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Decisive Factors for IT Ecosystem Development in Moravica District, Serbia

Marija Blagojević, Miloš Papić, Danijela Milošević and Darko Petrović

University of Kragujevac, Faculty of Technical Sciences Čačak, Serbia

E-mail address: marija.blagojevic@ftn.kg.ac.rs, milos.papic@ftn.kg.ac.rs, danijela.milosevic@ftn.kg.ac.rs, V

Abstract—**The research presents the role of the Information Technology study program, offered at the Faculty of Technical Sciences Čačak, in the development of the IT ecosystem in the Moravica District in Serbia. The data was collected from the companies and their employees, as well as on the percentage of the students and graduates of the mentioned study program in these companies. The correlation between the growth of the number of companies and the development of the study program was measured and the Pearson's coefficient (0.755) was calculated, which points to the existence of a strong relationship between the number of students enrolled in the IT study program and the number of IT companies in the Moravica District. Future work relates to further monitoring of the IT ecosystem and improvement of the study program following the market needs.**

Keywords- curriculum; courses; study program; IT

I. INTRODUCTION

University of Kragujevac (UNIKG) is one of nine state Universities in Serbia – Universities whose founder is the Republic of Serbia. UNIKG consists of twelve Faculties whereby half of them are located in the city of Kragujevac and the other half in Kraljevo, Jagodina, Užice, Vrnjačka Banja and Čačak. The city of Čačak has two faculties – Faculty of Agronomy and Faculty of Technical Sciences (FTS).

Faculty of Technical Sciences in Čačak offers study programs on all three levels (bachelor, master and doctoral studies). Besides academic studies, there is a large variety of study programs of professional studies. With more than 110 teachers and associates, and more than 2100 active students, FTS Čačak represents the largest faculty on UNIKG.

The city of Čačak is the administrative center of the Moravica District which is located in the western part of Central Serbia (Fig. 1). Besides the city of Čačak, Moravica District includes three municipalities: Lučani, Ivanjica and Gornji Milanovac with 190.554 inhabitants in total – 106.453 in Čačak, 17.090 in Lučani, 27.767 in Ivanjica and 39.244 in Gornji Milanovac.

IT companies in the District currently employ around 500 people and there is a pressing need for at least another 100 employees from various IT fields. However, the real demand for IT experts is twice or even triple as high.

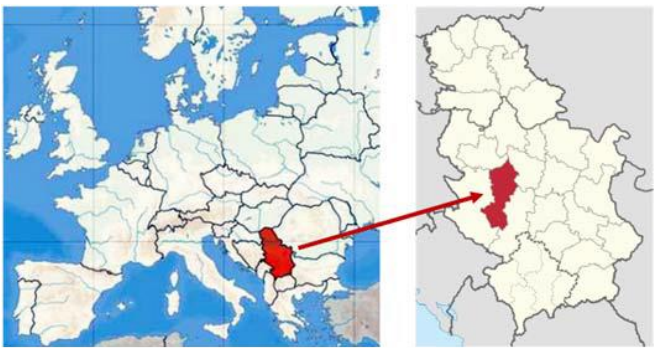

Figure 1. Location of the Moravica District in Serbia

The study program of bachelor academic studies in Information Technologies (IT) at the Faculty of Technical Sciences Čačak, was first accredited in 2009 with an enrollment quota of 40 students. The second accreditation process occurred in 2014 when the number of students to be enrolled was increased to 80. In 2017, the curriculum was further innovated since the Faculty was included in the Action Plan for IT Development of the Government of the Republic of Serbia, implemented by the Council of Ministers for IT.

