Evaluating existing educational initiatives in the area of ICT in MOLDOVA and development of ICT education strategy

2020

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EXECUTIVE SUMMARY

Emerging Digital Technologies are changing the structure of the global value chain. With the world now undergoing a fourth industrial revolution (Industry 4.0) and COVID-19 pandemic, Moldova needs to better position itself to leverage global trends. The report seeks to identify strategic repositioning options for Moldova's IT sector development and based on that options, adjusting the IT Education development to increase the country's competitiveness.

The Moldova's IT industry experienced a rapid growth in the recent years and has become one of the most dynamic and competitive sectors of the Moldova's economy. The sector was one of the main catalysts for the economic development, which greatly contributed to the country's GDP (6% in 2019). Moldova's international trade in high-tech sectors is dominated by ICT services and in 2018 the export of the sector comprised 10.5 percent of total service exports. The development of IT sector in Moldova is driven by the export of software development, support and testing services and software development outsourcing services are accountable for over 95% of IT exports revenues in Moldova. As a result, country's IT industry,mainly driven my outsourcing is currently facing maturity and significant competitive pressures. There is a need to modify the competitive model in order not to lose to other destinations over the long run.

A scarce and limited labor force supply is the major constraint for the future growth of the industry. The companies in the sector, mainly dealing with software development services, report growing shortage of professionals for hiring, the demanded skillset of which is quite mainstream. Despite the number of graduates from universities, companies struggle with qualified personnel, hence there is a problem of quality rather than quantity. Another issue that impact the pool of available specialist is the migration. Currently there is a significant migration outflow from Moldova caused by economic conditions, which causes a brain drain in IT and High technology industry.

The demographic challenges and the rapidly changing tech labor market highlight the need for reforms in Moldova's education system to meet the skill demand. There has been a continuous decline in number of educational institutions and students enrolled in those institutions. This combined with the aging teaching staff, low brand of TVETS and quality of the curricula, put a pressure on the education system in providing the necessary specialists. Meanwhile, the Universities struggle with attracting enough students in STEM related areas, despite the availability of 12 universities with IT related disciplines. At the current point of development of the sector, the skills gap increases with the positive dynamics and development of the industry. This implies that the shortage of the skills will increase in parallel with the sophistication of the industry, and education needs to align to face those developments.

The gaps in higher educational systems are partially being filled by various educational initiatives in the IT sector and by IT training providers. Various initiatives are being done by donor community, private sector and government in order to boost the interest of kids towards STEM related subject, as well provide necessary training for people to upgrade their tech skills or reprofile to tech industry. The Education Pyramid framework was used to evaluate the existing initiatives. The initiatives are quite successful, however there is a need to conduct systematic and institutional changes in schools and TVETS, as well as increase the brand of University as an academic institution.

EXECUTIVE SUMMARY

Moldova's IT sector is facing a strategic choice of a future model for development. As the industry is maturing, the future growth is becoming harder to achieve. The competitive advantage and Moldova's value proposition need to be clearly articulated. The value proposition will have to go beyond mere supply of teams of high-quality engineers and programmers who are ingrained in selected elements of global value chains of multinationals. Moldova can strive to capture its "niche" based on an attractive positioning clearly comprehensible by global players.

Based on the analyses of the experience of countries that succeeded in developing IT industries in relatively short periods of time, three competitive development models are proposed as follows **(i) MNC Model: Platform for accessing regional markets – EU and CEE; (ii) R&D Model: Tech Powerhouse; (iii) Startup Model: New products and services based on the demand of local and global market**

Model 1 – Multinational Company (MNC) Model: Platform for accessing regional markets – EU and CEE. Positioning Moldova in the global market as platform for global players to penetrate large regional markets, by providing advantages for global companies to serve targeted regional markets more effectively. This includes creation of a favorable business environment, provision of high skilled labor force and developing necessary infrastructure. With this model, Moldova can manage to become an attractive investment destination for mostly market-seeking FDI's in the region.
Model 2 -R&D Model: Tech Powerhouse. This model implies creation of world-class science and technology schools, improvement of quality of math and science education in public schools and heavy investments in R&D (both public and private). It requires developing advanced technologies & science-based clusters, and infrastructure. The value proposition to leading technology MNCs includes unique and sophisticated competences for their global value chains. The model to a large degree rests on creation of a highly skilled workforce pool able to develop and design innovative and sophisticated products and services.
Model 3- Startup Model: New products and services based on the demand of global market. Global market demand will drive the development of new innovative products and solutions for local ICT enabled services and products that can be exported into global markets. Government initiatives, such as fiscal and financial incentives for development of high-tech export-oriented products, coupled with business development skills through technology incubator programs, attract global venture capital to fund risky innovative start-ups. Solid and effective financial markets (especially stock markets) should be in place to support business initiatives and, particularly, venture capital exit strategies.

Based on the strategic choice of country's IT sector development, relevant IT Education Development strategy can be developed. Model 1 will mainly require availability of workforce, being able to deal with not very sophisticated technologies, i.e. the mainstream of tech specialists. The skillset and employee profile are similar the ones currently demanded in the local market– Software Developers, Testers, Network Administrators etc. These skills can be developed by initiating training programs for IT related graduates and build strategic alliances with companies to ensure the production of high-quality IT graduates according to business needs. **Model 2 and Model 3** will require developing specialists for the top level of the education pyramid, i.e. highly skilled science and technology graduates. It will require significant investment in the educational sector and particularly in the higher education, through close trilateral partnerships (government-business-academia). The universities will need to seek new ways of maintaining the talent in the country and further promoting them towards development of their own products or involvement in scientific research activities.

EXECUTIVE SUMMARY

Focusing on the Golden "middle". The win-win situation for Moldova to develop its IT sector and IT education, is focusing on the middle level of the pyramid and the MNC model can be a good starting point. Moldova needs to improve its higher education system in tech disciplines and provide necessary incentives to keep its talent in the country. The enhancement of this level will also ensure higher percentage of people going to the top level of the pyramid and in a long run build the necessary foundation for an innovative products, scientific breakthroughs and unicorn companies, and preparing for the R&D model. In order to ensure that Moldova gets a lot of top specialist in the top level of the pyramid, higher education is a crucial component in the process. For a long-term sustainable development of IT industry, the strong university base is of a critical importance. While company base training can provide basic IT skills, the ever-increasing sophistication of IT products will require strong multidisciplinary educational background that can be provided only on the platform of university education at graduate and postgraduate level.

Importance of creation of a new entity. Considering the proposed models, a need of establishment a new entity is needed to be able to implement various projects, not limited only to specific industry group and expand the initiatives all over the country. It will basically take the role of industry development all over Moldova, by serving as a liaison between various stakeholders, including private companies, donor organization and public institutions. Establishment of a new entity will give the flexibility to develop new content and strategies based on the market needs that can be out of core activities of existing organizations.

Proposed short-term and mid-term actions:

- A new university curriculum should be developed together with the private sector.
- The prestigious status in academic career and low salaries of teachers should be addressed.
- Creation of training centers within companies can help to close the skill gap.
- The university funding needs considerable increase as well as diversification through research grants.
- If Moldova aspires to transition from outsourcing, development center destination to one own product development model, it must integrate fundamental, hard-core research into its university system.
- The number of university-based laboratories, which are established with the help of multinationals, should be scaled up.
- Creating an alternative program to prepare software programmers in less than 3 or 4 years will help increase the supply of labor in the medium term.

COVID-19 implications for sector and IT education development

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- Tech companies, working on outsourcing market, lost their clients as a result of cost cutting and efficiency seeking by the companies.
- ·All the non-tech sectors of economy are heavily impacted by the COVID-19, which will lead to a greater number of people re-profiling to tech sector.
- ·The role of science and scientific research became vital.
- ·The importance of the physical environment and space as a core to build content around is diminished.
- ·The integration of information technology in education will be further accelerated and online education will eventually become an integral component of education.

