ORIGINAL SCIENTIFIC PAPER
UDK: 005.336.5:004]:37
330.341.1(497.11)
Date of Receipt: February 1, 2016

Ana S. Trbovich
Singidunum University
FEFA
Belgrade

Nebojša Savić
Singidunum University
FEFA
Belgrade

Zoja Kukić
StartIt
Belgrade

SOFTWARE EDUCATION AND DIGITAL ECONOMY DEVELOPMENT IN SERBIA*

Obrazovanje programera i razvoj digitalne ekonomije u Srbiji

Abstract

The concept of digital transformation, or the use of technology to improve performance, is analysed in the context of sustainable economic development and technological preparedness of Serbia. The authors further focus on the role of software engineering education. Software developers are key enablers of new information technologies, providing programming services behind the adapted and new business models. The first assessment of current technical competencies, educational background and working conditions of software developers in Serbia was the subject of an empirical study conducted in October 2015, which is discussed in this article. The findings concur with global research, which discerns a shift away from formal education, in part as a result of a gap in the classic curricula and the market demand for agile programming and project management. This gap needs to be supplemented with non-technical skills in addition to teaching innovative programming, and this could be a subject of further study. Additional research is required to understand the low level of digital adoption by the business sector in Serbia, as well as to investigate the impact that European integration and foreign investments produce on this process. In Serbia, one important positive trend is a high level of openness to entrepreneurship among software developers, and this may be the source of new innovations. A further challenge is to link developers as technical enablers with the traditionally organised businesses in Serbia to facilitate a wider digital transformation and creation of a true digital economy.

Keywords: *digital economy, transformation, education, software developers, ICT, Serbia*

Sažetak

Pojam digitalne transformacije, odnosno upotrebe tehnologije radi unapređenja učinka, proučava se u kontekstu održivog ekonomskog razvoja i tehnološke spremnosti Srbije. Autori se dodatno usredsređuju na ulogu obrazovanja u oblasti softverskog inženjerstva. Programeri su ključni nosioci procesa primene novih tehnologija, pružajući tehničku podršku stvaranju prilagođenih i novih poslovnih modela. Stoga članak razmatra rezultate prve studije tehničkih kompetencija, obrazovanja i uslova rada srpskih programera, koja je sprovedena u oktobru 2015. godine. Nalazi potvrđuju međunarodna istraživanja koja uočavaju udaljavanje od formalnog obrazovanja, delom zbog jaza između etabliranih nastavnih planova i potreba tržišta za agilnim programiranjem i upravljanjem projektima. Ovaj jaz treba popuniti ne samo učenjem inovativnog programiranja, već i netehničkim kompetencijama, što može da bude tema daljih istraživanja. Pored toga, treba proučiti razloge za nizak stepen prihvatanja digitalnih tehnologija u poslovnom sektoru u Srbiji, te ispitati ulogu evropskih integracija i stranih ulaganja u ovom procesu. Jedan značajan pozitivan trend u Srbiji predstavlja velika otvorenost programera prema preduzetništvu, što može da bude izvor novih inovacija. Dodatan izazov je kako spojiti programere sa tradicionalnim preduzećima da bi se omogućila šira digitalna transformacija i stvaranje istinske digitalne ekonomije.

Ključne reči: *digitalna ekonomija, transformacija, obrazovanje, programeri, IKT, Srbija*

* This article was produced with the support of the research project "Advancing Serbia's Competitiveness in the Process of EU Accession", no. 47028, during the 2011-2017 period, supported by the Ministry of Education, Science and Technological Development of the Government of Serbia.

Introduction: Digital transformation and new competencies

Although the term "Digital Economy" was coined as late as in the mid-1990s [21], referring to a concept that is also termed e-business and e-commerce, and essentially describing doing business in part by using the Internet, just two decades later it coincides with the majority of the economy. Most businesses today use the Internet, and competitiveness becomes determined by the extent to which the Internet and other advanced information technologies (IT), such as mobile and cloud applications, and most recently blockchain, are embraced, transforming the business models. Therefore, the concept of digital transformation, or the use of technology to improve performance, is one that deserves more attention, especially in relation to the study of sustainable economic development. Companies transform the way they are doing business to benefit from the low and potentially zero marginal cost provided by the digital platform for trade in their intangible products. Likewise, the public sector transforms its service delivery, and the economy benefits from its increased efficiency and transparency.

Digital transformation reduces a range of costs, especially those relating to labour. It alters the way in which market research is performed, with abundant and often current or even real-time data availability. Wu and Brynjolfsson [27] further emphasise that the availability of such data enables easier predictions of consumer behaviour and preferences. Indeed, the collection and analysis of this kind of data is a business model for many technology companies, notably Google. Yet, authors such as David Rogers [13] convincingly argue that the essence of digital transformation for businesses does not lie in updating the technology but in "upgrading strategic thinking" and reshaping business models. According to Westerman, Bonnet and McAfee [26], new digital technologies not only create new entrepreneurial opportunities, but impact the organisational structure and often lead to a shift from physical products alone to service-based or service-complemented products. Together with Karen Dillon, Taddy Hall and David S. Duncan [4], Clayton Christensen further contends the established notion that understanding the customer is the crux of innovation. Instead, the said authors argue that products are purchased to do a job and that "understanding customers does not drive innovation success, but understanding customer jobs."