A new curriculum for 130 students with state-of-the-art courses which were in line with industry needs was developed. In addition to increasing the enrollment quota, both the infrastructural and staff capacities have been strengthened following the guidelines of the Strategy for the Development of the Information Technology Industry for the period from 2017 to 2020 [1] and Information Society and Information Security Development Strategy of the Republic of Serbia for the period 2021-2026 [2]. Acting according to the Action Plan, the experts from IT sector were hired as auxiliary external

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lecturers ie lecturer outside the employment relationship on Faculty. This measure brought considerable improvement of the quality of teaching process. Moreover, the Faculty successfully appeals for the Ministry funds every year and consequently constantly updates and improves individual courses within the new IT study program (through projects of Higher Education Development Ministry of Education, Science and Technological Development). Furthermore, since 2017 the Faculty of Technical Sciences Čačak has been offering the second and the third level of IT studies (master's and PhD studies).

The study program has clearly defined goals which are in accordance with the: (1) recommendations and guidelines of ACM/IEEE curriculum for the field of information technologies (IT), (2) education Strategy in Serbia, as well as (3) the information technology industry development strategy until 2020. The goals of the study program are aimed at acquiring academic knowledge, skills and specific experiences ie competencies in accordance with current world practice. The study program aims to provide graduated students with the necessary skills and knowledge for successfully performing IT jobs, advancement towards leadership positions or further research and scientific work. The Faculty of Technical Sciences in Čačak defined basic tasks and goals within the Quality assurance strategy, with which the goals of the study program are fully harmonized.

In recent years the interest for the mentioned study program has been very high. New generations of students come with better scores from high schools than before. Besides the better input quality aspect, the number of interested students exceeds the enrolment quota every year.

As the number of IT experts is the major limiting factor in the overall development of the IT industry and since the enrolment quota cannot be broadened at the moment, the Faculty organizes non-formal education short cycle courses, thus trying to contribute to bridging the existing gap on the labor market.

The goal of the proposed research is to determine the correlation and role of the IT study program in the IT ecosystem development in the Moravica District. The development of the IT study program implies continuous work on improving the curriculum and subject content, as well as increasing the enrolment quota. On the other hand, the development of the IT ecosystem in the Moravica district implies an increase in the number of IT companies and the number of open positions for IT experts.

II. IT ECOSYSTEMS

The development of a robust and thriving IT ecosystem is of significant importance for various stakeholders, including governments, businesses, and society as a whole.

The development of an IT ecosystem is significant as it drives economic growth, fosters innovation, creates jobs, promotes digital transformation, enhances global competitiveness, and has positive social impacts. It is a critical enabler for countries and regions to thrive in the digital era and leverage the power of technology for the benefit of individuals, businesses, and society as a whole. According to [3] the information economy based on the large-scale use of the Internet and information and communication technologies (ICT) is of great importance for improving the quality of life of citizens. ICT's role in enabling economic growth has become more significant as governments are investing to stem the effects of the global financial crisis [4]. According to [5] information technology is critical towards the development of both manufacturing and service industries. Lin et al. [6] confirmed that the development of information industry is good for the economy. Here are some explanations [7-11,7, respectively] for the mentioned key reasons why the development of an IT ecosystem is significant:

- Economic Growth: The IT industry is a key driver of economic growth in many countries. A well-developed IT ecosystem can contribute to economic growth by generating high-value jobs, attracting investments, promoting innovation, and fostering entrepreneurship. It can also stimulate other sectors of the economy through digital transformation, increased productivity, and improved competitiveness.
- Innovation and Technological Advancement: The IT ecosystem serves as a breeding ground for innovation and technological advancement. It encourages research and development, fosters collaboration among technology stakeholders, and promotes the creation of cutting-edge technologies and solutions. This leads to technological advancements, new products and services, and disruptive innovations that can transform industries and societies.
- Job Creation and Talent Development: A robust IT ecosystem creates a wide range of job opportunities across various roles, from software developers and data scientists to cybersecurity experts and IT consultants. It also promotes talent development through education, training, and skill-building programs, ensuring a skilled workforce capable of driving technological innovation and contributing to economic growth.
- Digital Transformation: The development of an IT ecosystem enables digital transformation across various sectors, including government, healthcare, finance, education, and agriculture, among others. Digital transformation can lead to increased efficiency, improved service delivery, and enhanced user experience, resulting in better outcomes for businesses, individuals, and society as a whole.
- Global Competitiveness: A well-developed IT ecosystem enhances the global competitiveness of a country or region. It attracts foreign investments, promotes international collaborations, and enables businesses to leverage digital technologies for expanding their markets and reaching global customers. It also enables governments to offer advanced e-governance services and participate in the global digital economy.
- Social Impact: The development of an IT ecosystem can have positive social impacts, including increased access to information, improved communication and connectivity, enhanced healthcare and education services, and increased social inclusion. It can also enable solutions to societal challenges, such as

