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Economics of Software Engineering in Slovenia

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ABSTRACT – Information technologies and their software engineering branch are an important part of the modern economy and its digitalization. At the same time, they are influenced also by the economy, and have formed their own economic fields. However, this field remains poorly studied in some apects. Understanding them can improve the field's operation. The research presented is of a sequential qualitative nature. The first part is a scoping literature review of the global software engineering economics. This is followed by a narrative literature review of the identified topics in the Slovenian environment. The results have shown similarities and deviations in the national economy. Some of the latter, like public sector -related specifics, need additional consideration, and some of them, like digital piracy- and sustainability -related, identify challenges for the country's software engineering sector. Research results can be used by professionals to improve their knowledge about the economics of the business field both globally and locally. Also, they can be used for the promotion and improvement of the studied concepts in Slovenia and as a good starting point for continuing research works on the topics analyzed.

Izvirni znanstveni članek

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KLJUČNE BESEDE: digitalizacija, digitalno piratstvo, ekonomija, javna uprava, programsko inženirstvo, odprtokodna programska oprema, Slovenija, trajnost

POVZETEK – Informacijske tehnologije in njihova veja programski inženiring so pomemben del sodobnega gospodarstva in njegove digitalizacije. Hkrati pa so pod vplivom ekonomike in so oblikovali svoja gospodarska področja. Vendar so ta področja na nekaterih podpodročjih še vedno slabo raziskana. Njihovo razumevanje lahko izboljša delovanje področja. Predstavljena raziskava je zaporedne kvalitativne narave. Prvi del je pregled literature o globalni ekonomiji programskega inženiringa. Nato sledi pripovedni literarni pregled identificiranih tem v slovenskem okolju. Rezultati so pokazali podobnosti in odstopanja v nacionalnem gospodarstvu. Nekatere od slednjih, kot so posebnosti, povezane z javnim sektorjem, je treba dodatno upoštevati, nekatere od njih, kot sta digitalno piratstvo in trajnost, pa predstavljajo izzive za sektor programskega inženiringa v državi. Rezultate raziskave lahko strokovnjaki uporabijo za izboljšanje svojega znanja o ekonomiji poslovnega področja na svetovni in lokalni ravni. Prav tako se lahko uporabijo za promocijo in izboljšanje proučevanih konceptov v Sloveniji in kot dobro izhodišče za nadaljevanje raziskovalnega dela o analiziranih temah.

1 Introduction

Information technologies (IT) have become omnipresent in all spheres of human life and activities in the recent past. This applies to economics as well. The influence of IT and digitalization there is hard to overestimate. At the same time, information technologies have become a huge economic sector as well. It has its own basic principles, model, techniques utilized, and other specifics (Boehm, 1984; Madauss, 2024; Sneed, 1991).

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Software engineering is a branch of IT that deals with the development of computer software. It is extremely important because without software computers cannot operate by themselves and, in the end, become useless. The mentioned branch focuses on the process of development at all stages, from planning and design to deployment and maintenance. It has been developing rapidly in the past few decades and is now extremely huge with its own economic and management principles (Felderer et.al. 2020).

Despite its importance, active study and development of software engineering still remain risky and are, in some cases, a poorly studied economic and business field. Recent research works have shown that 20-30 percent of all software projects are nowadays still failing, and 80-90 percent of employees from the field believe that the projects they are working on will not be successful or, even worse, that they are "doomed" (Money et.al., 2021). For this reason, it is very important to continue the research in the field that will enhance the understanding of the field's economics and improve its business.

In Slovenia, this field is poorly studied. However, official statistics show that it is quite popular and the number of companies and people employed in the IT and software engineering sectors has grown, while the number of closed companies has decreased by 7, 9, and 21 percent accordingly in the years 2020-2022 (Enterprise Births and Enterprise Deaths by ACTIVITY, YEAR, MEASURES and SIZE OF ENTERPRISE-PxWeb, n.d.; High-growth Enterprises by ACTIVITY, YEAR and INDICATOR-PxWeb, n.d.). This is more or less expected because of the ongoing immutable digitalization of all economic and business areas (Oršič, 2023; Zabukovšek, 2016; Zabukovšek, 2024).

Despite IT, in general, and software engineering, in particular, being treated as a very internationalized and globalized area, national specifics play an important role. Especially when it comes to the economic aspects, because the area is influenced by the national environment and specifics as well as all others. Also, the production of the companies dealing with software development is still distributed in the nationalized business markets. For this reason, it is important to study the economics of software engineering in the scope of national environments, like the Slovenian one.

The economics of software engineering in Slovenia and its study are very important since digitalization has been immutably ongoing in all sectors of national economics for a relatively long period of time. For example, the number of organizations utilizing digital technologies in any form has grown by 4 percent in the period of 2010-2019 (The Usage of ICT Hardware and Computer Networks in Enterprises With 10 or More Persons Employed (NACE Rev. 2) by YEAR, ICT USAGE IN ENTERPRISES and ACTIVITY-PxWeb, n.d.), those of them using cloud services by 11 percent in the years 2021-2023 (Number of Enterprises by YEAR, PURCHASE OF CLOUD COMPUTING SERVICE and ENTERPRISE SIZE CLASS-PxWeb, n.d.) and finally, those of them implementing e-business and related software by 15 percents in the period of 2021-2024 (Number of Enterprises by YEAR, ELECTRONIC EXCHANGE OF INFORMATION IN THE ENTERPRISE and ENTERPRISE SIZE CLASS-PxWeb,

n.d.). There are several reasons for such a trend, mainly related to the efficiency of the business operation and improved decision-making. As was mentioned, software plays a critical role in the process of digitalization of the economy, driving innovations and enhancing products and services (Felderer et.al. 2020). However, the related business area still stays poorly studied and risky, particularly on the national level. This makes its study and understanding critical for the development and the future of the national economy.