ABBREVIATIONS

ATIC – National Association of ICT Companies
TVET- Technical vocational and education training
HEI -Higher educational Institution
MNC- Multinational corporation.
UTM – Technical University of Moldova
USM – Moldova State University
ASEM – Academy of Economic Studies of Moldova
USARB – Balti State Alecu Russo University
CSU – Comrat State University
USCH – Cahul State Bohdan Petriceicu Hasdeu University
MCP – Moldova Competitiveness Project
USAID – United States Agency for International Development
WB – World Bank
EU- European Union
ICT – Information and Communication Technologies
IT – Information technologies

SCOPE OF THE ASSIGNMENT

The scope of the project includes the analysts of the development of IT industry in Moldova, IT job market analysis, current situation in education and specifically in IT education, as well as analysis of IT education initiatives in the country. Particularly, he report has the following objectives:

- Research on international experience in similar countries such as Armenia, Georgia, Albania, Kosovo as developing countries, as well as Sweden, Estonia, Finland, etc as world known success examples. Create a vision related to worldwide experiences in a) introducing digital skills as a must b) nurturing tech skills to meet market needs c) create demand for IT related solutions introduced in education Desk research
- Interviews with local companies, agencies, universities, government representatives and other stakeholders
- Evaluate existing educational initiatives and their business models on the market, provided by donor community, private sector and the Government Desk research, interviews with the main stakeholders on the market, including private companies, implementing agencies, government, educational institutions representatives, donors, civil society
- Assessment of the ICT education conditions in the Moldova.
- Development of high level strategy for improving the situation.
- Presentation midterm results to different stakeholders
- Field work
- Final report and public presentation

ORGANIZATION OF THE REPORT

Chapter 1 looks at the ICT sector and job market and elaborates on the shortages of the skills. Chapter 2 elaborates on the IT Education sector of Moldova, including schools, TVETs and higher education institutions. Chapter 3 maps and describes the current IT education initiatives and formal educational responsible for creating the tech talent. Chapter 4 introduces a framework for assessing the initiatives. Chapter 5 summarizes the challenges identified and looks at the best-case practices in the world as a solution. Chapter 6 provides IT sector development Models and projects their implication on IT Education Development strategy. The final chapter provides conclusions and proposals on short-term and mid – term actions.

METHODOLOGY

This report was prepared based on information collected through:

- Analyzing the cases of the following countries: Armenia, Georgia, Kosovo, Sweden, Finland, US, Estonia, Germany.
- Visit to Moldova, interview with the following stakeholders:
  - Donors – USAID/MCP project, GIZ, EU, WB, Helvetas
  - Tekwill -TA, TAK, Tekwill in Every School
  - Government – Ministry of Education, Research and Culture, Ministry of Economy and Infrastructure
  - Universities/ Colleges – UTM, USM, State Pedagogical University, State University from Tiraspol, ICT Excellence Center (College)
  - Companies – Orange, Roundtable with local IT companies
  - Association of Employers from Manufgacturing Industry (APIP)
  - Balti University
  - Focus groups

In addition, study of various reports and publications were carried out. The statistics from the Ministry of Education, as well as data provided by the National Statistical Bureau was analyzed.

INTRODUCTION

The world and Moldova are facing a new reality, which arrived within a few days- COVID-19. The threats of coronavirus pandemic have forced many countries to introduce unprecedented preventative measures that severely restrict the overall economic activity. The tech sector is remaining the less impacted sector, and some specific areas of the sector were drastically immersed into the economy to deal with this crisis. COVID-19 accelerated the transformation from an Industrial Age to a Technological Age and proved the importance of non-tech and traditional industries integrating technological solutions (e.g. the growing dominance of a delivery economy over a retail economy, remote work, online education, etc.) The situation implies, that the economic risks stemming from the COVID-19 can be immense and, in many cases, irreversible: the traditional economic approaches will not be relevant. World is calling upon all innovators and entrepreneurs to come up with new innovative approaches and solutions to deal with current crisis and the technology sector is the one to take the lead.

As coronavirus is continuing to spread, the education system is facing a new crisis. It has changed dramatically, with the distinctive rise of e-learning, whereby teaching is undertaken remotely and on digital platforms. The integration of information technology in education is and will be further accelerated and online education will eventually become an integral component of school education.

On the other hand, the current, unparalleled global technological advancements, widely believed to represent the Fourth Industrial Revolution or Industry 4.0, are having a deep impact on all the sector of economies due to its exponential nature of change. Whereas previous technological revolutions were largely driven by a single dominating technology, the current revolution can be characterized by the simultaneous overlay of several radically innovative technologies. The rapid technological progress and increasing importance of knowledge-based capital means that knowledge has become the most important factor in economic development. Adjusting the education and development of relevant workforce to meet the market demands of Industry 4.0 products should be the main driver of the economy.

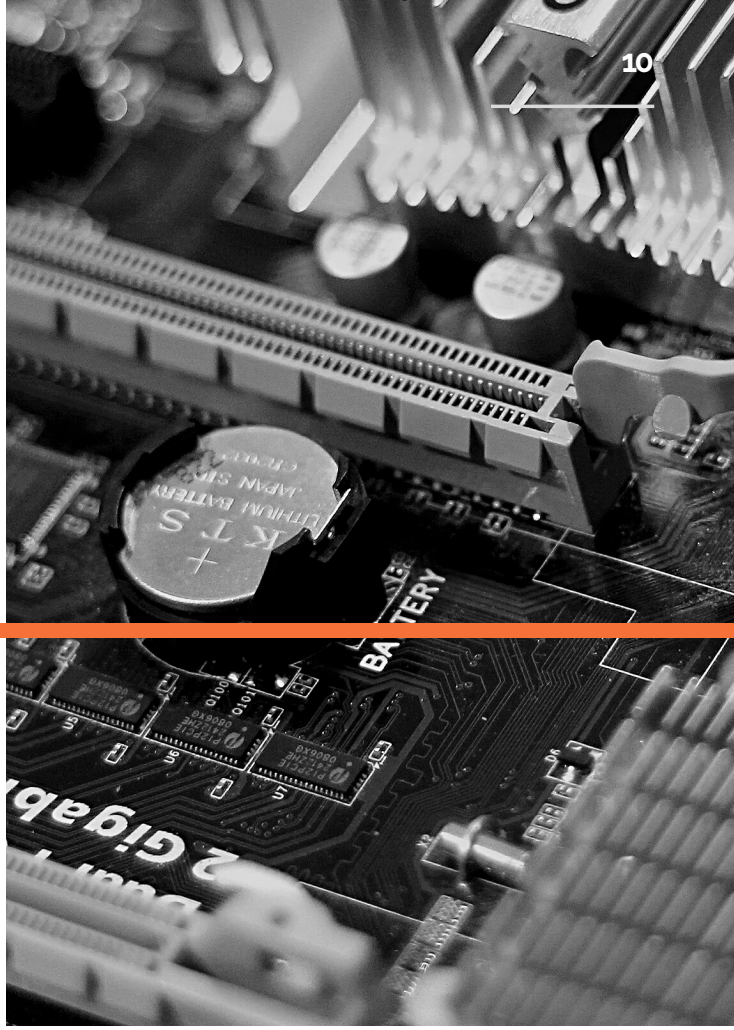
Moldova can't stay away from these changes and shall create its IT sector growth model around this reality. The export of IT products and services from Moldova demonstrated an impressive increase in the last years contributing to overall economic development of the country. In order to keep its global economic competitiveness, Moldova needs to choose a strategic repositioning option and drive the development of IT education based on that option.

With that in mind, the National Association of ICT Companies (ATIC) initiated the evaluation of existing educational initiatives in the area of ICT in Moldova. Current report takes a look at the country's IT sector and IT education initiatives and provides possible strategies to increase the overall competitiveness of the sector in the country and drive the education, taking into consideration recent development regarding the COVID-19.

The methodologies used for preparation of the report included Desk research, during which relevant documents and reports were reviewed, Field visits during which visits were done to the institutions and organizations dealing with IT education development in the country and Interviews were conducted with a large cross-section of stakeholders, including representatives from Government, donor community and private sector.

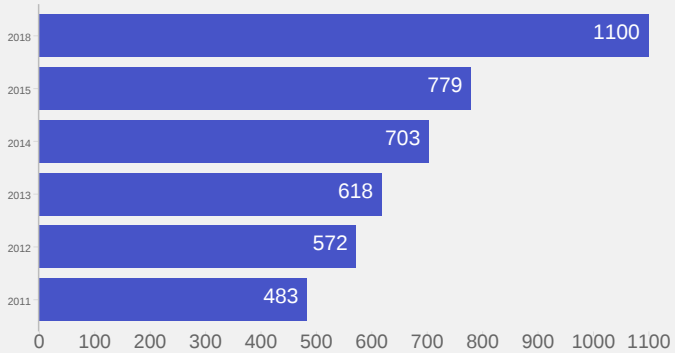
1. MOLDOVA'S CURRENT POSITIONING IN ICT SECTOR

1.1 ICT SECTOR OVERVIEW



Moldova's economy has recorded quite a stable growth rate during recent years and improved its competitiveness, ranking 86th in 2019 among 141 countries in the Global Competitiveness Index (GCI). Moldova has experienced solid economic performance in recent years, with an average of 4.5% increase in real GDP. According to the Doing Business 2020 report, Moldova ranks 48th of the 190 countries measured on ease of doing business. Over the past several years, Moldova has enacted several reforms to reduce barriers to business entry and now ranks 14th among all countries. Moldova has a dynamic and competitive telecommunications market which is characterized by high internet access speeds, good mobile services accessibility and technological development. Moldova ranks among the best (15th) in international Internet bandwidth, coming ahead of the Baltic States, Poland.