addressing environmental issues, promoting sustainability, and improving governance and transparency.

III. IT ECOSYSTEMS WORLDWIDE

IT ecosystem can vary significantly across different countries depending on factors such as technological infrastructure, government policies, workforce talent, and economic conditions. Here's a brief overview of the IT ecosystems in different countries [12, 12, 13, 14, 15, 16], respectively for every country.

- United States: The United States has one of the most advanced and mature IT ecosystems in the world. It is home to many global technology giants such as Apple, Microsoft, Google, and Amazon. The country has a highly developed technology infrastructure, a large pool of skilled IT professionals, and a vibrant startup culture. The U.S. also has a favorable environment for venture capital investment, which fuels innovation and growth in the IT industry.
- China: China has emerged as a global IT powerhouse in recent years. The country has a massive domestic market, a large pool of tech-savvy consumers, and a strong manufacturing base. China is known for its leading technology companies such as Alibaba, Tencent, and Huawei, and it has a rapidly growing tech startup ecosystem. The government also plays a significant role in shaping the IT ecosystem through policies that promote domestic innovation and restrict foreign competition.
- India: India is known for its strong IT services industry, with many global companies outsourcing their IT operations to Indian service providers. The country has a large pool of skilled IT professionals and a growing startup ecosystem, particularly in areas such as software development, e-commerce, and fintech. India also has a favorable regulatory environment for technology companies, with initiatives such as "Digital India" aimed at driving digital transformation across various sectors.
- Israel: Despite being a small country, Israel has a vibrant and dynamic IT ecosystem. Known as the "Startup Nation," Israel has a high concentration of tech startups, particularly in areas such as cybersecurity, artificial intelligence, and biotechnology. The country has a strong culture of innovation and entrepreneurship, with a supportive government, access to venture capital funding, and a highly skilled workforce.
- Germany: Germany has a robust IT ecosystem, with a focus on industrial technology and engineering. The country is known for its advanced manufacturing capabilities and is a leader in areas such as automotive technology, robotics, and automation. Germany also has a strong research and development culture, with many collaborative initiatives between academia, industry, and government to drive innovation in the IT sector.
- Japan: Japan has a mature IT ecosystem with a focus on electronics, automotive technology, and robotics. The country has a strong manufacturing base and is known for its high-quality consumer electronics products. Japan also has a highly skilled workforce and invests significantly in research and development, particularly in areas such as artificial intelligence, Internet of Things (IoT), and advanced robotics.
- Brazil: Brazil has a growing IT ecosystem, with a focus on areas such as fintech, e-commerce, and mobile applications. The country has a large domestic market and a young population that is increasingly tech-savvy. Brazil also has a growing startup culture, with initiatives by the government and private organizations to support entrepreneurship and innovation in the IT sector.

It's important to note that the IT ecosystem in each country is constantly evolving and can be influenced by various factors. This overview provides a general snapshot of the IT ecosystems in different countries, but the landscape may change over time due to technological advancements, economic conditions, regulatory changes, and other factors.