The work presented in continuation is intended for the systematization of the existing knowledge, concepts, and models in the area of economics of software engineering and their extension for Slovenia as well as for the countries with similar local environments and specifics, like for instance huge public sector of the economy.

2 Methodology

The entire research was designed as two sequential literature researches. First, the scoping literature review was planned to be conducted because the topic of the study is still relatively new and poorly studied. The goal was to analyze the field and the existing trends in the global environment. Then, the second part should have followed: the narrative literature research. This part should have been based on the results of the scoping literature review and study of the topics, identified in the Slovenian environment.

2.1 Scoping literature review

As a methodology for the research of the theory, the scoping literature review was selected, as was mentioned since the topic of the study is still relatively new and poorly studied.

This methodology is known, because it helps ensure a complete and comprehensive overview of some relatively new or poorly studied themes. Its goal is to find, map, analyze, and summarize as many sources on the topic of study as possible with the purpose of making sure no existing knowledge is missed, as well as to identify the most important concepts and gaps. The key steps here are as follows:

1. Definition of the research question
2. Definition of the query for search
3. Search for sources
4. Selection of the relevant sources
5. Data extraction and organization
6. Analysis and summarization of data
7. Synthesis and presentation of the results (Hart, 1998; Ma, 2022)

The research questions (RQs) defined by the author were as follows:

- RQ1. What is software engineering economics?
- RQ2. What are the world specifics of the software engineering sector economics?

- RQ3. What are the specifics of the software engineering economic sector in Slovenia?
- RQ4. What are the key similarities and differences between Slovenian and world specifics?
- RQ5. What are world trends in the software engineering economic sector?
- RQ6. What are the trends of the software engineering economic sector in Slovenia?
- RQ7. What are the key similarities and differences between Slovenian and world trends?

Considering these questions and the popularity of agile methodologies in the software engineering sphere (Nikitashin et. al., 2024), the keywords selected for the query were as follows:

- Agile methodologies
- Economics
- Management
- Software development
- Software engineering

The filtering criteria were defined as shown in Table 1

Table 1

Criteria for the scoping literature review

Criteria	Description	Objectives
Actuality	The work is not older than 20 years.	Ensure that only valid knowledge was included in the analysis.
Reliability	The work was peer-reviewed, according to the data for the website of the resource.	Ensure the results of the analyzed work are reliable and officially confirmed.
Uniqueness	The work does not repeat and reference one of the works already analysed.	Ensure the results of the analysis do not contain unnecessary repetitions and are balanced.
Validity	The work studies one of the topics specified by one of the research questions or its relationship with agile methodologies.	Ensure the work is relevant to the analysis.

For the search, the Scopus database was selected as one of the biggest and most recognized interdisciplinary databases. Also, some sub-sources of the research items found, which the latter were referring to, were included in the analysis.

2.2 Narrative literature review

The narrative literature review methodology is intended to summarize the existing knowledge on the selected topic and critically analyze the findings. Its aim is to give a comprehensive overview of the current state of knowledge on the topic of interest. The steps to successfully conduct the review are the following:

1. Definition of the scope (identification of the key themes, questions, and boundaries of the topic of study)
2. Search for literature (definition of the keywords, search for the sources in databa-

ses and reference lists to find relevant studies)
3. Evaluation of the sources (evaluation with a focus on quality, relevance, and credibility)
4. Synthesis of the information (identification of common themes, patterns, and contradictions in the literature)
5. Organization and writing of the review (organization of the results on a thematic, chronological, or methodological basis) (Hart, 1998)

Based on the results of the scoping literature review, the topics and keywords were defined as follows:

- Digital piracy
- Digitalization
- Economics
- Open-source software
- Public administration
- Software engineering
- Sustainability

The search was conducted in the COBISS database as the most comprehensive source of the scientific works on the selected topic in the Slovenian national environment.

3 Results

After conducting both parts of the research, the following results were obtained and organized into two meaningful parts.

3.1 The world

Both software engineering and economics influence each other.

Digital transformation and information technologies (IT) in general play an important role in the field of economy. They can help to improve such aspects as:

- General efficiency by streamlining economic processes and enhancing data analysis and management with higher efficiency and accuracy;
- Decision-making with the help of comprehensive data analysis;
- Resource management with optimization of the allocation and reducing costs. (Rusakova & Bystrov, 2024)

Software engineering as a branch of information technologies has a key role in digital transformation in all economic sectors. It is a key innovation driver enhancing all aspects, including products, systems, and services. Software is already integrated and will continue its integration in the listed aspects as well as in everyday lives of people. For this reason, it will require the involvement of economic and business specialists in development (Felderer et.al. 2020).