Indeed, digital transformation is the core of management consulting services today, dominating their research and public presentations. This only seemingly contrasts with the view of Shapiro and Varian, who maintain that companies need to return to the fundamental market-driving forces in economics to understand the digital market, and that market rules have not changed to the same extent as has the technology [17, pp. 1-2]. In essence, digital transformation strategies are adapted corporate growth and restructuring strategies. For instance, based on case research of 20 large companies in North America and Europe across different industries, investigating the effects of new information technologies (NIT) in transforming industries and value chains, Andal-Ancion, Cartwright and Yip [1] concluded that the deployment of NIT ultimately resulted in three types of strategies to achieve digital transformation: a) reducing layers of intermediaries, such as distributors, which separate the company from its customers (termed classic disintermediation); b) embracing intermediaries (remediation), and c) building strategic alliances and partnerships with new and existing market participants in a tangle of complex relationships (network-based mediation).

Brynjolfsson and McAfee [3, p. 62] highlight two significant consequences of digitisation: "new ways of acquiring knowledge (in other words, of doing science) and higher rates of innovation." This has led to changes in the formal education system and a concurrent increase in self-learning, facilitated by the new information technologies. Software developers are key enablers of NIT application, providing programming services behind the new and adapted business models. The first assessment of current technical competencies and educational background of software developers in Serbia is the subject of the empirical study discussed in this article. The study is placed in the context of Serbia's technological preparedness.

Productivity, sustainable growth and Serbia's preparedness for digital transformation

Stephen S. Roach [12] has revived the intense discussion on the "productivity paradox" from the late 1990s, referring to the phenomenon of massive IT investments that did not deliver significant productivity gains. Today, new markets are created (digital media and computerised wearables), as well as new services (energy management and DNA sequencing), products (smartphones and robotics) and technology companies (Alibaba and Apple), but the growth is not (sufficiently) visible. As Roach suggests, "it is possible that all America has accomplished are transitional efficiency improvements associated with the IT-enabled shift from one technology platform to another." Yet, he also insists that the quality-of-life improvements have not been captured in official statistics, and more importantly, "the undercounting of work time associated with the widespread use of portable information appliances". This argument may counter the pessimism of Barry Eichengreen [8], who deduced that growth of the TFP (total factor productivity), the combined measure of capital and labour productivity, was essentially zero for three consecutive years, concluding: "If the rate of TFP growth has in fact fallen from its historical norm of 1.5% per year to near zero in countries like the United States, then the living standards of today's young adults will rise much more slowly than those of their parents". Nonetheless, as emphasised by Eichengreeen, "Any increase will depend entirely on improvements in education and training, which are absent from the data, and from investment in equipment and structures, which is depressed relative to historical levels." Education is still perceived as a principle factor to buttress productivity and sustained growth.

Recognising the strong correlation between digital transformation and sustainable development, the World Bank devotes increasing resources to this topic. The most recent World Development Report focuses on digital development, and it is called Digital Dividends [25]. It turns attention to automation and potential employment loss that could affect the developing countries, as well as to possibilities of job creation. Education is analysed both in the context of the use of technology, where the findings are inconclusive because some of the most advanced education systems such as the Finnish model use limited technology in classrooms, and in the context of acquiring new skills. As noted in the report, "Modern labor markets require creativity, teamwork, problem solving, and critical thinking in ever-changing environments — skills that traditional education systems do not teach and that are the hardest to measure" [25, p. 32]. As a consequence, many countries are adapting their approach to education, which is encouraged by the World Bank, as is more overall investment in information and communications technologies (ICT) education. Importantly, the World Bank reiterates that there are high returns for individuals investing in education, especially in tertiary ICT education: "Returns to tertiary education are the highest, at 14.6 percent; tertiary education is the only educational level for which returns have not fallen since the early to mid-1990s. That reflects strong demand for advanced skills, especially among women. Returns to education are higher and have been rising more rapidly in ICT-intensive occupations compared to the rest of the economy" [25, p. 112].