There are several statistical analyses and metrics that are commonly used to evaluate and understand the IT ecosystem of a country or region. Some of the well-known statistical analyses related to the IT ecosystem include:

- Gross Domestic Product (GDP) contribution: This metric measures the contribution of the IT industry to the overall GDP of a country. It provides an indication of the economic significance of the IT sector and its impact on the country's economy.
- Employment and Workforce: This metric measures the number of people employed in the IT industry and related sectors, as well as the skills and qualifications of the IT workforce. It provides insights into the availability of talent and the size of the IT job market in a country.
- Research and Development (R&D) expenditure: This metric measures the amount of investment in research and development activities related to IT, including funding for technological innovation, product development, and academic research. It provides insights into the level of investment in IT-related R&D and the potential for technological advancement in a country.
- Venture capital investment: This metric measures the amount of venture capital funding invested in IT startups and emerging technology companies. It provides insights into the level of investor confidence, innovation potential, and growth prospects of the IT ecosystem.
- Number of startups and innovation hubs: This metric measures the number of technology startups and innovation hubs in a country or region. It provides insights into the vibrancy of the startup ecosystem, the level of entrepreneurial activity, and the potential for disruptive innovation.
- Digital infrastructure and connectivity: This metric measures the quality and availability of digital infrastructure, including internet penetration, broadband connectivity, and mobile network coverage.

It provides insights into the level of digital connectivity and technological readiness of a country or region.

- International rankings and indices: There are various international rankings and indices that assess the competitiveness, innovation, and development of IT ecosystems, such as the Global Innovation Index (GII), World Economic Forum's Global Competitiveness Index (GCI), and the ICT Development Index (IDI) by the International Telecommunication Union (ITU). These rankings provide comparative assessments of IT ecosystems across different countries or regions.

These statistical analyses and metrics can provide valuable insights into the state of the IT ecosystem in a country or region, helping policymakers, investors, and stakeholders understand the strengths, weaknesses, and opportunities for growth in the IT industry. It's important to use these analyses in conjunction with other qualitative and contextual information to obtain a comprehensive understanding of the IT ecosystem in a particular country or region.

IV. IT ECOSYSTEM IN ČAČAK

Collaboration between the community and faculties is very important, especially for the faculties in the field of engineering. Professors and students should be closely connected with the community, and partnerships between the faculty members and the community are established in various ways [18].

The authors in [19] proposed collaboration between the faculty and the community through various students' projects to solve specific needs of the community. IT education and education in general can be viewed as a way of preparing the students (future workforce) to engage in the selection of their future careers from an ethical standpoint in order to become "good citizens" beneficial for the society [20]. According to [21], "engineering students must be prepared to function as professionals in increasingly diverse societies". Batool and Liu [22] anticipated quantifying the impact of socio-economic indicators and underlying situations on students' enrollment in higher education in Pakistan. Numan et al. [23] analysed students' enrollment pattern in different programs of BOU using linear regression.

When it comes to cooperation between science and economy in the Moravica district, but also in Šumadija and Western Serbia if we look at the broader picture, Faculty of technical sciences in Čačak has a large support and excellent partnership in Science Technology Park (STP). STP Čačak is one of only four Science technology parks in Serbia. His founders are besides the Government of the Republic of Serbia and the City of Čačak, both faculties in Čačak, the Fruit Research Institute and two large business associations (Gradac 97 and Unija Čačak 2000) as well.

STP Čačak is an influential factor in local and regional economic development that provides conditions for the development of entrepreneurship, application of innovations and cooperation between science and business in the area of western Serbia. STP Čačak enables the cooperation of the economy, science and research, the development of new ideas and the application of innovative solutions in order to increase the competitiveness of the regional economy, create high-tech jobs and improve the quality of life. It provides infrastructural, professional and technical support to startup and technology development companies, as well as startup teams. STP Čačak is an organization that quickly adapts to changes. It encourages flexibility, continuous learning, entrepreneurship and motivates with a positive atmosphere.