Project management software can serve as a more particular example. While the process itself is possible even without the IT support, in this case, it is much less effective. At the same time, project management software is just a tool, and it cannot do everything by itself. Here, similarly to any IT-supported economic and managerial sphere, it is important to consider an adequate level of integration, as well as good organizational culture and management, and also technological and educational preparedness for the implementation of the technology (Madauss, 2024).

As was mentioned, software solutions can enhance almost all economic spheres in different aspects. As an example, we can use farming. Implementation of specially developed software, enhanced with the most actual features, like artificial intelligence (AI), can help in the optimization of crop yields and consequently increment of profitability of small-size farms (Kulibaba & Barinov, 2024). Another example is shipbuilding. Possible benefits here are improved planning, design, construction, and management of ships; in particular, reduced risks related to errors in planning and design, more efficient collaboration among the project participants, and enhanced maintenance and management of ships (Yanchenko, 2024).

At the same time, as was mentioned, economics and management play an important role in software engineering.

While planning and designing a software project, it is critical to consider such economic aspects as long-term viability and sustainability, well-analyzed cost-effectiveness, and value creation with improvements in performance, maintainability, and scalability (Grundy, 2014).

Historically, at the very beginning of the software engineering era, it was a standard that the entire process of development was conducted by the engineers themselves. This approach very often causes cost overruns and user-unfriendly systems because of a weak understanding of the relationship between requirements and costs. Here, it is important to integrate requirements, architecture, and development process, as well as utilize cost and schedule estimates for effective management of the projects, to avoid the creation of mission-disruptive systems. Also, it is important to consider fast changes in the area and adequately adopt techniques, models, and tools for them (Boehm & Sullivan, 2000).

The earliest and the most comprehensive sources about the topic of software engineering economics were authored by Boehm (1984) and Sneed (1991). Despite their age, they are still very popular in the sphere and are addressed in a large number of very recent sources. For this reason, they were included in the analysis, even though they do not meet all the filtering criteria.

The economic analysis techniques and models play an important role in software engineering and management. Examples are the following:

- Cost-benefit analysis (determination of the overall value and feasibility of the project)
- Return on Investment (ROI) analysis (allocation of resources to maximize financial return)

- Risks analysis (consideration of potential financial impacts in planning of the project)
- Cost estimation analysis (utilization of COCOMO (Constructive Cost Model) for estimation of the costs of the project)
- Trade-off analysis (comparison of different design and implementation options considering their economic implications, to balance performance, costs, and other important factors) (Boehm, 1984; Sneed, 1991)

Considering the recommendations for the utilization of cost-effectiveness principles can be pointed to the possibility of the use of Markov models (Hamori & Bhar, 2004).

The described techniques are important, because the most critical roles in the projects are given to accurate cost estimation as well as effective resource allocation, due to their limitedness. Decision-making in such projects must always consider both technical and economic points of view, keeping an adequate balance between them. The stated applies both for software development and re-engineering projects (Boehm, 1984; Sneed, 1991).

In the recent past, economic models' utilization in software engineering has been studied in different contexts, for example, in terms of implementation of software product line engineering (SPLE). The core idea of SPLE is the development of a family of systems with reusable core assets. Realization of this concept requires a huge initial investment. For this reason, the analysis of the cost-benefit aspects plays an important role. Besides the already described techniques and models, the following are proposed:

- Total Cost of Ownership (TCO) (understanding of the long-term financial effect and sustainability of SPLE)
- Net Present Value (NPV) (comparison of SPLE with other opportunities for investment in terms of economic viability)
- Economic Value Added (EVA) (determination of whether SPLE will generate sufficient returns of value to justify the investments) (Thurimella & Padmaja, 2014)

Some additional important software development aspects have been studied from an economic perspective and should be considered while managing projects:

- Software quality (usability, ease of learning, usage frequency)
- Economic incentives (the biggest and the most successful software companies are incentivized to create high-quality, well-balanced, and user-friendly software) (Zhu & He, 2016)

Software quality is closely related to software testing. In this area, a high level of cooperation between technical and business specialists is recommended. This may help to achieve better results by balancing testing effectiveness (number of errors uncovered) with economic aspects like cost and time consumption (amount of resources and time spent) (Shi, 2010).

Additionally, an important aspect influencing software quality is technical debt arising during the development process. They can be described as events of change

of trade-off and requirement or conflicts of interest occasionally happening during the development process, for instance rushing a system to the market at the expense of its quality. Here, a proper analysis with such techniques as real options, cost-benefit, and value-based analysis is recommended. Also, it is critical to establish a common vocabulary for the business and technical specialists (Ampatzoglou et al., 2015).

While developing and planning software solutions, it is important to consider some additional important business aspects:

- User involvement (active participation of users in the development and adoption processes including their training engagement and organized feedback provision)
- Self-efficacy (confidence of the users in their ability to use the new software effectively)
- Perception of need (positive perception of the necessity for software solution)
- Public recognition (recognition and support from the stakeholders and broader community) (Begicheva et al., 2024)

In the recent past, some authors have proposed a deeper development of the theory of the software engineering economics; for example, with the creation of taxonomy and classification. It may help to improve such aspects as cost-benefit analysis, helping to make more informed decisions and resource allocation and management, leading to a much more economically efficient process of software development (Usman et al., 2017).