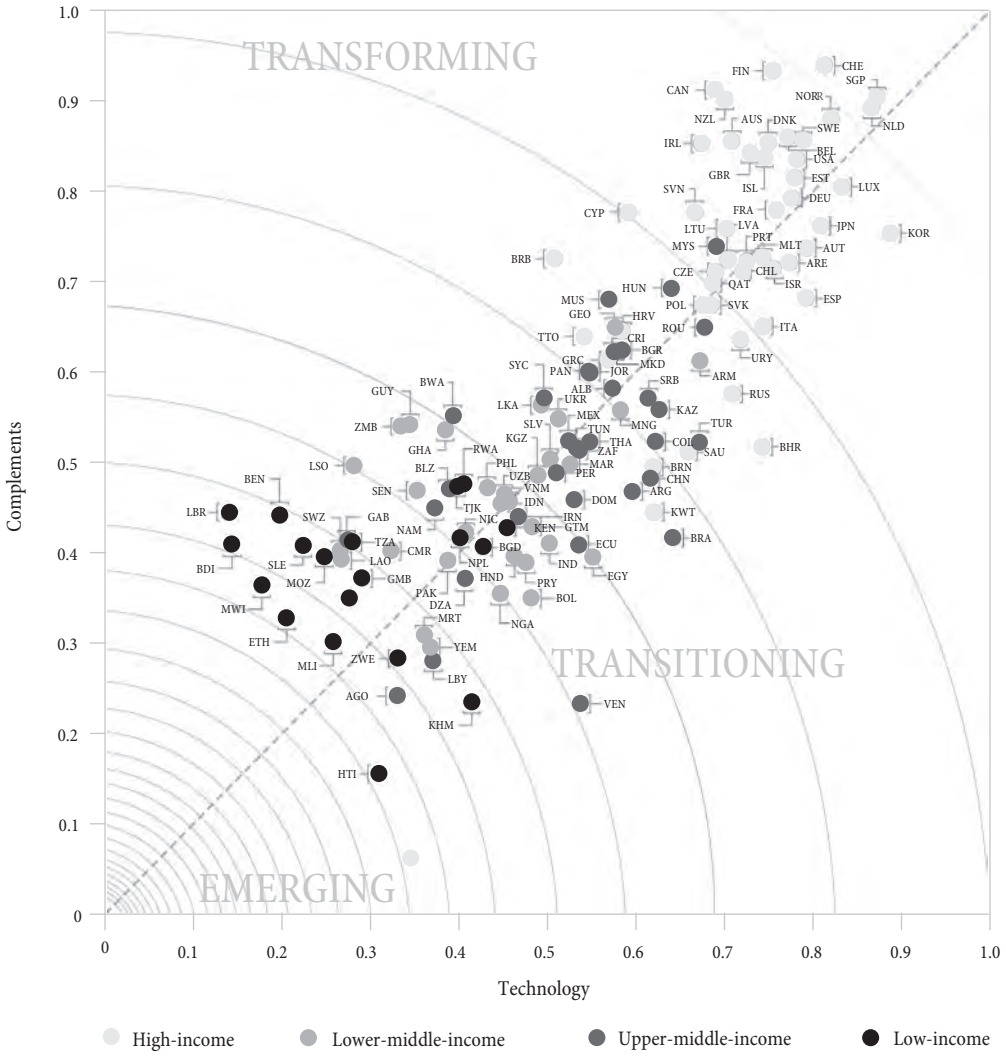
In the framework of the report, the World Bank has constructed the Digital Adoption Index (DAI) in cooperation with the Microsoft Corporation to measure the global spread of digital technologies across three segments of the economy: businesses (3G coverage, download speed and number of secure servers), people (Internet and mobile access at home), and governments (online public services, digital identification and core administrative systems). Each subindex is the simple average of several normalised indicators measuring the adoption rate for the relevant groups. Similarly, complements, as defined by the World Bank's team, are the average of three subindicators: starting a business; years of education adjusted for skills; and quality of institutions. Serbia's DAI is at 0.61, and while the Government's DAI is ahead of Europe and Central Asia region average, it is lagging in terms of adoption by the people, with the most significant lag in adoption by businesses (0.41). In comparison, a country of comparable size from the same region and a European Union member, Hungary, has a DAI of 0.64, with business adoption at 0.5, while Germany, one of the most dynamic economies in Europe, has a DAI of 0.78 and business adoption index

of 0.66. On a global spectrum, Serbia is an outlier in the group of transitioning countries. The World Bank report ranks Serbia among upper-middle-income countries which are still in the process of transition towards universal Internet use, with only 4-5 percent of its gross domestic product (GDP) coming from digital economy. According to the report, priorities of such countries in the field of digital economy should be to "build effective competition regulation and enforcement capacity, teach advanced cognitive and socio-emotional skills that complement technology, and move toward effective e-government system" [25 p. 30].

The analysis of the state of innovation infrastructure in Serbia based on aggregate data collected by the World Economic Forum [22], [23], [24] indicates that in 2008 Serbia's innovation infrastructure was at a higher stage of development when benchmarked against other countries globally than in 2012 or 2016. Specifically, in two of the indicators, "Country's capacity to retain talent", and "Country's capacity to attract talent" (previously integrated under one heading - "Brain drain"), Serbia has consistently been at the bottom of the global rankings over the last decade (in 2016, it held the 137th position out of 144 countries, for both of these indicators). This is an alarming result.

By analysing the most recent Global Innovation Index (GII) published by Cornell University, INSEAD and WIPO [5], [6], [7], we affirm the trends discussed in earlier work [15], [16]. Notably, we deduce that the countries in the Central and Eastern Europe (CEE) and South East Europe (SEE) regions are sub-optimally exploiting their potential for commercialising innovation, since they

Figure 1: The quality of complements and technology is increased exponentially to income



Source: [25].

rank more highly in terms of innovation than in terms of GDPpc PPP. Furthermore, together with Bosnia and Herzegovina and Macedonia, Serbia still lies at the lower end of the SEE region's performance in terms of effective innovation output.

Methodologically, the Global Innovation Index (GII, 2016) relies on two subindices: (i) the Innovation input subindex, measuring factors that enable innovative activities; and (ii) the Innovation output subindex, which is based on innovative activities within the economy. In Figure 2, we graphically present the effectiveness of the GII outputs based on the available inputs for Serbia. The derived results in 2016 are poorer compared to 2012, especially when assessing "Market sophistication", "Knowledge and technology output" and "Creative outputs". The Innovation Infrastructure ranking of Serbia is 87, with the Skills subindex of 75, and Innovation subindex of 95. In two of the indicators within the Skills subindex, "Quality of management schools" (105) and "Quality of the educational system" (103), Serbia holds a particularly unsatisfactory position. At the same time, in 2016 Serbia scored considerably well for "Tertiary education enrolment rate" (46), "Quality of math and science education" (46), "Utility patents per million population" (50), and "Quality of scientific research institutions" (60).