As part of the local economic development of the district in support of business ideas, STP Čačak provides [24]:

- Connecting to institutions and organizations, access to financial resources;
- Support for the development of startup ideas/teams through Startup Center;
- Support for economic entities through equipped infrastructure capacities and high-technological equipment (STP Lab);
- Support within the mentoring program for economic entities, technological companies, young startups (lectures, trainings, courses) and mentoring for startup teams and frilensers (consulting and educational content);
- Virtual incubation (promotion and set of services in the field of management and marketing particularly intended for newly established and startup companies);
- Infrastructural support to different groups of users (public sectors, science, researchers, economy, innovators, startup teams).

Although modern paradigm of cooperation between technical faculties and community is such that the largest emphasis is placed on cooperation with the economy, directly or through various projects, professors must not forget about their first and most important role – teaching. Under this role, not only the teaching of students is considered, but also engaging in providing aid for teachers in primary and secondary education. In this regard, professors should follow the changes in the education system and react to them through creating various forms of training for primary and secondary education teachers since innovated materials in the field of IT are continuously incorporated in learning programs.

Čačak has a Center for professional development of teachers (CPD) which belongs to the network of twelve state centers of such kind. CPD Čačak is the place where FTS professors are involved in trainings and other forms of informal lifelong learning. These teacher trainings are accredited by the Institute for the Improvement of Education and Training ie its Center for professional development of employees in education.

The Institute was established by the Government of the Republic of Serbia in order to monitor, ensure and improve the quality and development of the education and training system in preschool, primary and secondary education and upbringing, as well as other work in accordance with the law. The Institute participates in the preparation of regulations in the field of education and training under the jurisdiction of the Ministry of Education and Science, the National Education Council, the Council for Vocational Education and Adult

Education. In its composition, the Institute has eight organizational units and one of the is the mentioned Center for professional development of employees in education.

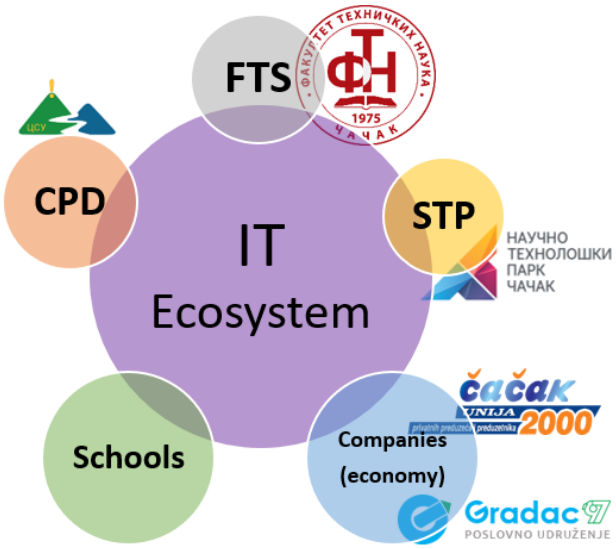

Figure 2. IT ecosystem in Moravica district

The FTS in Čačak has a long tradition of both informal and formal teacher education and training. Graduates on integrated academic studies in technics and informatics may teach in primary and secondary schools (courses: informatics and computing, technics and technology, computing and informatics, etc.). There are 38 primary and 14 high schools in Moravica district whereas the majority of them are located in Čačak. Educational profiles in high schools which are related to IT have the enrollment quota of 320 students:

- Mechanical technician for computer engineering – 30 students in 2 schools
- Technician for computer control (CNC) machines – 30 students in 2 schools
- Mechatronics technician – 30 students in 2 schools
- Students with special abilities for computing and informatics – 20 students
- Technician for digital graphics and internet design – 30 students
- Electrical technician of information technologies – 60 students
- Electrical technician of computers – 30 students

The teaching materials in the field of programming in primary schools in Serbia, started like electoral modules within the election subject but soon became the teaching topic within the compulsory subject that takes half of the annual classes. The present topic is more complex for students than other topics in the subject Informatics and computing but it is incomparably more significant from the point of view of future employment in the IT sector, which is constantly developing and in which employee standard is generally higher than other areas [25].