FIGURE 1: NUMBER OF COMPANIES IN IT

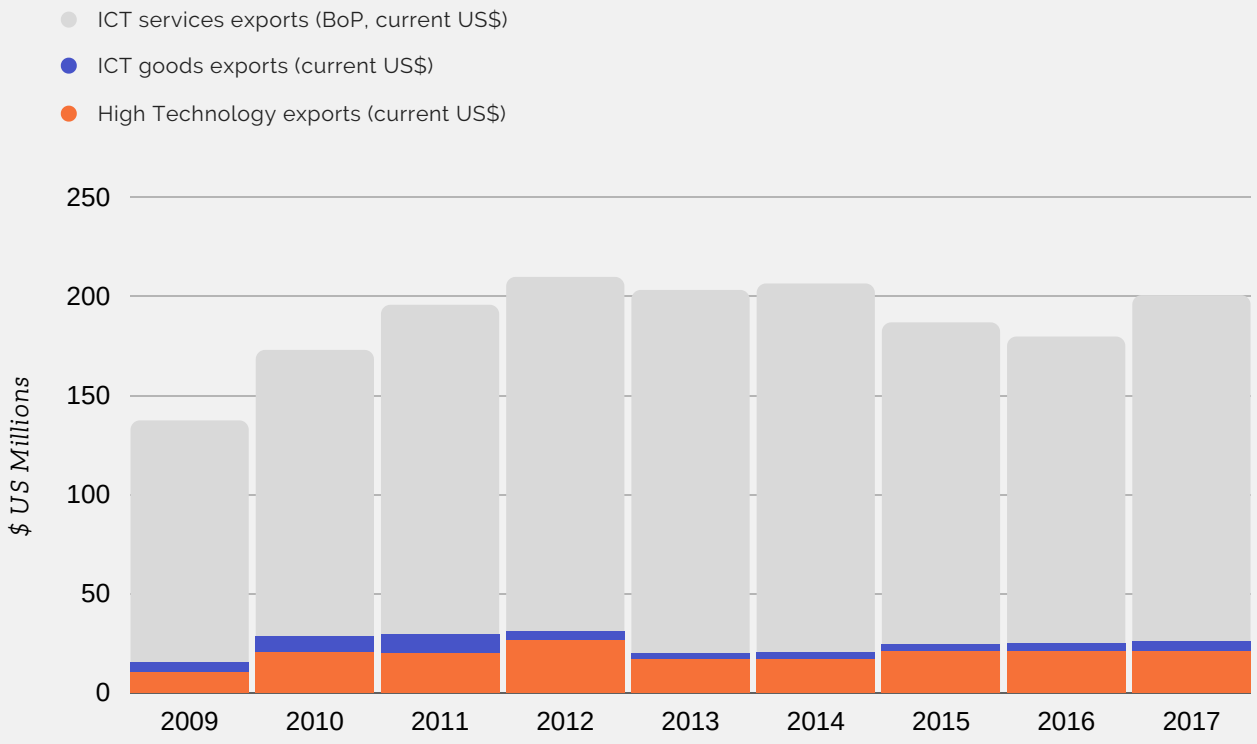


The Moldova's IT industry experienced a rapid growth in the recent years and has become one of the most dynamic and competitive sectors of the Moldova's economy. The number of companies in IT sector is growing with CAGR 12.5%, with 1100 registered companies in 2018, while the labor force growth was CAGR 9% from 2014-2018. The four largest companies with more than 250 employees each are Allied testing, Cedacri, En-dava and Global phoning Group. The survival rate for the IT companies in Moldova in their first 2 years is 54.4%, which is 18 % higher than in any other sector of economy. Tax benefits resulted in a notable increase of newly registered companies. As a result, in September of 2019 190 out of 480 IT Park residents were newly established enterprises. These companies reported $13.6m sales revenues in Q1-Q3 2019 or 9.4% of the total sales recorded by IT park residents in January-September 2019

ICT sector was one of the main catalysts for the economic development, which greatly contributed to the country's GDP (6% in 2019). The ICT sector has been identified as a priority sector by the Government of Moldova, as a result of which several important steps have been taken to promote the sector development. Among them was the launch of Virtual IT Park on January 1, 2018 to promote technological innovations and entrepreneurship in the sector, attract investment and new technologies to the national economy. Another important action was the Law on Virtual Parks, which introduced a single tax of 7% on the sales and increased the interest of foreign investors. The development of free economic zones and IT parks, along with other incentives and reforms are anticipated to accelerate the growth in the sector.

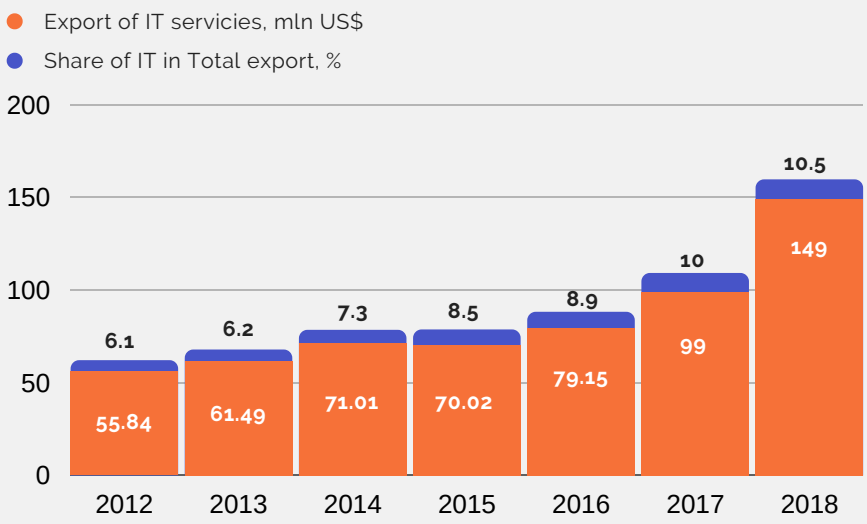
While information and communication technology (ICT) services dominate Moldova's high-tech export activity, it is still a relatively small share of the overall economy. Moldova's international trade in high-tech sectors is dominated ICT services, which far outweigh tangible ICT goods exports (see Figure 2). There has been an 49.5% growth in the exports in ICT services, which increased from USD 121.9 mln in 2009 to USD 174.5 mln in 2017. Although growth in Moldova's ICT services exports is encouraging, these exports comprised only 10.5 percent of total service exports in 2018 (see Figure 3).

FIGURE 2: MOLDOVA ICT SERVICE EXPORTS VS OTHER HIGH-TECH EXPORTS, 2009-17 (US$) SOURCE: WORLD BANK, 2019



ICT services exports include computer and communications services (telecommunications and postal and courier services) and information services (computer data, news-related service transactions). ICT goods exports include hardware such as computers and peripheral equipment, communication equipment, consumer electronic equipment, electronic components, and other information and technology goods (miscellaneous). Other high-technology exports are products with high R&D intensity, such as in aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery. Source: (World Bank, 2019).