Another very important indicator of innovation and ICT is the Networked Readiness Index (NRI), which measures the propensity of countries to exploit the opportunities offered by information and communications technologies (ICT) [2, p. xi].

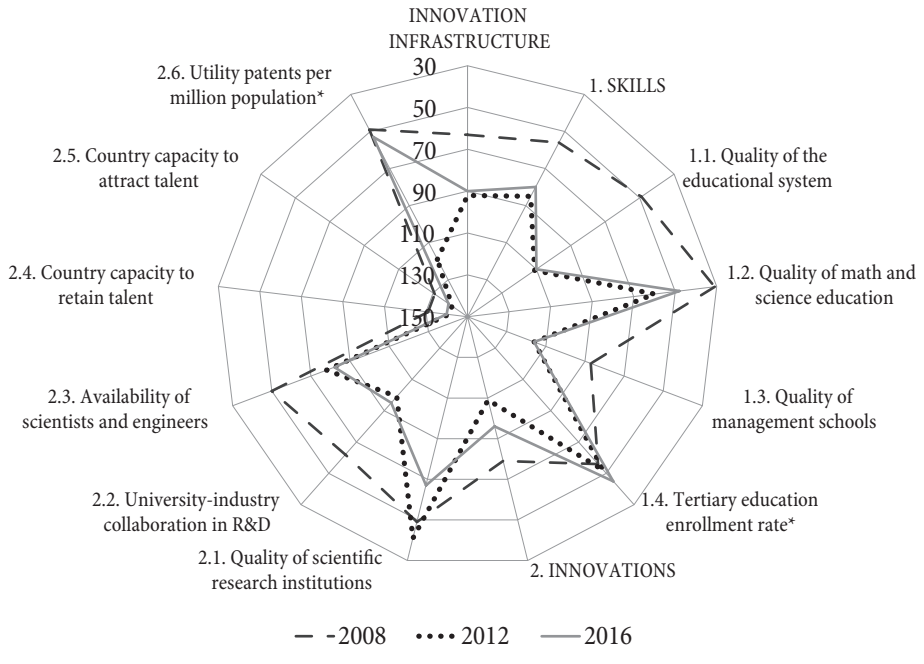
Figure 3 illustrates positions of Serbia according to the NRI in 2012, the first year when such data became available, and in 2016.

Serbia has steadily improved its ranking in terms of the NRI Index, finding itself at the 75th position (out of 139 countries) in 2016, which is a leap of 20 places compared to the 95th position in 2012. The current ranking of Serbia corresponds to its GDPpc PPP.

The NRI consists of four subindices: i) Environment subindex, (ii) Readiness subindex, (iii) Usage subindex and (iv) Impact subindex.

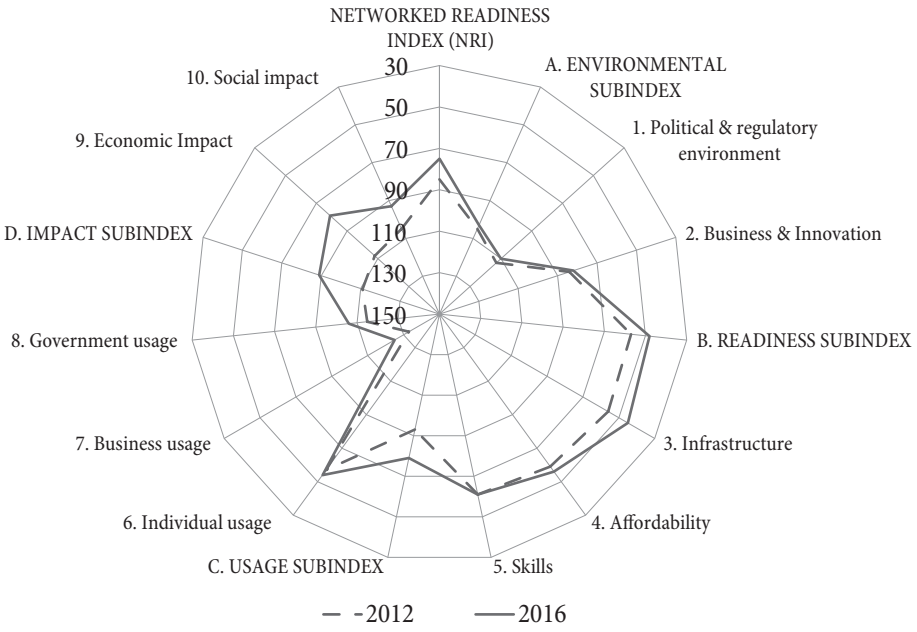
Serbia scored particularly well in the Readiness subindex (48), especially in the Infrastructure (45) and Affordability segments (56), but also faring relatively well in the Skills segment, observed on average (61). Serbia was also well ranked in some segments of the Usage subindex, specifically in the Individual usage (54). Poor results are recorded in the Environmental subindex (103), the Business (125) and Government usage (106) indicators of the Usage subindex (79), and to an extent in the Impact

Figure 2: Innovation Infrastructure in Serbia



Source: [22], [23], [24].