Changes in the status of the subject of informatics and computing in primary schools occurred from the school year 2017/2018, while the application of the new Rulebook on the program of teaching and learning for the fifth grade started from the school year 2018/2019 [26]. The same regulations envisages a change in teaching and learning programs for the sixth grade, with it to take effect from the school year 2019/2020. Successively, regulations for the seventh and eighth grade were published [27, 28] and been applied in school years 2020/2021 and 2021/2022, respectively. These regulations envisaged that the subject of informatics and computing is performed in the scope of 36 classes in the fifth, sixth and seventh grade, and 34 hours in the eighth grade. Contents and outcomes of teaching and learning programs from the eight grade are studied in the second year of high school, where teachers have more than a double number of classes for the realization of materials (74) in comparison to primary schools [29]. Rulebook related to the eighth grade informatics and computing was already in mid-2021 (one year after the adoption of the basic version), supplemented with contets related to artificial inteligence and inovated with some contents in the field of programing [28: Educational Gazette 5/21].

Based on the above, it can be realized how the field of IT is dynamic and subject to changes or improvements and how important the role of the faculties is to help teachers in primary and secondary schools, and consequently provide oneself better input in terms of better trained students to enroll in the near future.

V. METHODOLOGY

Based on the subject of the paper, the following hypothesis was defined:

H: *There is a statistically significant correlation between the development of the Information Technology study program and the development of the IT ecosystem in the Moravica district.*

In order to prove or reject the hypothesis, research methodology, consisting of four phases, was defined, as shown in Figure 3.

Figure 3. Structure of the research

Data Collection: General data on individual IT companies in the Moravica District were collected through official business portals [30, 31]. Then, specific data on the employees, company activities, etc. were collected through direct contact with the representatives of the given companies.

Data preprocessing: In the second phase, the data were transformed into the appropriate format and prepared for further analysis. Namely, the data were recorded in different periods, in different formats, and the analysis required all data to be recorded uniformly.

Data analysis: In order to determine the correlation, Pearson correlation technique was used in the research. Pearson correlation, also known as Pearson's correlation coefficient or simply "r," is a statistical measure that quantifies the strength and direction of the linear relationship between

two variables. It is named after Karl Pearson, who introduced it in the late 19th century.

Pearson correlation coefficient is calculated using the following formula:

$$r = (\Sigma((X_i - \bar{X})(Y_i - \bar{Y}))) / (n * s_x * s_\gamma) \quad (1)$$

Where:
X_i and Y_i are the individual values of the two variables being compared,
$\bar{X}$ and $\bar{Y}$ are the means of the X and Y values (number of students and number of IT companies), respectively.
n is the number of data points. Data points are formed annually.
s_x and s_γ are the standard deviations of the X and Y values, respectively.

The Pearson correlation coefficient can have a value between -1 and 1, where:

- 1 indicates a perfect positive linear relationship, where as one variable increases, the other also increases in a linear fashion.
- -1 indicates a perfect negative linear relationship, where as one variable increases, the other decreases in a linear fashion.
- 0 indicates no linear relationship, implying that the variables are not correlated.

A Pearson correlation coefficient close to 1 or -1 indicates a strong linear relationship, while a value close to 0 indicates a weak or no linear relationship. The sign of the Pearson correlation coefficient indicates the direction of the relationship, with positive values indicating a positive linear relationship and negative values indicating a negative linear relationship.

Pearson correlation is commonly used in statistics, data analysis, and machine learning to assess the strength and direction of relationships between variables, and it is widely used in fields such as social sciences, finance, and economics for studying patterns and making predictions. However, it is important to note that Pearson correlation only measures linear relationships and may not capture other types of relationships, such as nonlinear or curvilinear relationships, or causation between variables.