Besides the factors mentioned, economy and its conditions are important in software engineering as in any sector as well. Nevertheless, the IT sector in general is obviously treated as global and less dependent on some local disturbances; bad conditions, like uncertainties and layoffs, can significantly influence the software development market. Like anywhere else, companies there must always monitor the situation and be ready to adapt themselves, their strategies, behaviour, models, and management (Żatuchin, 2024). The last one is especially important, because the right selection of the development model and methodology can significantly influence different factors, from productivity to satisfaction of the employees in the sector (Nikitashin et al., 2024).

In recent years, besides the previously described, there have been two of the most popular topics in the relationship between software engineering and economics.

The first is software piracy and its economic impact. As may be expected, it was determined that piracy hurts economic growth by reducing incentives for development companies to create new products, which slows down technological progress and the growth of productivity. At the same time, it was pointed out that this relationship is very complex and controversial. Also, high levels of piracy can serve as an indicator of poor economic and legal institutional quality in the country (Fernandez et al., 2018).

The second topic is open-source software (OSS), which can be treated as a solution to the piracy problem.

OSS is a unique economic phenomenon. It is software developed by volunteer programmers collaborating through informal communities. These systems are distri-

buted freely and despite being developed by volunteers, they often achieve a high level of complexity and quality. Thus, OSS can be a competitor to the traditional paid software and the companies developing it. Such organizations must adapt their strategies to this competition.

At the same time, OSS engineering changes exist and create a new economic and business model. It has a minimal cost of development due to volunteer contribution. Developers of such systems invent absolutely new monetization strategies, like paid support services, development of custom versions, licensing, and hosting services. Last but not least, OSS accelerates innovations in the field thanks to its openness, and consequently, rapid improvements and implementation of new, sometimes unique features. Due to its high competitiveness, some traditional companies are now switching their models to OSS-based ones (Bitzer & Schröder, 2006).

Such software may help in the economic development of the field by reducing costs and increasing innovation, because it allows more developers to contribute and improve the systems and because it provides access to advanced technologies for a broader audience (Kamau & Namuye, 2012; Kshetri, 2025). At the same time, there are some considerations about the sustainability of OSS present (Kshetri, 2025). Additionally, such reasons as loyalty to more popular and widely recognized solutions, as well as lack of awareness, training, and public support, are mentioned as stoppers of development and utilization of OSS (Kamau & Namuye, 2012).

Public and governmental institutions' support may be a solution for the described issues. On the one hand, OSS can contribute to the growth of the economy of a country by accelerating digitalization, increasing market competitiveness, creating innovation and jobs, and the development of new business models. On the other hand, public support and funding can reduce the financial burden related to the development and provide long-term stability for OSS projects. At the same time as with any software project, it is important to consider all economic aspects and conduct all the standards previously described before actual investments. This may be very complex and problematic, and here, specially developed toolkits should be utilized, considering potential economic, social, and technical impacts (Osborne et al., 2024).

An additional factor that must be considered in modern software engineering economics is sustainability. It is important because of the long-term economic and financial benefits for companies, like reduced operational costs, and because nowadays it may significantly influence public reputation which is especially important in the case of OSS projects. The term sustainability can be used in different meanings such as:

- Environmental sustainability (energy efficiency, utilization of green data centers, prioritization of renewable energy sources)
- Social sustainability (inclusive and diverse working environment, fair labour practices, accessibility of products to all users)
- Economic sustainability (cost-effective resource management, sustainable business models, economic benefits of adopting sustainable practices)

Integration of all listed aspects is critically important for establishing sustainable development process and products (Schott & Ovtcharova, 2024).

Two very important steps helping on the way to achieve sustainable software engineering in a company are the implementation of Life Cycle Analysis (LCA) and ISO quality models.

The first one means a complex analysis of the entire development process in all key steps. It can be used to evaluate the impact of software on the environment, including both its development and operation, for instance, through monitoring energy consumption, usage of resources, and emissions. This may help to identify specific areas where impacts on the environment can be reduced; for example, by optimizing code for better energy efficiency, sustainable materials selection, or process improvements to minimize waste.

ISO quality models in turn can help through the following:

- Providing standardized guidelines helps to integrate sustainable practices into software development processes and ensure that sustainability practices are consistently applied across different projects and organizations.
- Achieving and balancing high-quality and sustainable outcomes by emphasizing the importance of paying equal attention to performance, reliability, and environmental responsibility.
- Promoting a culture of continuous improvement and motivating organizations to regularly evaluate and enhance their sustainability practices, helping them to identify new opportunities to reduce the impact on the environment and improve the efficiency of utilization of resources.
- Ensuring that sustainable practices are recognized worldwide and can be implemented in different regions and industries. Such universal applicability makes it easier for organizations to adopt and implement sustainability practices (Qiang et al., 2024).

The social sustainability aspect plays an extremely important role in modern software development as well. It involves creating technology that helps to improve people's lives and at the same time mitigates social risks and tends to minimize negative impacts on society and human beings, as well as on economy and the environment. It helps to reduce negative social impacts, like social isolation, cybercrime, and surveillance capitalism. One of the key recommendations for developers and organizations is to deprioritize antisocial features and promote positive social interactions and inclusivity in their products (Ayoola et al., 2024).

3.2 Slovenia

Digital transformation of the different economic sectors is ongoing both in Slovenia and the world now. For example, in the automobile industry, the integration of enterprise resource planning (ERP) and manufacturing execution (MES) systems for the automation of processes is recommended by some authors. The reasons are that it brings such benefits as improved efficiency of production, decision-making as well as error reduction, and a more productive working environment (Zabukovšek, 2016). Another example is logistics, where digitalization helps to achieve better sustainability and consequently economic results (Oršič, 2023).

