes, and also to see the standards that describe a document, i.e. key words, information about the author, etc. XML is short for Extensible Markup Language, whose format can be adjusted to different areas, such as electronic data exchange, data storage, voice mail, and the development of new markup languages [9].

The first search engines

Archie, an FTP archive indexing tool, was considered to be the first search engine, which facilitated file identification. It was created in 1990 when Alan Emtage searched for names of files and titles, without indexing the content. Then he came up with the idea to collect information about the structure of files by accessing public FTPs (File Transfer Protocol). As a result of his work, there was no longer the need to manually browse FTPs; instead, users could type in a file name in Archie and receive a list of all FTPs with the requested file. The next search engine was Google, which was based on analysing the relations between websites. It yielded better results compared to other technologies which ranked results based on how many times the searched item appeared on the page. Google introduced a search based on user traffic. In other words, the more visits a page has, the better it ranks, i.e. Google places it at the top of the search results page. This search engine quickly attracted many users on account of its functionality and design [11].

4.2. Web 2.0 – including end users in service creation

The switch from static HTML web pages to a more dynamic and better organised web came with the second generation of the World Wide Web, Web 2.0, which focused on the ability of people to communicate and cooperate.

Other Web 2.0 functionalities include open communication and more open information exchange. Web 2.0 comprises three development aspects:

- the technological aspect, which provides the basic infrastructure (hardware and software). In addition, it includes service-oriented architecture (SOA), such as RSS feeds, CMS, web servers, and mashups;
- the application aspect, which includes Rich Internet Application (RIA), whose services resemble that of desktop apps and apps used on the Internet. Their main feature is unlimited navigation. In the future, almost all programs will be set as services on the web, thus providing components used in other apps;
- the social aspect, which entails the involvement of users and their contribution on the web. The so-called social web includes social media, tagging, Wikis, podcasting, vodcasting, blogging, etc. [3,4].

Owing to the fact that many internet companies believed they would make much higher profits because of the rapid expansion of websites, the Internet gained even greater importance from 1995 to 2001 which led to a phenomenon called **dot.com bubble**.

The dot.com bubble prompted developers and engineers to enhance web pages and introduce various additional features. Subsequently, a system for targeted advertising called AdWords was set up, which enabled a return to the Internet and the web.

Using entirely new apps, the web itself started to behave like a computer, as services and apps were now also available on the Internet. This is why Web 2.0 is considered to be the new generation of web communities and servers whose single goal is to facilitate cooperation. This allows users to perform most tasks in web clients (browsers) [3,4].

4.3. Web 3.0 – Smart technology and smart business

The third generation of Internet-based services is Web 3.0, designed by John Markoff. Web 3.0 is the Intelligent Web, i.e. a combination of the semantic web, natural language processing, microformats, machine learning, etc. In other words, Web 3.0 entails reading, writing and research on the web.

Web 3.0 is a great advancement that involves turning the web into a database and creating content available from multiple apps using artificial intelligence. In fact, this term refers to different evolutions of usage and interaction on the web [3,4].

5. The development of a dimensional model for analysing ICT use in Serbia

A dimensional model has been developed for the purposes of analysing ICT use in Serbia and comparing data with that from EU countries. Dimension tables and fact tables were created in MS Excel, which were then loaded into the Power BI software. The following sources have provided data for the fact tables:

- https://www.stat.gov.rs/sr-latn/oblasti/upotreba-ikt/;
- https://stats.oecd.org/.

The first website has provided data regarding devices used in households in Serbia in the period 2011–2020, and this information refers to households that have *"a computer, internet connection, and broadband by region, income, type of settlement"*[1]; and *"individuals – computer and internet use frequency by education level, employment status, gender, age, and use"*[1].

The second website has provided data for the EU regarding households that have "*internet connection and a computer"*[2] and "*individuals aged 16–74 who have internet connection"*[2].

The fact table for Serbia contains data collected in relation to indicators, period and territory.

The dimension tables are criteria used for analysis purposes. The following dimension tables have been created using databases for Serbia and EU countries:

- Indicator (*"Household that have a computer, per region"*; *"Household that have Internet connection, by region"*; *"Households that have broadband Internet connection, by region"*; *"Individuals – computer use frequency"*; *"Individuals – Internet use frequency"*; *"Individuals – computer users (in the last 3 months, by age"*; *"Individuals – Internet users (in the last 3 months), by age"*; *"Individuals – computer users (in the last 3 months), by education level"*; *"Individuals – Internet users (in the last 3 months), by education level"*; *"Individuals – computer users (in the last 3 months), by gender"*; *"Individuals – Internet users (in the last 3 months), by gender"*; *"Individuals – computer users (in the last 3 months), by employment status"*; *"Individuals – Internet users (in the last 3 months), by employment status"*; *"Households that have a computer, by income"*; *"Households that have Internet connection, by income"*; *"Households that have a broadband Internet connection, by income"*; *"Individuals – e-commerce, by gender"*; *"Individuals – e-commerce"*; *"Devices used in households"*); [1]
- Territory (REPUBLIC OF SERBIA; regions: Belgrade, Vojvodina, Šumadija and Western Serbia, Southern and Eastern Serbia);
- Years (2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020);
- Indicator – category (up to €300, €300–600, over €600, has never used, in the last 3 months, more than 3 months ago (less than 1 year), more than a year ago, no education and primary education, secondary and higher education, employed, unemployed, student, others, male, female, 16–24, 25–34, 35–44, 45–54, 55–64, 65–74, TV, mobile phone, personal computer (PC), cable TV, laptop);
- Countries in Europe (Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Norway, Poland, Portugal, Slovakia,

Slovenia, Spain, Sweden, Switzerland, Hungary, Turkey, the United Kingdom).

The Indicator and Indicator – category tables are linked, as are the Year and Countries in Europe tables. The next step was to create a fact table. The fact table procedure is as follows:

- Data collected for Serbia. The table is then modified, and a new column is added – *"Territory"*. [1]
- This table contains data for *"Households that have a computer, Internet connection and broadband Internet connection, by region"*.

Subsequently, another fact table was created with new columns: Indicator - category and ID-SDI, which indicates that the dimensional data model is the constellation type model. This means that some dimensions are common to different fact tables.

In order to create the dimensional data model, the abovementioned dimension tables and fact tables were loaded into the Power BI software. The Power BI software is a collection of software services, applications, and connectors that work together to turn unconnected data sources into coherent ones. The data can be Excel spreadsheets or a collection of cloud-based data warehouses. Power BI facilitates visualisation and connection with data sources.

The data were prepared in MS – Excel and then loaded into Power BI. The next step was to create the dimensional model in Power BI. This dimensional model was used to analyse ICT use in Serbia and compare data with EU countries (figure 1).

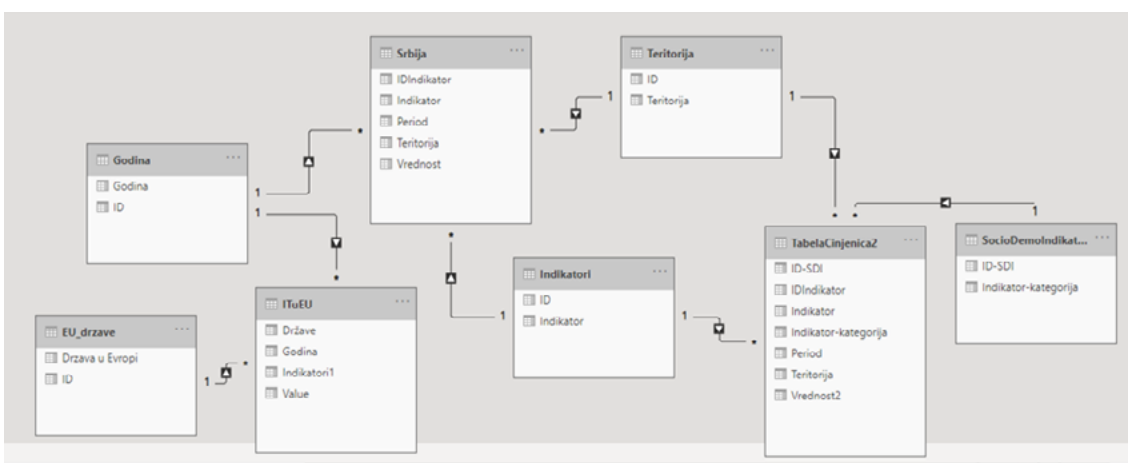

Figure 1. Fact constellation schema [12]

In order to analyse ICT use in Serbia, an analysis was done based on the dimensional model. The analysis refers to the use of computers, the Internet and a broadband Internet connection by households and individuals by region, income, education level, age, employment status, gender and use. The subsequent analysis compared Serbia with EU countries in relation to their indicators.

Figure 2 shows the percentage of households in Serbia that have a computer. In 2011, the percentage was 52.1%, while in 2020 it increased to 74.3%.