VI. Results and Discussion

After collection and preprocessing, the data were analyzed and the most important results are the following:

- 75% of the employees in the IT companies in the Moravica district are former (or current) students of the Faculty of Technical Sciences Čačak
- Over 90% of the companies declared that they want to achieve business and technical cooperation with the Faculty
- Over 90% of the companies plan to expand their capacities in terms of human resources

Data visualization: Figure 4 presents the share of different IT business areas that the companies from the IT community in the Moravica district are engaged into.

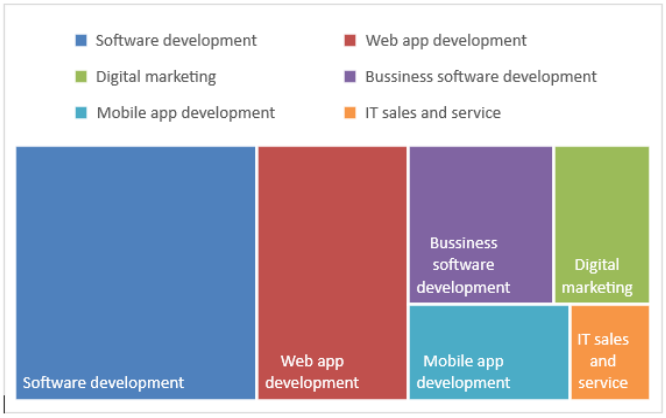

Figure 4. IT business areas of the IT companies in the Moravica district

The most dominant areas are *software development* and *web app development*, but the areas of *business software development* and *mobile app development* are also prominently displayed in the figure above. The areas that are not directly related to development, such as *digital marketing* and *IT sales and services*, are represented to a lesser extent. If we were to analyze the curriculum of the IT study program, we would come to the conclusion that knowledge and skills necessary for work in all areas shown in the figure are obtained through the compulsory and optional subjects to a significant extent.

Figure 5 presents a visualization of the number of candidates who applied and those who were enrolled. These numbers also show a significant trend of growth, which is approximated with trendlines and equations (1) and (2). Equation (1) represents the trendline for the number of candidates who applied, while equation (2) represents the trendline for the number of enrolled candidates.

$$yp = 28.861\ln(x) + 85.503 \quad (1)$$

$$yu = 28.615\ln(x) + 128.52 \quad (2)$$

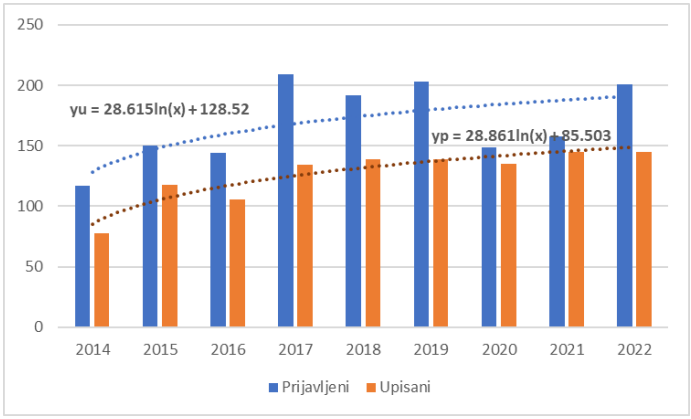

Figure 5. Visualization and trendlines for interested students

Table I shows the correlation values between the quantitative indicators in both categories – on one hand, we have the number of students, and on the other hand, we have the number of IT companies.