Figure 3: Networked Readiness Index (NRI)



Source: The Global Information Technology Report, 2016 and 2012.

subindex (89), particularly regarding the Social impact indicator (93).

When investigating the Skills pillar in further detail, we notice that the quality of math and science education is highly ranked, as noted above, but that the overall quality of education is at 110, which is of concern, as is the firm-level technology absorption (127) and the extremely low capacity of businesses for innovation (131) and staff training (134).

Empirical study of Serbian software developers: Methodology and discussion of results

To determine the level of education, skills and compensation of software developers in Serbia, who are the key enablers of digital transformation, a study was undertaken from October 8-26, 2015. The methodology was devised by one of the authors of this article, structurally following the questionnaire design of the "Mom Test" framework developed by Robert Fitzpatrick [9], and covering the following segments:

a) Demographics;
b) Current and desired skills;
c) Educational background and resources;
d) Working conditions;
e) Career plans.

The target audience for the survey were software developers in Serbia. The research question was formulated to define "Who are software developers in Serbia," assessing both the current status and future plans of programmers. The umbrella organisation conducting the survey was SEE ICT, a non-profit organisation founded in Belgrade, Serbia in 2010, with a mission to create a supportive environment for the development of start-up culture and community. To enhance the survey reach, SEE ICT cooperated with other organisations that are active in the Serbian information technology, including the following:

1. Agile Coaching Serbia,
2. DaFED (largest information technology organisation in the city of Novi Sad),
3. Drupal Srbija (association of Drupal developers in Serbia),
4. Hadoop Srbija (association of Hadoop developers and data scientists in Serbia),
5. HeapSpace (one of the first and largest association of information technology professionals in Serbia),
6. Honorarci.rs (association and online platform dedicated to freelance software developers in Serbia),
7. IT Serbia Podcast (podcast dedicated to Serbian information technology ecosystem),

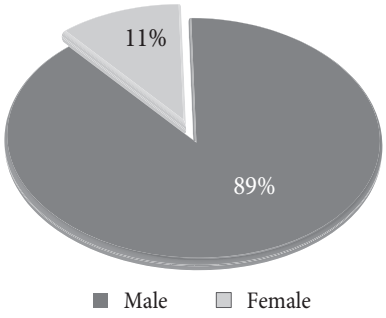
8. JS Belgrade (association of front-end and JavaScript developers in Serbia),
9. LevelUp (association of game developers in Serbia),
10. PHP Srbija (association of PHP developers in Serbia),
11. Silicone Drinkabout (Serbian branch of a global organisation for technology and start-up community gatherings),
12. Startit.rs (largest technology and start-up media in Serbia, part of SEE ICT),
13. Unity Srbija (association of Unity developers in Serbia),
14. WP Srbija (association of WordPress developers in Serbia),
15. Webinarium (online channel with video lessons and webinars for the regional start-up and information technology community).

All of the organisations noted above sent direct email requests to their members, posted the information on their websites, promoted the survey through their social media channels and at the events hosted throughout the survey period. The platform used for the online survey was the SEE ICT website, while TypeForm tool was used to collect anonymous responses from survey participants.

The questionnaires were designed in the form of closed-ended questions, permitting yes/no or graded (scaled) responses. Several questions included an option to add a comment in order to encourage respondents to provide additional valuable insight. The questions appeared one at a time, and the subsequent question was conditioned by the respondent's previous answer. This structure enabled a survey of 190 questions to be more accurate in terms of final results, while reducing the time required for completing the survey and increasing the response rate.

A total of 1,670 programmers completed the survey, which is estimated to be about 20% of all programmers in Serbia [14], [19]. The majority of respondents were male (89%), whereas 11% were female. The apparent gender gap is even more striking than the global ICT employment statistics, with "men 2.7 times more likely than women to work in the sector and 7.6 times more likely to be in ICT occupations" [25, p. 106], although similar results were obtained in the StackOverflow Developer Survey [18].

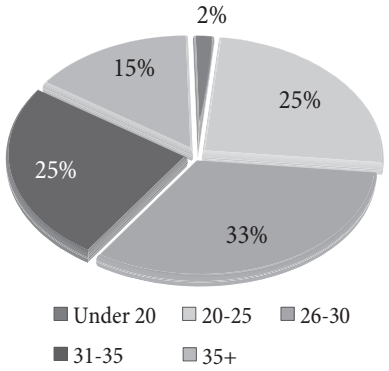
Figure 4: Respondents by gender (% share)



Source: Authors' Analysis of the Serbia Developers Survey conducted in October 2015.

Average age of the respondents was 29.7. Most of the respondents were between 26 and 30 years of age, while more than three quarters were between 20 and 35 years of age.

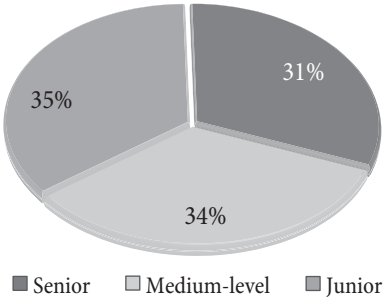
Figure 5: Respondents by age (% share)



Source: Authors' Analysis of the Serbia Developers Survey conducted in October 2015.