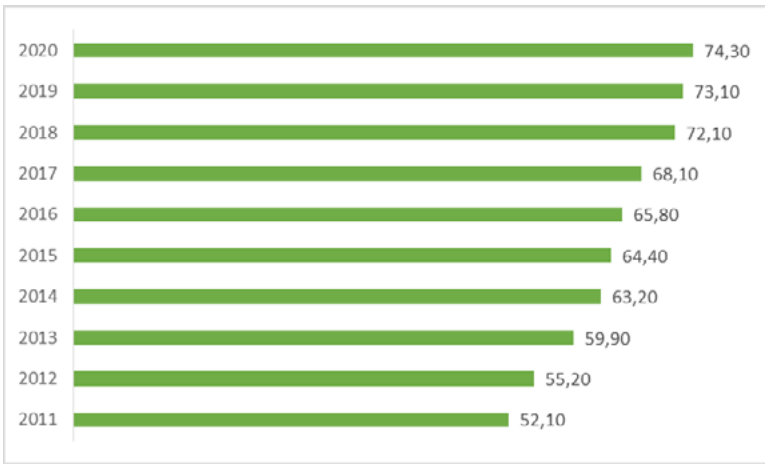

Figure 2. Serbia – households with a computer (%)

A significant increase has also been noted in relation to the number of Internet connections. In 2011, the number of households with an Internet connection was 39%, compared to 81% in 2020 (figure 3).

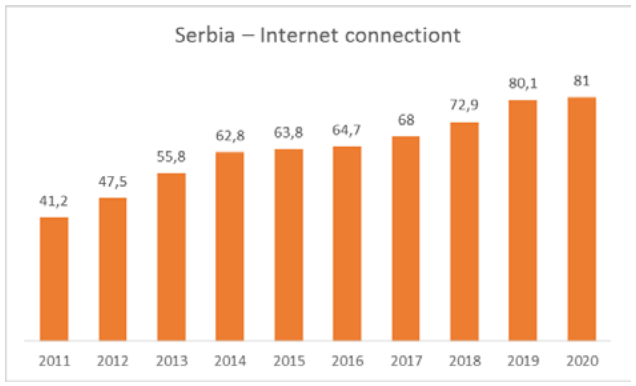

Figure 3. Serbia – Internet connection (%)

For comparison purposes, the following two figures show a trend in ICT use in two consecutive years, 2019 and 2020. The analysis results illustrate the number of households with a computer by income in 2019 and 2020 in Serbia, in percentage given in figure 4.

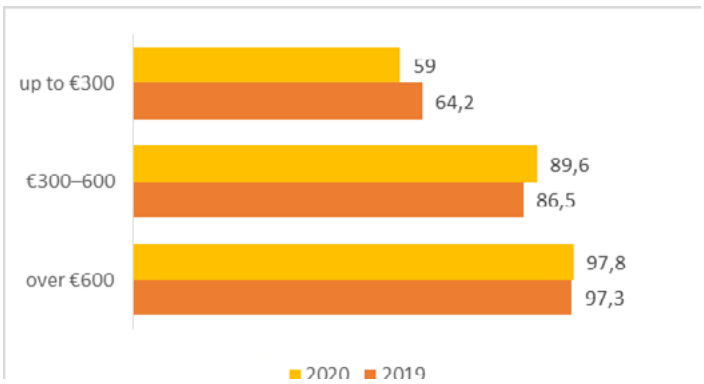

Figure 4. Households with a computer by income

Figure 5 shows analysis results regarding the number of households with an Internet connection by income in 2019 and 2020 in Serbia.

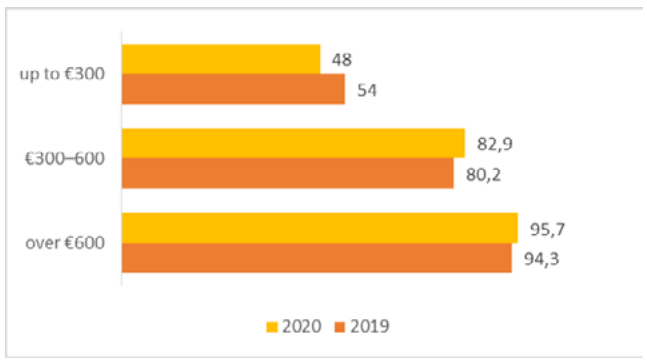

Figure 5. Households with an Internet connection by income

Figure 6 illustrates computer users by education level, with a clear decrease trend.

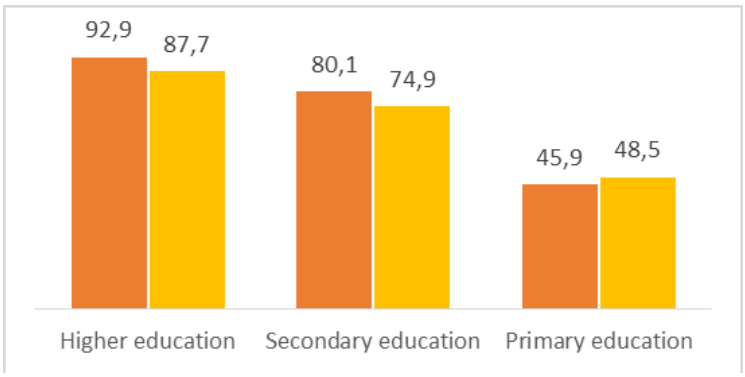

Figure 6. Individual computer and Internet users by education level

The diagram in figure 7 shows households with an Internet connection in EU countries in 2020.