TABLE I. THE CORRELATION BETWEEN THE NUMBER OS STUDENTS AND THE NUMBER OF IT COMPANIES

		Number of students	*Number of IT companies*
Number of students	Pearson correlation	1	0,755
	Sig.		0,019
Number of IT companies	Pearson correlation	0,755	1
	Sig.	0,19	

The size of the correlation coefficient indicates the strength of the connection between the enrollment quota (number of students) and the number of IT companies in the Moravica district. Given that the obtained Pearson coefficient value is positive, it is a positive correlation - large values on one scale are followed by large values on the other scale. The value of 0.755 indicates a high correlation [32, p. 79-81]. Therefore, it can be claimed that the research hypothesis has been confirmed.

VII. CONCLUSION

The main contribution of the research is a quantitative analysis of the data related to the IT study program which is being realized at the Faculty of Technical Sciences Čačak and its influence on the IT ecosystem in the Moravica District.

The results point to a crucial role of IT studies in the development of IT sector in the district. The obtained results could help stakeholders from both sides to plan their further activities for successful collaboration.

Future work relates to the dissemination of the obtained results and informing the policy makers both on local and republic level, in order to keep in mind the current situation and plan additional enrolment quota expansions, as was the case in 2017. An additional professional contribution of this research is that a database of IT companies has been formed, which will be constantly updated in the future. Further plans are to create a direct connection between the Faculty and IT companies from the aforementioned database through a portal implemented on the official website of the Faculty, whereby job or internship ads would be visible on the portal in real time. Only Faculty students will be able to access the portal, so the employers would have direct insight into the portfolio of registered candidates.

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Marija Blagojević is an Associate Professor at the Faculty of Technical Sciences Čačak, University of Kragujevac, at the Department of Information technology. Born in 1984, she obtained her MSc degree in technics and informatics in 2007 and PhD degree in technical sciences in 2014. Her current research interests include data mining, artificial neural networks, e-learning, programming, etc. With fifteen years of experience in teaching and research activities, she is the author or co-author of more than 80 research papers, patents, technical solution and a reviewer in numerous scientific journals. She is also a reviewer of projects and study programs and a member of partner university for Tempus project and Erasmus projects. She was project coordinator for one innovative project.

Miloš Papić is an Associate Professor at Faculty of Technical Sciences in Čačak, University of Kragujevac at the Department of Industrual Management. Born in 1986. BSc in Engineering Management in 2009. MSc in Technics and Informatics in 2010. PhD in Engineering Management in 2015. Current research interests: business information systems, educational technology, teacher training, etc. Author of more than 80 scientific articles, textbooks and handbooks. Member of Educational Research Association of Serbia, Union of Engineers and Technicians of Serbia and Association of professors of informatics and technics. NEAQA (National Entity for Accreditation and Quality Assurance in Higher Education of Serbia) reviewer for study programs in the field of techical and technological sciences. Author of textbooks and constructor kits for primary school pupils for Vulkan znanje publishing house – subjects: Informatics and computing and Technics and technology. Co-author and trainer of seminars for primary school and high school teachers (Hypermedia in teaching process, Static and dynamic presentations in the light of new technologies, Teaching programming in the cloud – a paradigm of the new era).

Danijela Milošević a graduated at Military Technical Faculty in Zagreb, Croatia, and received MSc and PhD degree at University of Belgrade. Her expertise includes technology enhanced learning, intelligent tutoring systems, human –computer interaction, and open educational resources. She teaches traditional, online and blended IT courses. She took active role for successfully finished several TEMPUS projects. She was coordinator of the regional Tempus project DL@WEB for improving the quality of distance learning in higher education institutions in the Western Balkans and responsible for development of accreditation standards for study programs for distance learning. She is the president of Balkan Distance Education Network BADEN.nd a short biography.

Darko Petrović is a Software developer at Faculty of Technical Sciences in Čačak, University of Kragujevac. Born in Čačak, Serbia in 1985, MSc in Technics and Informatics in 2013. He is an expert in database modeling and database development, web and mobile development and programming in various programming languages. Current research interests include: data mining, programming, business information systems, blockchain, e-learning, artificial intelligence, web design, database modeling, etc.