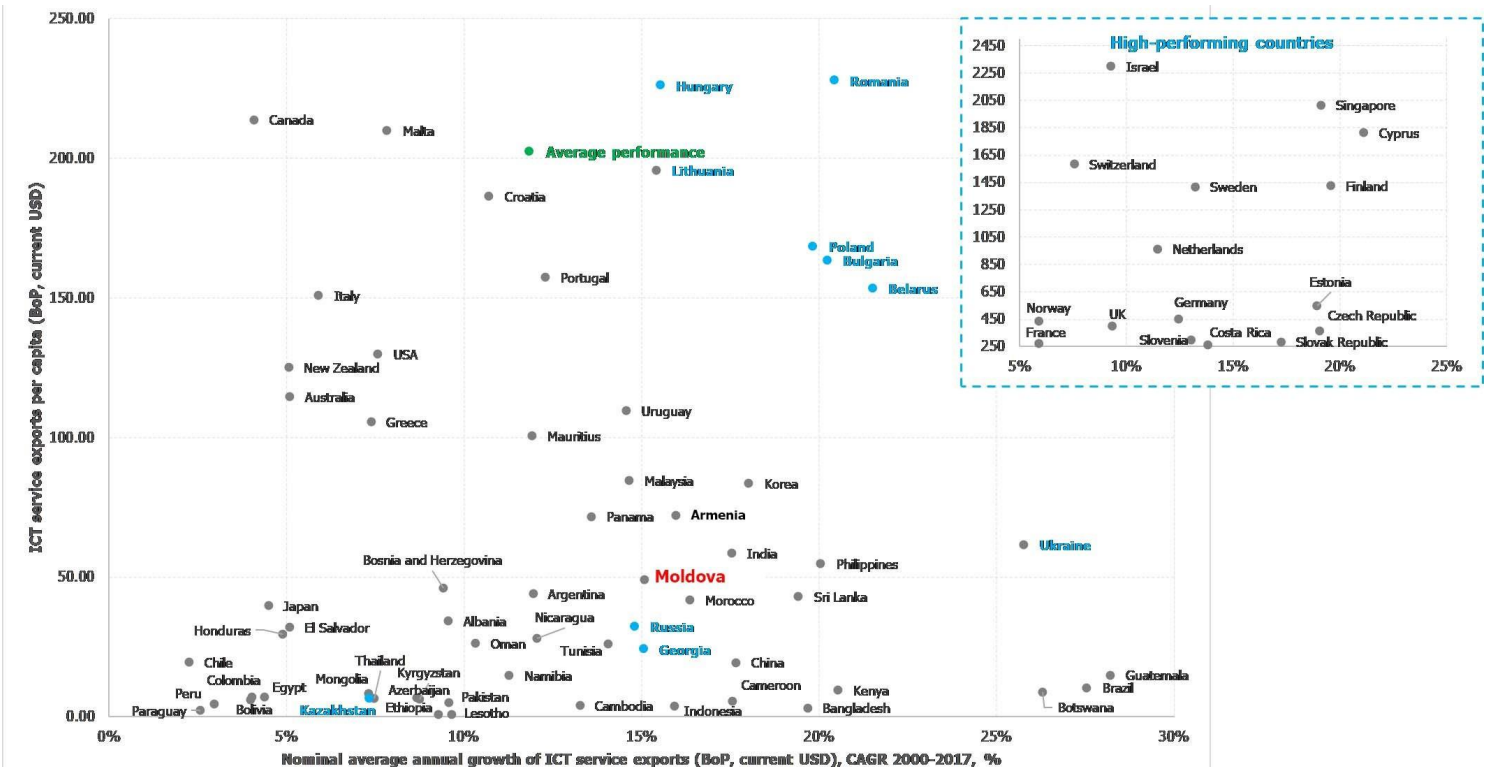
FIGURE 3: EXPORT OF IT SERVICES IN MOLDOVA SOURCE: IT STRATEGY OF MOLDOVA



Growth in ICT exports compares favorably with regional competitors, but there is still room for improvement. Moldova compares favorably with some of its regional competitors, including Kazakhstan, Albania, Georgia and Russia. In addition, Moldova outperforms global ICT service giants like China on a per capita basis (see Figure 4).

However, there is still room for improvement; Belarus, Bulgaria, Poland, Lithuania, Hungary, Romania, Slovenia and the Slovak Republic exported US$150 to US$250 in ICT services per capita in 2017, compared with Moldova's US$49 in ICT services per capita. (Exports per capita of global leaders are far higher, in excess of US$1,000 per capita in 2017.

FIGURE 4 - ICT EXPORTS PER CAPITA VS CAGR OF ICT SERVICE EXPORTS (US$). REGIONAL COMPARATOR COUNTRIES ARE HIGHLIGHTED IN BLUE. SOURCE: (WORLD BANK, 2019)



The development of IT sector in Moldova is driven by the export of software development, support and testing services. Currently, Software development outsourcing services are accountable for over 95% of IT exports revenues in Moldova. Moldova's software and hardware development community targets highly saturated global vertical sectors where: (i) Moldovan firms have little or no comparative advantage; (ii) opportunities for upgrading and vertical integration are limited; and (iii) building a customer base is reliant on proximity. Examples include HR management software development, banking software, etc. Companies have targeted these activities as they have low barriers to entry, and solutions that can be readily developed and delivered remotely. However, these same low barriers to entry that make the mass-market applications 'attractive', also make them highly competitive globally.

The Moldova's IT industry, the growth of which was spurred mainly by cost-driven outsourcing, is currently facing maturity and significant competitive pressures. This may put Moldova into a trap of losing to other destinations over the long run, if the competitive model is not modified. In 2018, the combined IT services market had an estimated value of 154.4 million with $33.5 million accounted for in the domestic market and $120.90 million representing exported services. The main drivers for the domestic market are implementation services (including software and hardware deployment and support), accounting for almost 46% of spending in 2018, driven mainly by the government's continuous investment into eservices.

The main driver of the outsourcing market is the IT services, which accounts about 70% of the total outsourcing market (IDC, 2019). While it is important to increase the value of Moldova's ICT Services exports, the types of exports (and underlying activities therein) are equally important. As noted in the World Development Report 2020, global trends are seeing a reduction in reliance on human resources to perform such activities.

FIGURE 5: IT SERVICES MARKET DISTRIBUTION, SOURCE, IDC, 2019

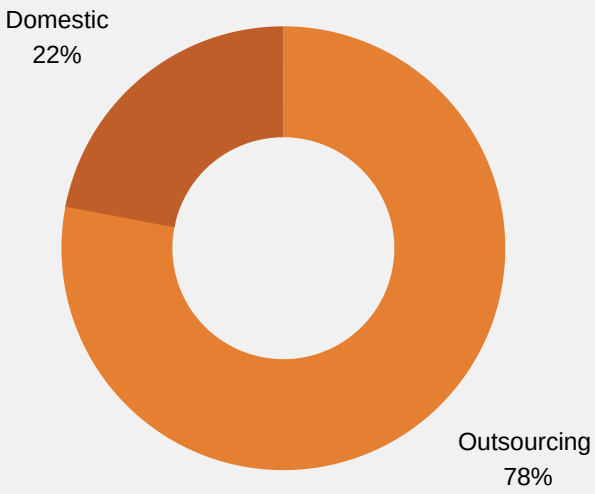
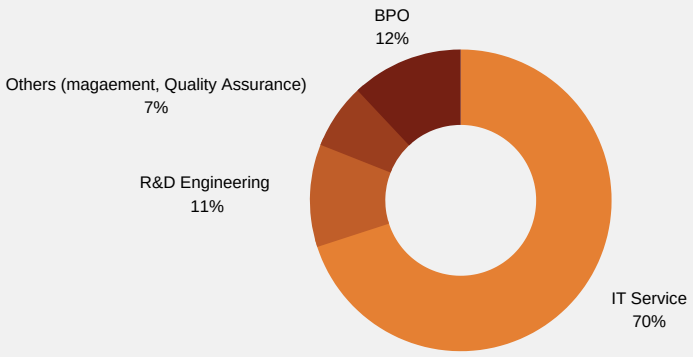


FIGURE 6: IT OUTSOURCING MARKET SOURCE: IDC, 2019



Own product development is starting to be in a positive trend. Tech entrepreneurship ecosystem has successful startup examples that can trigger local companies to move away from a service model toward product design. One of the successful startups is XOR, that started at Tekwill with 8 people and has grown to become a type of game changer in the sector. XOR is a human resource and talent acquisition workflow automation solution, that utilizes artificial intelligence and automation technologies to massively scale its customers' recruiting efforts, speed the hiring process and lower overall costs. It managed to raise more than $8m funding and is trying to scale the business in the Europe.

There are various institutions and initiatives aimed at the sector development. Moldovan Association of Information and Communications Technology Companies, ATIC, is the main entity promoting the development of the ICT sector in the Republic of Moldova through partnerships between the private companies, state institutions, and international organizations. USAID's Moldova Competitiveness Project (MCP) is another big initiative, which includes various project aimed at sector development. World Bank has contributed a lot to the enhancement of the existing education infrastructure as well as education quality in schools and HEI. Other donor organizations, such as EU, GIZ and Swiss Development Agency are actively involved in improving the VET education with focus on tech related specializations.

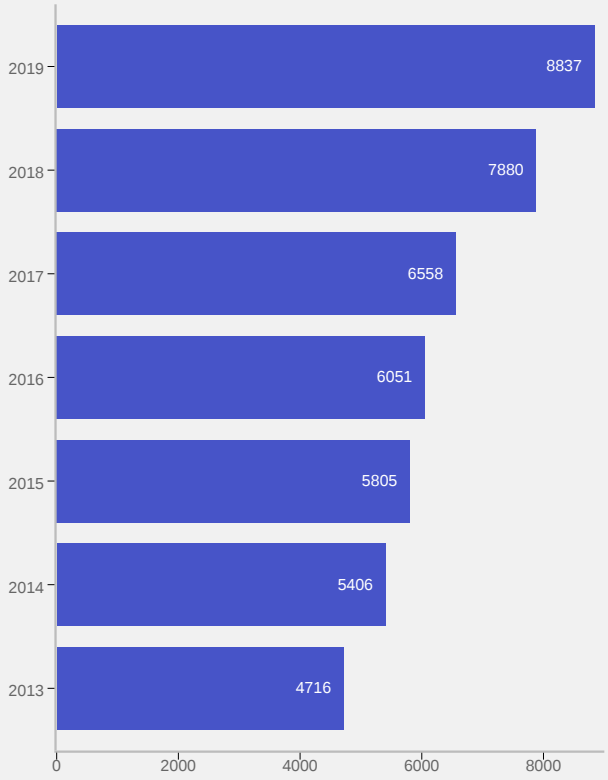
COVID-19 impact analysis on the sector shows, that companies mostly affected by the pandemic in the sector were the ones providing an outsourcing contract. As a result of cost cutting needs and company restructuring, companies in the sector working on pure outsourcing contracts, have faced the most difficulties. On the other hand, companies who represent the core development or R&D unit of multinational company were the less impacted ones. The same applies also for companies developing own products and dealing mainly in the B2C sector, rather than in B2B sector.