Some other research works conducted in Slovenian companies have shown the importance of digitalization and a strategic approach to conducting it. This strategy must be well-developed and aligned with the business one. Otherwise, even the most successful organizations may fail to adopt the best and the most successful business strategies if there are misalignments with the IT strategy (Zabukovšek, 2024). Digitalization brings several benefits, like improved productivity, less workload for employees, time savings, and reduced costs. At the same time, it requires good adoption of employees and management of the organization.

Considering the specifics of the market with a large number of small- and medium-sized enterprises, certain frameworks for informatics management in such organizations have been studied and developed (Levstek, 2022). Furthermore, studies include some specific digitalization topics, like optimization of business processes with artificial intelligence (AI) in Slovenian banks, which led to operating improvements (Smirnov, 2024). Additionally, the utilization of AI can have a positive impact on the management of projects in the software development area as well; for instance, by reducing time consumption and consequently decreasing costs of development and improving satisfaction of customers (Nikitashin, 2025).

Digitalization in Slovenia is taking place on different management levels. One of them, important in terms of this analysis and software engineering in general, is human resource management. Its digitalization in the country brings both opportunities and threats, and sometimes faces local problems as well. However, it remains an important factor in the success of any organization with improved information flow, innovation, creativity, and motivation of employees (Kiselak, 2022).

At the same time, some classical, hierarchical management approaches are identified as inefficient in the modern Slovenian organizations in general. For this reason, the utilization of some principally new, agile-like approaches, like self-organized working groups, has been proposed. Utilization of this approach helps to significantly increase developmental power, innovation, and to a lesser degree, efficiency inside an organization (Kopina, 2018).

Digital piracy is a significant issue present both in Slovenia and all developing countries. The reasons for the high rate of piracy are the high costs of legal content, unavailability of some services, and easy access to pirated content without strict control over its distribution. This led to economic losses for the creators and legal distributors of services and content. The situation has been changing for the better with the decrease in piracy rate in the recent past. However, there is still a need for changes to combat the problem; for example, increase in availability of the legal distribution sources or much stricter copyright law and control over its compliance (Žvar, 2023).

As anywhere else, availability of legal sources can be achieved with OSS promotion. It has already found utilization in some professional spheres in Slovenia, such as civil engineering. Research has identified that there are some solutions that already exist, and they have a good potential for future development. Implementation of such solutions may bring some economic benefits, like cost savings, especially for small businesses, which are present in big numbers on the national market (Prša, 2015).

Besides industry-specific applications, OSS can be utilized for purposes much more common across different organizations; for instance, for process engineering. OSS tools may bring such benefits as:

- Cost-effectiveness (tt eliminates costs of licensing, making it accessible for low -budget organizations like small businesses and educational institutions)
- Flexibility (tt allows extensive customizations and adaptations to specific problems of the organization, providing a universal tool for different applications)
- Support (tt has a community of developers and users, contributing to its regular, non-stop improvement and providing support)
- Integration (tt can be integrated with other software tools and libraries, which enhances its functionalities and allows comprehensive simulations of the processes)

At the same time, some disadvantages were identified, including:

- Complexity (it can be hard to understand and challenging for new users, requiring significant investments of time and effort to learn it)
- Poor documentation (its documentation may not always be up-to-date or comprehensive enough, which causes difficulties for users who need specific guidance or support)
- Performance (it can have limitations of performance in case of very complex simulations, particularly while being used with less powerful hardware) (Arih, 2024)

Digitalization is also happening in Slovenian public services and administration, where areas for potential enhancements with IT have been identified. For instance, in the public healthcare system, with systems for the provision of feedback of customers, which can help improve the quality of the services (Mohorič Kenda, 2018), or in tax collection, with improved data management systems, which can help simplify and streamline the process and collection, as well as distribution utilization of the taxes collected, for example, for the development of the infrastructure and services (Kozlovič, 2016).

In some cases, the implementation of IT enhancements has already started and was reported, for instance, a project for the renovation of information infrastructure in the Ministry of Public Administration. The results analysis has shown improved delivery of services, better management of data, increased transparency of operating, and general satisfaction of citizens as key benefits. At the same time, such projects require continuous monitoring, engagement of stakeholders, and regular adoption of technological advancements (Lojk, 2016). The results analysis of another project for the centralization of ICT at the same ministry has also identified some benefits, such as improved efficiency, reduction of costs, enhanced security of data, and better management of resources. At the same time, some challenges were also identified, primarily related to human resources, e.g. necessity for training, resistance to change, and technical issues. However, the benefits prevail, and it is recommended to continue such projects across the entire public sector (Primec, 2023).

Of course, there are or could be some issues present during the process of digitalization in the public sector. For example, data security risks, because the governmental institution can be the target of different kinds of cyberattacks. The success of such

attacks may have a significant negative effect on the citizens' trust. However, those problems can be prevented with the utilization of advanced encryption techniques and methods for secure authentication, as well as with the conduction of regular security audits. Additionally, digitalization may help to reduce risks of corruption by enhancing accountability, transparency, and traceability of distribution and utilization the public funds (Arnšek, 2024; Černe, 2022).