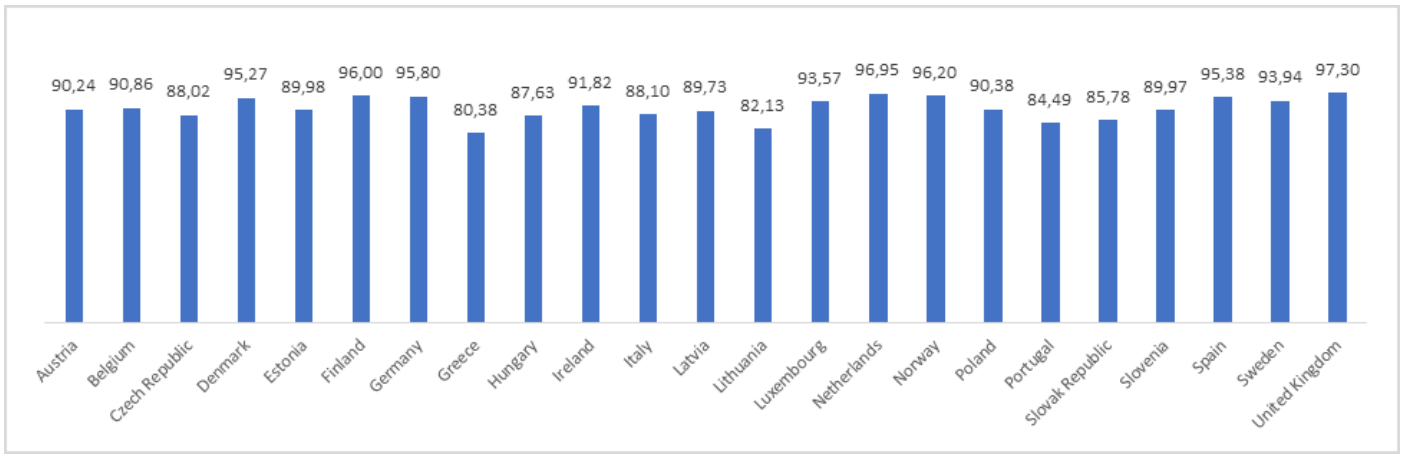

Figure 7. EU countries – households with an Internet connection in 2020

The diagram in the previous figure shows that the percentage of households with an Internet connection in EU countries ranges from 80.38% in Greece to 97.30% in the United Kingdom.

6. Conclusion

This paper presents an analysis of the use of information and communication technology in Serbia, observed from the aspect of households and individuals that have a computer and Internet connection. The analyses indicate a rising trend in ICT use in Serbia, by both households and individuals. In 2011, the percentage of households with a computer was 52.1%, compared to 74.3% in 2020. Also, the percentage of households with an Internet connection was 41.2% in 2011, compared to 81% in 2020.

In addition, the presented analyses show that Serbia is not lagging behind EU countries when it comes to the use of information and communication technology.

References

1. Statistical Office of the Republic of Serbia. [cited 1.9.2021]. Available from: https://www.stat.gov.rs/sr-latn/oblasti/upotreba-ikt/.
2. OECD Statistic. [cited 1.9.2021]. Available from: https://stats.oecd.org/.
3. Siankimsnet. [cited 1.9.2021]. Available from: https://siankimsnet.weebly.com/blog/20022013-web-10-20-30.
4. Infilbnet. [cited 10.9.2021]. Available from: https://ir.inflibnet.ac.in/bitstream/1944/1285/1/54.pdf.
5. Tzfr. [cited 1.9.2021]. Available from: http://www.tfzr.uns.ac.rs/Content/files/0/Microsoft%20PowerPoint%20-%20HTTP.pdf.
6. Web programiranje. [cited 1.9.2021]. Available from: https://www.webprogramiranje.org/mrezni-protokoli-osnove/.
7. Vpsle. [cited 1.9.2021]. Available from: https://vpsle.edu.rs/wp-content/uploads/2018/01/INFORMACIONE-TEHNOLOGIJE.pdf.
8. NAP. [cited 1.9.2021]. Available from: https://www.nap.edu/read/6323/chapter/9.
9. Tutoriali. [cited 1.9.2021]. Available from: http://tutoriali.org/Uvod_u_XML_i_XML_tehnologije.html.
10. Berners-Lee T. Weaving the Web: The original design and ultimate destiny of the World Wide Web by its inventor. San Francisco: Harper; 1999.
11. Pokorni S, Radić G. Informacione i internet tehnologije. Belgrade: ITS Information Technology School; 2018
12. Đorđevski S. The development of a dimensional model for the analysis of information and communications technology use in Serbia, Final thesis. Belgrade: ITS Information Technology School; 2021.