Interestingly, although they are of relatively young age, almost a third of the respondents identified themselves as senior developers (31%), and the three groups, including junior and medium-level developers, were almost evenly distributed.

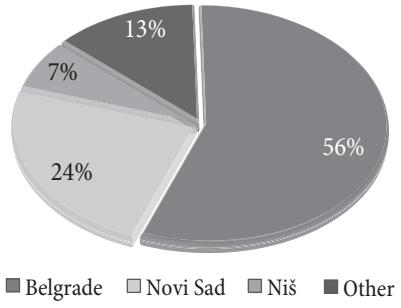
Figure 6: Respondents' level of experience: senior, medium-level and junior (% share)



Source: Authors' Analysis of the Serbia Developers Survey conducted in October 2015.

Majority of the respondents came from the largest, capital city of Belgrade (56%), followed by Novi Sad (24%) and Niš (7%), which are also the main university centres in Serbia. About 13% of respondents were from other cities (Subotica, Kragujevac, Čačak, etc.), and each of these towns was identified as a place of residence by up to 2% of the respondents.

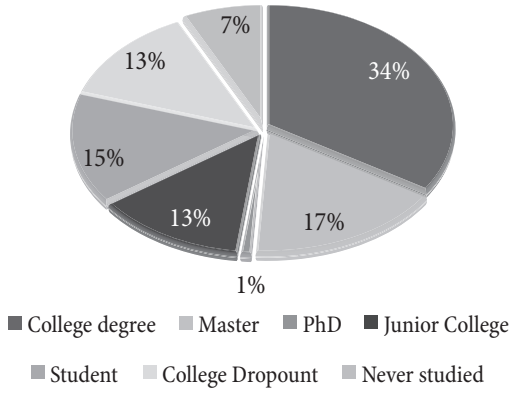
Figure 7: Respondents' location



Source: Authors' Analysis of the Serbia Developers Survey conducted in October 2015.

We shaped the survey questions to examine the level of formal education, which led to the most significant result of the study, which is that only 52% of software developers in Serbia completed formal undergraduate (34%) and graduate education (17% hold a master's degree and 1% a PhD degree), with 13% having completed junior colleges and 15% still in the course of studying. One fifth of all respondents either dropped out (13%) or never enrolled in undergraduate study programmes (7%).

Figure 8: Respondents' level of education



Source: Authors' Analysis of the Serbia Developers Survey conducted in October 2015.

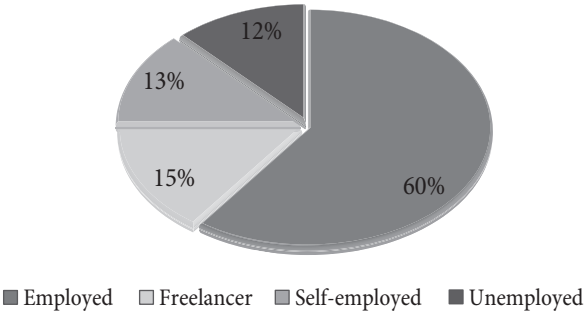
Another significant finding was that among those with a formal degree, more than a third did not obtain it from a technical undergraduate study programme, i.e. 62.7% of the respondents who completed formal education programmes hold an engineering or another relevant technical degree. This reduces the total number of respondents with a formal technical education to 32.2%. These results coincide with the global statistics. Namely, the most representative global developer survey conducted by StackOverflow reveals the same trends: 48% of the respondents never received a degree in computer science and 33% of respondents never attended a university course in computer science [18]. The World Bank World Development Report [25, p. 106] brings out similar statistics: "In developing countries, on average, half of all workers in the ICT sector have a tertiary education, compared with one-quarter elsewhere."

Among educational alternatives, both formal and informal, Serbian developers mostly rely on self-learning and learning on the job, options that are graded with 4.73 on a scale of 1 to 5. The least attractive options for current programmers are formal education (2.69/5) and informal trainings (2.51/5).

When asked about the programming languages that they would like to learn, a high 90% of the respondents expressed a desire to learn at least one additional programming language, and 65% reported two or more additional languages, which reveals both a knowledge gap and a desire to obtain additional skills.

Precisely 60% of software developers who participated in the survey are employed, with additional 13% who are self-employed and 15% freelance programmers. Only 12% of the respondents are unemployed, and these tend to be junior developers (91.7%).

Figure 9: Respondents' employment status



Source: Authors' Analysis of the Serbia Developers Survey conducted in October 2015.