As elsewhere, the digitalization of the public administration in Slovenia can be enhanced by OSS. Organizations from the governmental sector often face such challenges as budget limitations and high expectations and demands from the citizens. Utilization of modern IT and software can help make their operation faster and much more efficient. Some European countries have already implemented a certain kind of OSS in the public sector organizations. Analysis has shown that this helped improve such aspects as efficiency and cost-effectiveness by reducing licensing costs associated with proprietary software. OSS also has such benefits as adaptability and flexibility, because it can be tailored to meet the specific customers' needs. Additionally, OSS may provide governmental institutions independence from the specific traditional private providers. Of course, there are some smaller short-term shortcomings, similar to other economic sectors, but still, long-term opportunities and benefits outweigh (Dujić, 2007; Upelj, 2010).

In terms of sustainability of IT in Slovenia, for instance, the so-called green computing has been studied. It is a kind of strategy intended to reduce the carbon emissions of computing and consequently contribute to a healthier and safer environment. There were both positive and negative findings in this field. On the one side, Slovenia stays outside of the rest of the world in terms of awareness and adoption, with approximately 80 percent of the population never having heard about the concept itself. At the same time, there is a growing recognition of the importance of green computing and its potential benefits, with half of the respondents of the thematical survey recognizing it as a significant element of the organizational strategy in the near future (Milošič, 2023).

4 Discussion

With respect to RQ1, it can be identified that software engineering economics is a branch of economics studying the business area related to the development of software at all stages. It plays an important role in the ongoing digitalization of the entire economy, which was one of its most significant trends in the recent past, and the results of both parts of the research have shown its importance in global and Slovenian environments. In both of them, digitalization faces issues but still brings much more benefits than problems. Answering RQ2-RQ4, it can be stated that the economic branch of software engineering and its specifics have similarities in both environments as well. Despite the fact that the models and techniques utilized on the national market have not been studied locally in the recent past, they can be assumed to be similar because

of the large number of the same trends and issues. For example, both the national and the global business fields have a trend of implementating and utilizing agile principles in management. Also, both of them are facing the negative impact of digital piracy, even though in Slovenia, the problem is a little bit more acute, similarly to all developing countries. Also, in the local and the global environments, the potential of cooperation between the developers and distributors of OSS and the public institutions, as well as its overweighing benefits, have been identified (RQ2-RQ7).

At the same time, some local deviations and specifics were found, for example, addressing RQ2-RQ4, in the structure of the markets in general. The Slovenian market has a much bigger share of the small and medium-sized organizations. For this reason, some specific models for IT management have been developed and recommended for utilization there.

Additionally, similarly to most post-socialistic countries, Slovenia has a relatively big public sector in terms of economy. According to the data published by the OECD, Slovenia has a small under-average percentage of working power employed in the public sector and above average size of the sector ("Government at a Glance 2023: Slovenia," n.d.). It is probably due to this reason that more research on the IT and software in governmental organizations was conducted than on average. Also for this reason, it is much more important to consider the research results and finding about OSS, as well as the cooperation of its developers with public institutions, since it may be more critical for the country and its economic environment and can bring import benefits for both parts, as well as help in the development of the Slovenian national economy (RQ3, RQ4).

Another important moment is sustainability and its promotion due to its important role in the modern economy; it can bring a lot of long-term benefits outweighing short -term issues. However, at the same time, it is still poorly known in Slovenia and a large percent of the population has never heard of some of the important concepts; on the other hand, people have shown the understanding of the importance of sustainability and its application in the economy in general (RQ3, RQ4, RQ6, RQ7).

5 Conclusion

In conclusion, it should be mentioned that the research has limitations, including its theoretical nature in general and the limited number of sources studied. It has not included any kind of analysis of the real economic and business area, neither globally nor locally. However, it was, for the most part, structurally and comprehensively conducted, in strict accordance with the well-established and widely recognized literature research methodologies and the plan defined at the beginning. For this reason, it can be described as successful and its results as useful.

The findings of this work can be utilized for different purposes. For instance, for professionals working in the field in leading or technical roles, both locally and around the globe, as a comprehensive overview and guidelines for understanding the econo-

mics of the area and work organization of companies. Also, this work can be utilized for the promotion and improvement of the studied concepts in Slovenia. In the end, it can be a good starting point for continuing the research on the topic both in Slovenian or similar national economic environments and globally.

Maksim Nikitashin

Ekonomija programskega inženirstva v Sloveniji

Informacijske tehnologije (IT) so v nedavni preteklosti postale pomemben del sodobnega gospodarstva in njegove nenehne digitalizacije. Hkrati so oblikovale lastno gospodarsko in poslovno polje z veliko posebnostmi. Tako informacijska tehnologija kot gospodarstvo vplivata drug na drugega. Prva s stalno neustavljivo digitalizacijo vseh poslovnih področij. Slednje z vplivom gospodarskih in nacionalnih posebnosti na ljudi in organizacije, ki se ukvarjajo z informacijskimi tehnologijami kjer koli po svetu.