A scarce and limited labor force supply is the major constraint for the future growth of the industry. Currently, the supply of high-quality programmers and engineers is limited, and some specific segments are far below the demand. There is a shortage of 1000 employees annually and companies spend on average 6 months for additional training to upskill the employees. The limited specialists supply is also one of the challenges for the startup ecosystem growth in Moldova. The inability of educational institutions to supply high quality specialists is the key obstacle.

1.2 IT JOB MARKET OVERVIEW

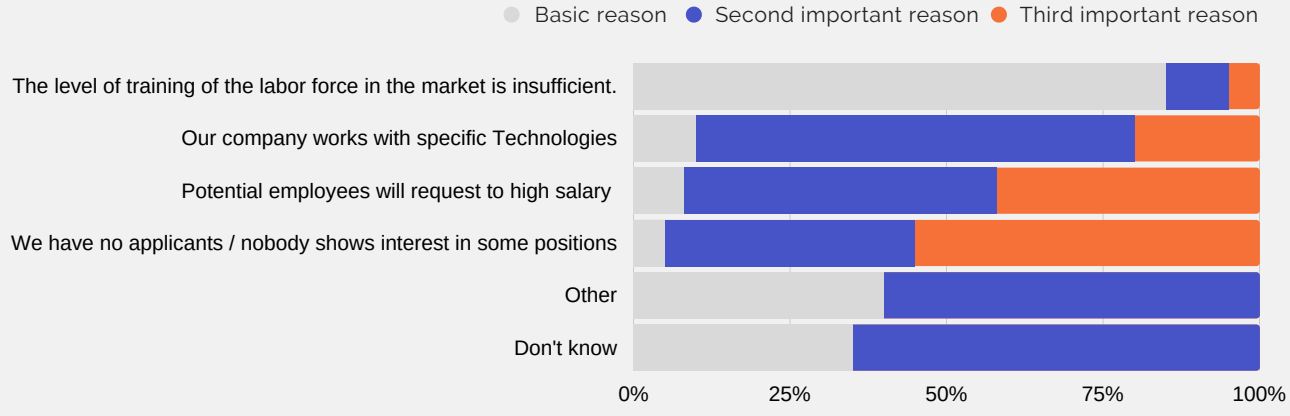
As of 2018, sector employs more than 7000 specialists, and labor market recorded 13% growth from the previous year. Due to growing number of IT companies in Moldova, demand in IT specialists will continue to increase. The tendencies of growth of local and international companies on the market shape a strong message about the increasing demand of IT specialists in Moldova. According to the estimation, if the market continues to grow with an average rate of 11%, the absorption potential of additional IT specialists will grow at a rate of 12% annually and reach ~25,000 by 2023. The sector's labor productivity is $22,000 for 2018.

FIGURE 7: NUMBER OF EMPLOYEES IN IT SECTOR IN MOLDOVA, 2013-2019 SOURCE, NBS, 2019



Moldova is facing limited human capital accumulation and low levels of innovation among firms. Skill mismatch is one of the main factors behind these issues. The companies in the sector, mainly dealing with software development services, report growing shortage of professionals for hiring. Despite the number of graduates from universities, companies struggle with qualified personnel, hence there is a problem of quality rather than quantity. The supply side is not able to provide enough quality specialists for the companies to hire and the main reason mentioned in the survey conducted by USAID in 2016 is that the level of training of the labor force in the market is insufficient. Share, requiring on-the-job training to become qualified enough to fill full-time positions. Moreover, the lack of qualified labor force is often mentioned as a reason not to settle a foreign business in Moldova.

FIGURE 8: MAIN REASON FOR LACK OF SPECIALISTS. SOURCE: USAID, 2016



Software developers dominate the IT job market, accounting about 17% of total workforce. Other occupations, like system engineers, testers and Database specialists and project managers are equally distributed with about 12% from total market share. Web Design and customer support comprise the lowest percent.

Skills shown in the chart below were mentioned by managers as essential for their IT staff, which manly comprises of the JAVA technology, PHP and Python. Security and networking were named by a majority of respondents as important for their business. Technology-wise Microsoft and Linux have about equal need among major enterprise.

FIGURE 9: IT STAFF EMPLOYED AND ITS SKILLS, SOURCE: USAID, 2016

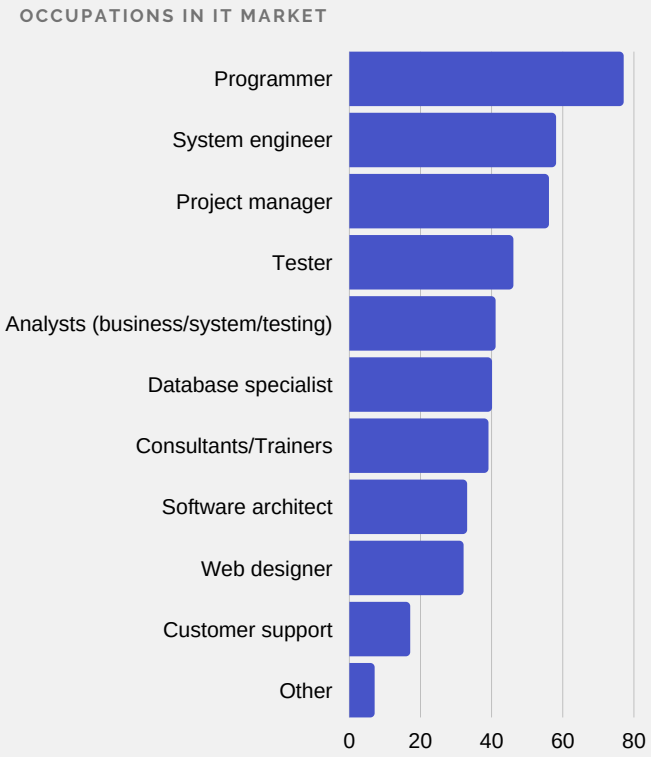
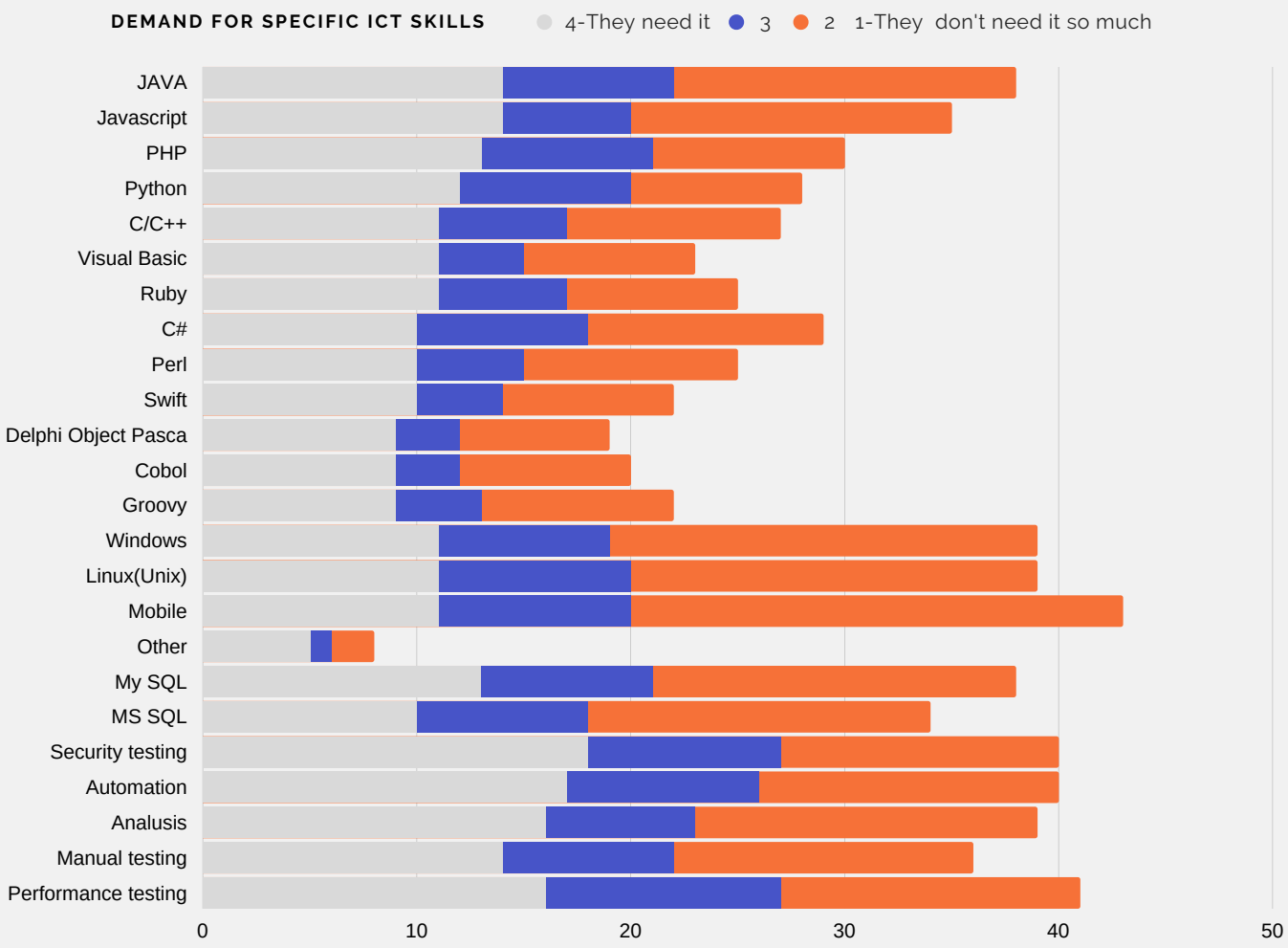