Among those who are employed, the average net salary is EUR 1,250, which is 3.5 times higher than the

average salary in Serbia (estimated at about EUR 360 net during the survey period in 2015, according to the official statistics). The following graph displays salary levels in different towns (Belgrade, Novi Sad, Niš and other towns, respectively), based on the level of work experience (defined as junior, medium-level and senior programming experience):

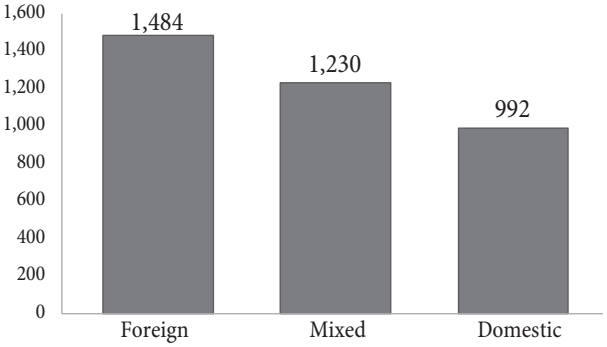
Almost two thirds of the employed developers are engaged via standard labour contracts (65%), 17% are contracted through their registered sole proprietorship agencies, and another 12% work under a standard contract, but receive a part of the compensation in cash as a form of unregistered payment. Another 5% receive unregistered cash payments or are paid via their virtual accounts (e.g. Skrill) or work under some other form of contract (e.g. part-time consulting agreement). This leads us to the conclusion that the grey economy is on the decrease, but this actually might be the result of underreporting.

Job satisfaction is rated relatively high, with a grade of 3.8 on a scale of 1 to 5. The most common reasons for changing jobs are the following: a) desire to obtain new skills and experience (45%), b) higher salary (29%), and c) better working conditions (17%).

Interestingly enough, education does not produce a significant impact on the salary level. Those with a formal degree receive only 4% higher salaries than those without formal education. However, there is a gender salary gap. Average salary for male developers is EUR 1,265, while women earn 24% less, with an average salary of EUR 965. To further accentuate the gap, every single female respondent attended a formal education programme, with a higher percentage of completion rate and a higher portion of master's and graduate degrees compared to the average respondent results. A total of 66.5% hold a formal degree, the majority of which obtained a Bachelor of Science degree (46.5%), followed by a Master's degree (16.7%), PhD (3.3%) and another 7.7% with a junior college degree. The dropout rate is at 7.7%, and 18.1% are still studying.

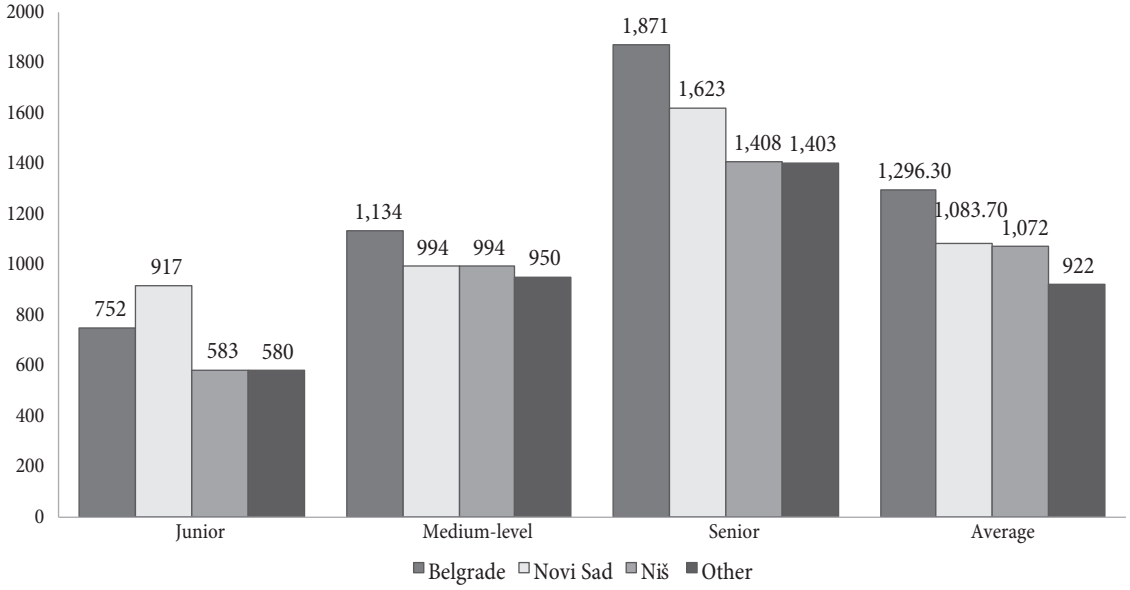
Company ownership structure also has a high impact on the salary level, i.e. foreign employers pay the largest salaries.

Figure 11: Respondents' salary level by company ownership



Source: Authors' Analysis of the Serbia Developers Survey conducted in October 2015.

Figure 10: Respondents' net salary by location and level of experience

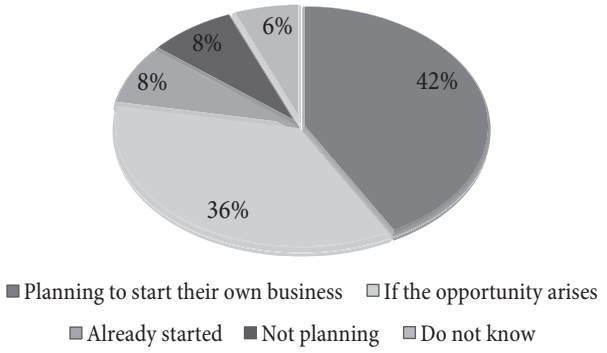


Source: Authors' Analysis of the Serbia Developers Survey conducted in October 2015.