Programsko inženirstvo je veja informacijskih tehnologij, ki se ukvarja s programsko opremo za računalnike. Ta je zelo pomembna za napredek informacijskih tehnologij in digitalizacijo gospodarstva, saj računalniki brez programske opreme lahko postanejo neuporabni. Tudi ta veja je v zadnjih desetletjih oblikovala svoje poslovno podpodročje z večjim številom posebnosti. Vendar sta tako informacijska tehnologija kot programski inženiring še vedno naložbeno tvegana in na nekaterih področjih slabo raziskana. To velja tudi za tematike ekonomskih principov, modelov, tehnik in njihovih specifik na področju IT. Navedeno je prisotno tako v svetovnem merilu kot predvsem v nekaterih lokalnih nacionalnih okoljih, kot je slovensko. Razumevanje teh tem lahko bistveno izboljša delovanje področja in delo na njem ter zmanjša število nastajajočih težav. Zaradi tega je pomembno izvajati strukturirane študije te tematike na globalni in tudi nacionalni ravni.

Predstavljena raziskava je zaporedne kvalitativne narave. Prvi del obsega pregled literature o globalni ekonomiji programskega inženiringa, njenih trendih in posebnostih. Navedena metodologija je izbrana predvsem zaradi slabe priučenosti tematike. Sledi drugi del: narativni literarni pregled izbranih tem v slovenskem okolju, ki temelji na ugotovitvah prvega dela. Pri obeh metodologijah je potrebno določiti tematike, vprašanja in ključne besede, nato pa opraviti iskanje, analizirati in sintetizirati rezultate ter zapisati ugotovitve. Razlika je v tem, da prva običajno v začetnem delu zahteva še določene kriterije ter je bolj splošna in manj selektivna kot druga. Za iskanje v prvem delu je bila izbrana znanstvena baza Scopus kot ena največjih in najbolj prepoznavnih. V primeru narativnega pregleda je iskanje potekalo v bazi podatkov COBISS kot največji nacionalni bazi podatkov, ki vsebuje največje število raziskovalnih del o Sloveniji in njenem okolju.

V prvem delu so določene posebnosti in trendi, kot so pomembnost in največje prednosti digitalizacije sodobnega gospodarstva in poslovanja na skoraj vseh obstoječih področjih z veliko primeri, pomemben vpliv programskega inženirstva na proces digitalizacije, uporaba predvsem modelov in tehnik, povezanih s stroškovno učinkovitostjo v sektorju razvoja programske opreme, kot so analiza stroškov in koristi, analiza donosnosti naložbe, analiza konstruktivnega stroškovnega modela (COCOMO), analiza kompromisov, analiza skupnih stroškov lastništva, analiza neto sedanje vrednosti in analiza ekonomske dodane vrednosti, tudi pomembna vloga upravljanja kakovosti, ekonomskih spodbud, vključevanja uporabnikov, posebej poslovnih strokovnjakov, efektivnosti in razumevanja potreb pri razvoju ter javne prepoznavnosti produkcije.

Določene so tudi posebnosti področja, kot je na primer trend uvajanja agilnih metodologij in principov, ki prispevajo k povečanju učinkovitosti in inovativnosti.

Drugačna izmed omenjenih posebnosti je odprtokodna programska oprema. To je vrsta opreme, ki so jo razvili prostovoljni programerji, ki sodelujejo prek neformalnih skupnosti. Ti sistemi se distribuirajo prosto in so lahko konkurenca klasični plačljivi programski opremi. Odprtokodna oprema močno pospešuje inovacije in razvoj ter ima svoji unikatni ekonomski načeli. Stroški razvoja so minimalni zaradi prostovoljnega prispevka. Razvijalci takšnih sistemov izumljajo povsem nove strategije monetizacije, kot so plačljive podporne storitve, razvoj prilagojenih različic, licenciranje in storitve gostovanja. Zaradi njene visoke konkurenčnosti nekatera tradicionalna podjetja zdaj svoje modele preusmerjajo na modele, ki temeljijo na odprtokodni opremi. Hkrati je prisotnih nekaj pomislekov o trajnosti takšne opreme. Poleg tega so razlogi, kot so zvestoba bolj priljubljenim in splošno priznanim rešitvam ter pomanjkanje ozaveščenosti, usposabljanja in podpore javnosti, omenjeni kot ovire pri razvoju in uporabi odprtokodne opreme.

Hkrati pa ima odprtokodna programska oprema potencial za vzajemno koristno uporabo v javnih institucijah. Podpora javnim in vladnim organizacijam je lahko rešitev za prej naštete omejitve. Po eni strani odprtokodna oprema lahko prispeva k rasti gospodarstva države s pospeševanjem digitalizacije, povečanjem konkurenčnosti trga, ustvarjanjem inovacij in delovnih mest ter razvojem novih poslovnih modelov. Po drugi strani pa lahko javna podpora in financiranje zmanjšata finančno breme, povezano z razvojem, in zagotovita dolgoročno stabilnost projektov odprtokodne programske opreme. Vendar kot pri vsakem programskem projektu je pomembno upoštevati vse ekonomske vidike in pred dejanskimi investicijami opraviti vse prej opisane analize standardov. To je lahko zelo zapleteno in problematično, zato je treba uporabiti posebej razvite komplete orodij, ki upoštevajo možne gospodarske, socialne in tehnične vplive.

Še ena posebnost je digitalno piratstvo in njegov negativni vpliv na poslovno področje. Ugotovljeno je bilo, da piratstvo škodi gospodarski rasti področja, saj zmanjšuje ekonomske spodbude razvojnim podjetjem za ustvarjanje novih izdelkov, kar upočasnjuje tehnološki napredek in rast produktivnosti. Ob tem je bilo poudarjeno, da je to razmerje zelo kompleksno in kontroverzno.