FIGURE 10: MAIN REASON FOR LACK OF SPECIALISTS. SOURCE: USAID, 2016



Although there are several institutions, that provide education in the relevant disciplines of Information technologies, the main supplier of the workforce is the higher education institution, and concentrated mainly at UTM.

Although we can see that the skillset demanded is not sophisticated and can be provided by colleges also, the main institution from where students get hired is UTM. Meanwhile, companies almost don't hire from the college students / graduates.

FIGURE 11: RECRUITMENT AND HIRING OF EMPLOYEES. SOURCE: USAID 2016

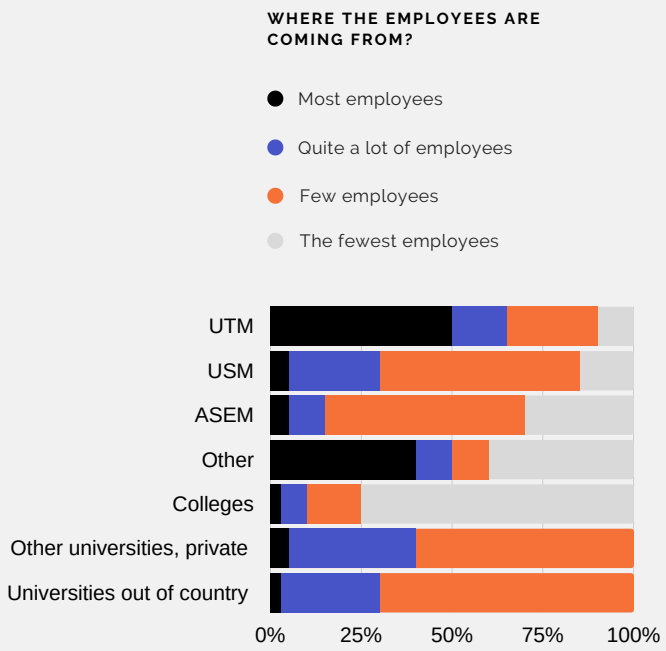
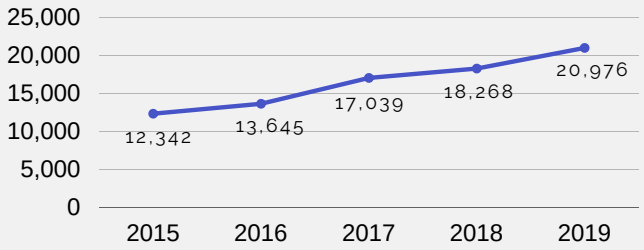


FIGURE 12: AVERAGE MONTHLY SALARY IN IT SECTOR IN MOLDOVA (MLD), 2015-2019 SOURCE: NBS, 2019



The migration trend severely impacts the pool of available IT specialists in Moldova. Currently there is a significant migration outflow from Moldova caused by economic conditions, which causes a brain drain in IT and High technology industry. Most of the interviewed companies confirm that recently retention is dropping due to the high number of emigrating employees. People who have the ambition of professional growth as a priority and who do not see enough opportunities in Moldova with respect to career are moving to other countries.

As a consequence of the IT skills gap in the industry, the qualified candidates become more demanded, which impacts their salaries.

Official average net salary in IT sector grew by CAGR 11% in 2015—2019, from MDL 12,342 ($686) in 2015 to MDL 20,976 ($1,178) in 2019 (NBS, 2019). The official level of average monthly net remuneration in Moldova for year 2018 was about $140. This indicates that IT sector is a very high value-added sector and the increase in the jobs of the sector will have a positive effect for the economy as a whole.

2. IT EDUCATION IN MOLDOVA

2.1. EDUCATION SYSTEM OVERVIEW

Moldova's population has been rapidly shrinking since the country's independence. An annual decrease of the population of around 1% has been recorded since 1991 as a result of youth emigration and declining birth rates. Emigration of youth (after finishing their general education at school) and brain drain of talented students and specialists is a key concern in Moldova, especially in high value-added sectors, such as IT sector. Moldova has one of the top ten highest emigrant stock shares of the total population among ECA region countries (World Bank, 2018). Data shows that the emigration rate of high-skilled workers is close to 40 percent in Moldova. Two thirds of the people who left the country are from rural areas and most of those are also young people. This decline has been clearly reflected in the education statistics - in the declining number of primary and general secondary education institutions, number of pupils, number of universities and students in the universities.

FIGURE 13: NUMBER OF INSTITUTIONS IN PRIMARY AND SECONDARY EDUCATION (2010-2018)

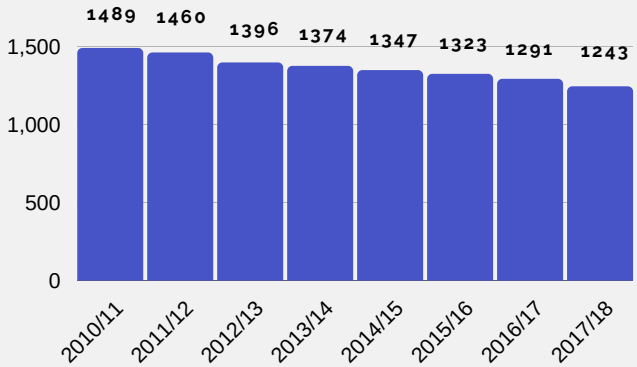
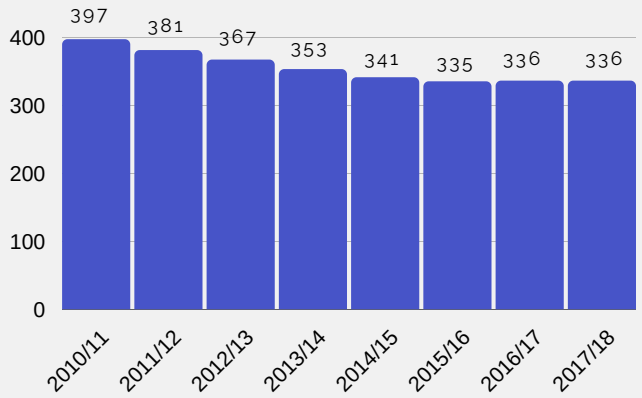


FIGURE 14: NUMBER OF PUPILS (THOUDSAND) (2010-2018)
SOURCE: NBS



The mentioned demographic challenges and the rapidly changing labor market highlight the need for reforms in Moldova's education system. A continuous decline of the number of students have had a negative impact on the education system's efficiency. Moldova's economic development objectives and the skills that are required for participation in a fast-changing labor market implies that increasing emphasis is placed on the acquisition of basic skills by students. Improving the relevance of Moldova's education system is fundamental to address this challenge.