The data also indicates that foreign ownership dominates the industry in Serbia. Foreign markets are also the primary source of employment for freelance programmers. The majority regularly works with clients from the USA (59%), Western Europe (42%) and Central Europe (24%). Top ways for them to obtain work are freelance platforms (UpWork, Elance, etc.) (41%), upon recommendation (38%), and by working mostly with the same clients (17%).

Nonetheless, there appears to be a shift in the mindset, possibly stemming from valuable employment experience, with an increasing number of programmers considering entrepreneurship. When we exclude the ones who are already running their own business, a high 42% of the respondents are planning to start a venture of their own, while 36% would do so if the opportunity arises. This means that 75% are open to the entrepreneurial work perspective.

Figure 12: Respondents' propensity for entrepreneurship



Source: Authors' Analysis of the Serbia Developers Survey conducted in October 2015.

To further stimulate digital transformation as project managers and/or entrepreneurs, programmers need to possess additional, non-technical skills in management and in designing innovation. Based on international best practices stemming from Europe and Asia, both the curricula and the teaching methods in software engineering education should be adjusted. Innovation and entrepreneurship education for engineers should be additionally reinforced, and the faculty should include a combination of academics and practitioners [11]. Furthermore, authors such as Armando Fox argue that the so-called massive open online courses (MOOOCs) need not be an alternative to traditional teaching, but that they could be integrated in formal education. He proposes the example of the University of California at Berkeley, which revised its software engineering course to teach agile programming and allow students to develop a new app that matches the requirements of non-technical customers while employing the same tools and techniques that professionals use. As he concludes, "by experiencing the whole software lifecycle repeatedly within a single college course, students learn to use and appreciate the skills that industry has long encouraged. The course is now popular with students, rewarding for faculty, and praised by industry" [10]. There is also an increasing discussion on including the study of ethics in software engineering (see, for instance [20]). The skills gap between traditional and agile software development should be further investigated, and the study undertaken for Serbia followed by a broader study researching a spectrum of competencies, including those that are non-technical.

Conclusion

The low level of Serbia's digital transformation, especially in the business sector, should become an increasing concern for both researchers and policymakers if sustainable growth is to be achieved and the development gap bridged more successfully. Further research is required to understand the low level of digital adoption by the business sector, as well as to investigate the impact of European integration and foreign investments on the said process. The empirical study conducted to investigate the level of education and working conditions of programmers, as enablers of digital transformation, reveals not only that this is a perspective market segment in need of additional programmers, but also that the formal education programmes need to be adapted. As indicated by our research results, the software engineering curriculum ought to be supplemented with non-technical competencies that lead to the reshaping of traditional businesses and the creation of new business models.

In Serbia, one important positive trend is the high level of openness to entrepreneurship among software developers, and this may be the source of new innovations. A further challenge is to link developers as technical

enablers with the traditionally organised businesses in Serbia to facilitate a wider digital transformation and creation of a true digital economy.

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Ana S. Trbovich

teaches Entrepreneurship and Strategic Management at FEFA, Belgrade, Serbia. She is co-founder of Grid Singularity, energy blockchain technology company, and Intersection, NGO promoting science in the Western Balkans. As Partner at EuroBalkan Advisors (EBA), she manages projects and consults on competitiveness and innovation policy for international organisations, including the EU, USAID and the World Bank. Dr. Trbovich serves on the board of the European Institute for Innovation and Technology (EIT) and several business and civil society organisations. She has actively participated in Serbia's economic reforms and EU accession process, both as an apolitical high government official and advisor. She holds a PhD (Fletcher School of Law and Diplomacy), two Masters Degrees (MALD, Fletcher School; MPA, Harvard Kennedy School of Government) and BA (Tufts University, triple-major in Economics, IR and French Literature). Author of "A Legal Geography of Yugoslavia's Disintegration" (Oxford University Press, 2008), and other books and articles.

Nebojša Savić

teaches Economics and Competitiveness at the Faculty of Economics, Finance and Administration (FEFA) and is a MOC affiliate faculty member of Institute for Strategy and Competitiveness, Harvard Business School. He is President of the Council of the Governor of the National Bank of Serbia. He has more than thirty years of experience in company-restructuring and institution-building towards market economy. Dr Savić was a member of top expert teams advising on economic reform policies in Serbia, member of the Serbian National Competitiveness Council (2008-2012), previously serving as President of the Yugoslav Economists Association and Editor-in-Chief of the Economic Barometer, a leading monthly publication on Yugoslav economy. He was member of the Board of Directors of Alpha Bank Serbia (2006-2012) and President of the Board of Directors of Komercijalna banka, Serbia (2003-2005). He holds a PhD and MA degree which he obtained from the University of Belgrade, Faculty of Economics. He authored seven books and more than fifty articles.

Zoja Kukić

is co-founder and Board Member of StartIT and SEE ICT, non-profit organisations dedicated to empowering the local tech and start-up scene. With seven centres across Serbia and two online platforms, the organisation reaches more than 60,000 people every month and provides education, information and networking related to technology, design and entrepreneurship. Zoja graduated from the University of Belgrade, Faculty of Economics and is currently preparing her master's thesis on Strategic Finance & Management. Before taking an executive position at SEE ICT, she was Executive Director of Crown Prince Alexander Foundation for Education, where she spent 3 years. She is also active in the field of empowering women in the tech sector and is founder of the local branch of Lean In, the largest female empowerment movement founded by Sheryl Sandberg, COO of Facebook.