Zadnja posebnost, ki pa ni po značaju prav določena posebnost, je trend trajnosti ter njene pretežne dolgoročne koristi ne zgolj za gospodarstvo, ampak tudi za družbo in okolje. Poseben značaj ima tako imenovana družbena trajnost. Njen vidik igra izjemno pomembno vlogo pri sodobnem razvoju programske opreme. Vključuje ustvarjanje tehnologije, ki pomaga izboljšati življenje ljudi in hkrati blaži socialna tveganja ter teži k minimaliziranju negativnih vplivov na družbo in ljudi ter gospodarstvo in okolje. Pomaga zmanjšati negativne družbene vplive, kot so socialna izolacija, kibernetski kriminal in kapitalizem nadzora. Tukaj je eno od ključnih priporočil za razvijalce in organizacije, ki naj dajo prednost antisocialnim funkcijam in spodbujajo v svojih izdelkih pozitivne socialne interakcije in vključenost.

Rezultati drugega dela raziskave so pokazali podobnosti in odstopanja med nacionalnim in globalnim gospodarstvom. Podobnosti, ki so bile najdene v trendih upravljanja, so implementacija in uporaba agilnih metodologij in principov ter rast trga odprtokodne programske opreme in njen dober potencial za sodelovanje z vladnimi in javnimi institucijami. Poleg tega so nekatere težave, s katerimi se soočajo, podobne tako globalno kot lokalno.

Hkrati pa obstajajo razlike, ki so posledica predvsem nacionalnih gospodarskih struktur. Na primer deleži organizacij na trgu glede na velikost, lahko z večjim odstotkom malih in srednje velikih podjetij, kar je vodilo v razvoj lokalno specifičnih modelov za upravljanje informacijskih tehnologij.

Drugi primer je nadpovprečna velikost javnega sektorja, značilna za postsocialistične države. Analiza rezultatov projekta informatizacije in digitalizacije na ministrstvu za javno upravo je kot ključne koristi pokazala izboljšano učinkovitost poslovanja, zmanjšanje stroškov, večjo varnost podatkov, boljše upravljanje virov, izboljšano izvajanje storitev, boljše upravljanje s podatki, večjo transparentnost poslovanja in splošno zadovoljstvo občanov. Hkrati pa tovrstni projekti zahtevajo stalno spremljanje, vključevanje deležnikov in redno sprejemanje tehnoloških dosežkov.

Zaradi velikosti in značilnosti javnega sektorja so ugotovitve v zvezi z njo, zlasti tiste, povezane z odprtokodno programsko opremo, veliko bolj kritične, saj lahko pripomore tako k večji učinkovitosti in transparentnosti delovanja kot tudi zadovoljstvu prebivalstva. Ta odstopanja morajo upoštevati vsi akterji na nacionalnem trgu.

Prav tako so nekateri ugotovljeni izzivi bolj pereči ali specifični za Slovenijo. Na primer, višja od povprečja je stopnja digitalnega piratstva, značilna za države v razvoju. Ugotovljeni razlogi za visoko stopnjo piratstva so visoki stroški legalnih vsebin, nedostopnost nekaterih storitev in enostaven dostop do piratskih vsebin brez strogega nadzora nad njihovo distribucijo. To povzroča gospodarske izgube ustvarjalcem in zakonitim distributerjem storitev in vsebin. Razmere so se spremenile na bolje z zmanjšanjem stopnje piratstva v bližnji preteklosti. Vendar pa so še vedno potrebne spremembe za boj proti navedenemu problemu, na primer povečanje dostopnosti do zakonitih virov distribucije ali veliko strožja zakonodaja o avtorskih pravicah in nadzor nad njeno skladnostjo.

Drugačno glede na omenjene izzive je slabo prepoznavanje načel trajnosti informacijskih tehnologij in zelenega računalništva med prebivalstvom. Na eni strani Slovenija ostaja pod svetovnim povprečjem v smislu ozaveščenosti in sprejemanja, saj približno 80 odstotkov prebivalstva še nikoli ni slišalo za sam koncept. Hkrati narašča prepoznavnost pomena zelenega računalništva in njegovih potencialnih koristi, saj ga polovica anketirancev tematske ankete prepoznava kot pomemben element strategije organizacij v bližnji prihodnosti. Opisani vidik trajnosti je ključen za prihodnost države in njenega gospodarstva nasploh zaradi dolgoročnih koristi za naravno okolje, družbo in gospodarstvo samo ter pretehta vse kratkoročne pomanjkljivosti.

Ugotovljene razlike zahtevajo dodatno posebno obravnavo na lokalni ravni in nekatere od njih, kot sta digitalno piratstvo in trajnost, opredeljujejo izzive za prihodnost sektorja programskega inženiringa v Sloveniji. Izsledke raziskave lahko poslovni in tehniški strokovnjaki, zaposleni na tem področju, uporabijo za izboljšanje razumevanja in znanja o ekonomiji poslovnega področja tako globalno kot lokalno. Prav tako jih je mogoče uporabiti za promocijo in izboljšanje proučevanih konceptov v Sloveniji ter kot dobro izhodišče za nadaljevanje raziskovalnega dela o analiziranih temah.

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