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Moldova improved its PISA scores in 2018 and ranked 52n from 78 countries. PISA is an international study conducted every three years which aims to assess education systems globally by testing 15-year-old students' abilities and knowledge in three subject areas - science, math, and reading. Students in Moldova scored lower than the OECD and CEE average in mathematics and science, although improved scores since 2015. There are 1,243 schools in Moldova and total number of kids and children studying at the lyceums, gymnasiums and elementary schools in the country was 336,000 in 2018. The overall quality of the education has a room to improve, which is also demonstrated in World Economic Forum's (WEF) ranking on the Quality of Educational System. Moldova ranks 103rd in the world in terms of quality of educational systems by WEF.

FIGURE 15: NUMBER OF INSTITUTIONS IN PRIMARY AND SECONDARY EDUCATION (2010-2018)

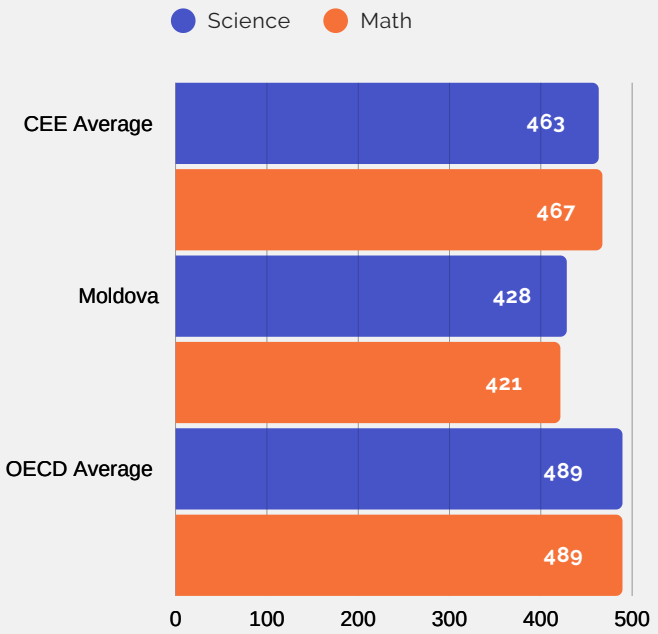
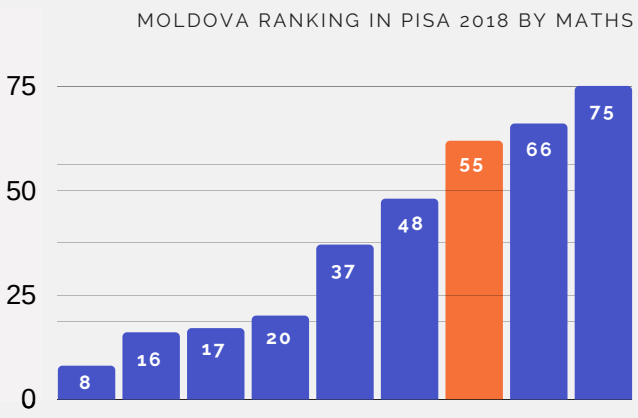


FIGURE 16: NUMBER OF PUPILS (2010-2018) SOURCE: NSB



The country's Vocational Education and Training (VET) system struggles with its low brand, which leads to the small size of student enrollment. At present, there are 89 VET institutions in Moldova, which enroll around 44,000 students Based on the demand of the skills mentioned by the IT companies, and discussed in chapter 1, the skillset can be also provided by the VET institutions. However, it is not being done currently, leading again to the industry and education gap. Various donor organizations, including European Union and GIZ are conducting projects to improve the system.

FIGURE 17: NUMBER OF INSTITUTIONS IN PRIMARY AND SECONDARY EDUCATION (2010-2018)

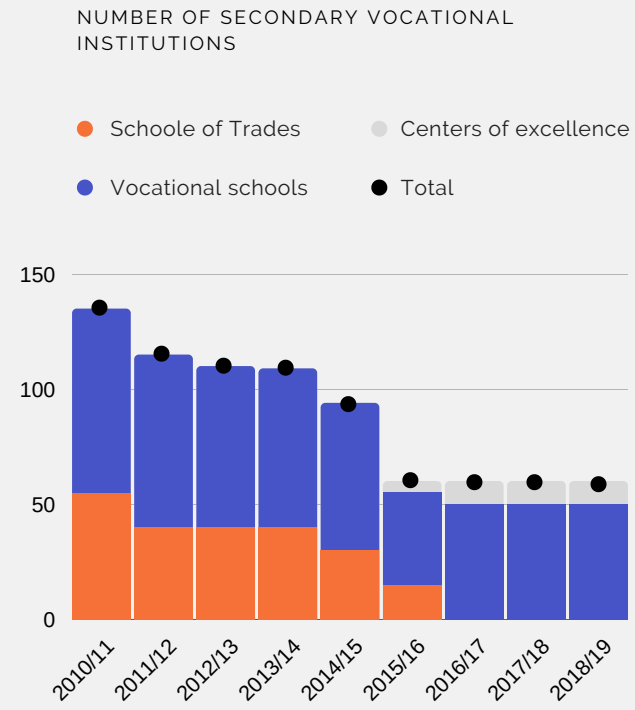
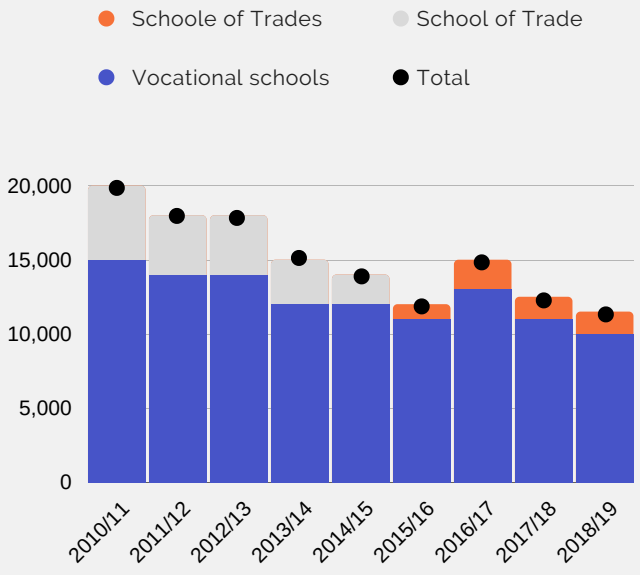


FIGURE 18: NUMBER OF STUDENTS IN SECONDARY VOCATIONAL INSTITUTIONS (2010-2018) SOURCE: NSB



Moldova's higher education system has been facing significant declining enrolment rates over the past 6 years. The country currently has 29 higher education institutions (a drop from 35 institutions in 2005), out of which 19 (65%) are public. There has been a decline of 37% in the number of enrolled students at the universities from 2010-2016. This decline in the number of enrolled students is a matter of concern. The main reasons for this phenomenon include falling birth rates, incentives for studying abroad, emigration for better living conditions, etc.

FIGURE 19: NUMBER OF HEI (2010-2018) SOURCE: NSB

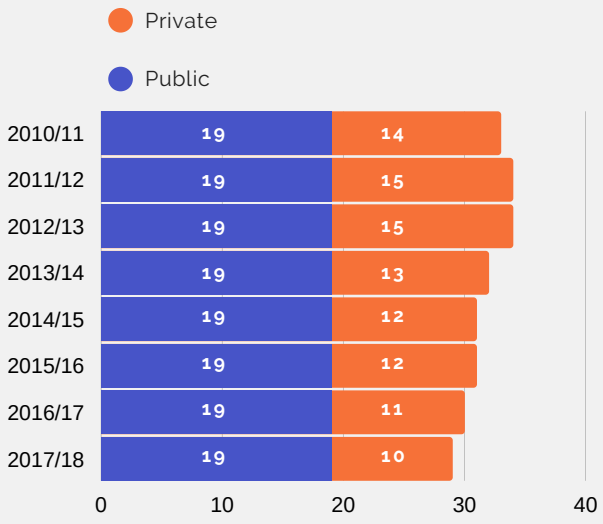
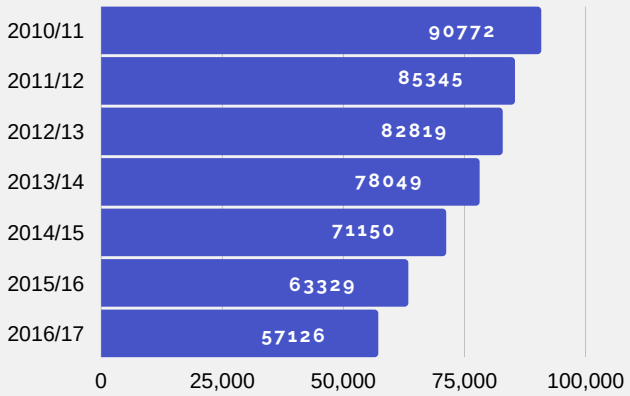


FIGURE 20: NUMBER OF ENROLLED STUDENTS AT HEI

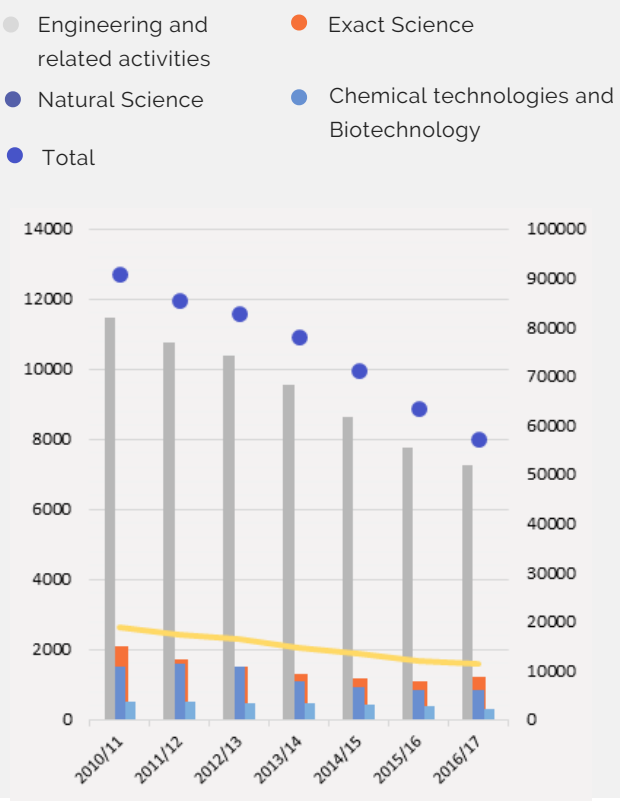


2.2. IT EDUCATION

Out of 29 universities and 45 colleges in Moldova, only in 12 of universities and 7 colleges are thought IT related studies. The available academic infrastructure is in place for educating professionals in IT. General informatics, software and telecom engineering graduate studies are provided by 12 universities in the country including three regional schools with the campuses in Balti, Cahul and Comrat.

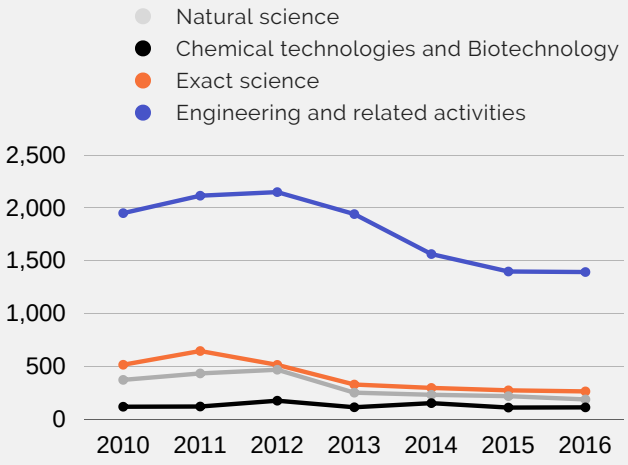
There is a decreasing number of Students and Graduates at higher education institutions (HEI) in STEM related fields. There are 2000 graduates yearly with degrees in IT, Engineering and Math. Computer science students account for 6% of the total number of graduates (Moldova IT strategy, 2016). UTM is Moldova's largest technology university. In 2019, this school accepted 708 young people or 63% of all enrollees in ICT bachelor level studies in the country. Together with overall decline in number of students at HEI, the enrollment rate in the STEM related subject has also declined by 39% since 2010. Highest subject of enrollment - 75%, is the Engineering and related activities areas, followed by 13% in exact sciences and 12% in Natural Science and Chemical technologies.

FIGURE 21: NUMBER OF STUDENTS HEI IN STEM VS OTHER AREAS. SOURCE: NSB



Every year approximately 12-15% bachelor's students at IT and telecom study programs drop out the studies. Some of them leave for studies abroad, some of them find a job and don't want to continue their studies, but majority do this because of weak lyceum background and wrong assumptions and expectations.

FIGURE 22: NUMBER OF GRADUATES S AT HEI IN STEM. SOURCE: NSB



The teaching staff is gradually aging, which combined with a weak links with private sector makes the teaching practice less valuable. The necessity of the existing lecturers to go through requalification programs and to adapt international teaching methodologies is undeniable, as the existing curriculum and methodological practices are already out-of-date. Simultaneously, due to low remuneration and diminishing prestige in academic career, there is an acute deficit of younger specialists teaching in academia, with hands on practice in sector. As another precondition, the lecturers are required to possess higher scientific degree for teaching the lower degree course programs, e.g. lecturer with Master's degree has the right to teach Bachelor's course. This diminishes the potential pool of the candidates further.

Due to the gaps between the university program and industry requirements, job applicants tend to learn the upgraded technical knowledge and skills mostly during the probation period in the company. Higher education plays a key role in developing basic skills of graduates. These skills form the basis of theoretical and practical knowledge levels of the graduates, as well as shapes fundamental mathematical and algorithmic thinking after school. However, local companies consider that these skills are mostly below expected average and are outdated. This relates to both the fundamental technical knowledge and the more generic soft skills of the graduates.

The gaps in higher educational systems are partially being filled by the increasing role of the IT training providers. Several innovation centers, training centers and laboratories were established within the premises of universities with the collaborative effort of state, non-profit, private and government sectors. Among the established center is the Tekwill located in the premises of Technical University of Moldova. It was created with the support of the United States Agency for International Development (USAID) and the Government of Sweden through Sida/Swedish International Development Agency in the framework of the project "Development of Moldova ICT Excellence Center" implemented by Moldovan Association of ICT Companies (ATIC) in partnership with Technical University of Moldova.

The quality gap of the skills in IT and High technology sector is due to low quality of graduates from local higher education institutions, according to the sector companies. The university degree of candidates is in fact not important at all, as the knowledge and skills provided in the degree programs are not enough for the entry to the industry.

Educational sector needs to quickly adapt and reflect these challenges in order to sustain the sector competitiveness. In order to sustain the growth based on the high-quality labor force, the country currently faces the issue of providing enough supply. The increasing IT skills is a global trend, but in Moldova it is more constraining due to small size of the industry and the country. At the current point of development of the sector, this is a complex issue, as the skills gap increases with the positive dynamics and development of the industry. This implies that the shortage of the skills will increase in parallel with the sophistication of the industry, and education needs to aligned to face those developments.

3. MAPPING AND ASSESSMENT OF CURRENT IT EDUCATIONAL INITIATIVES

3.1. MAPPING & DESCRIPTION OF THE INITIATIVES

The following map includes key initiatives in the IT education, as well as formal educational institutions, that contribute to the talent development. The mapping was done mainly using the age group and type of education they get.

KIDS
(working with students studying at schools)

- Educational Robotics
- Future Classroom LAB
- Coder Dojo
- Tekwill in Every School
- Tekwill Academy Kids
- Novoteca

JUNIOR
(working with students studying at universities)

- USM
- UTM
- ASEM
- USCH
- State University of Bălți
- ULIM
- UPS "I. Creanga"
- Tiraspol State University
- Comrat State University
- Colleges
- FabLab
- CIRCLE Labs
- Tekwill Academy
- OPTIM program (SDS)
- Scholarship for VET (Orange)

MIDDLE
(working with post-graduate young people <30)

SENIOR / TEACHERS
(working with senior talent >30, including teachers)

- Tekwill Ambassadors Program
- Future Classroom LAB
- Scholarships for Excellence (Orange)
- ProDidactica

3.1.1. IT EDUCATION INITIATIVES

Educational Robotics

The program aims to increase the quality of formal education in school and introduce innovation into classroom education. It also aims to inspire and empower students ages 8 to 16 to get more excited and interested in STEAM related subjects and motivates them to pursue further careers in tech. Educational Robotics program has several components, including training teachers in using robotics for Building Robots, Building Careers educational activities, equipping schools with LEGO robots, creating robotics clubs where students aged 8 to 16 experience a hands-on application of science and engineering and organizing thematic contests for implementation of competition-based learning. Currently, the Educational Robotics program focuses on elementary and middle school aged youth in 112 schools and 19 libraries across Moldova, and at least 150 teachers delivering courses in robotics. Moldovan Ministry of Education has introduced robotics into the optional curriculum and the Government decided to introduce robotics also in the formal curriculum.

Impact: More than 15,000 Moldovan youth (almost 10% of all pupils) and 240 teachers participate in the program, including participants from rural areas. With the help of this program, students have gone on to compete and win international robotics competitions (3 Gold medals last year from Dubai), including the FIRST LEGO League. Besides technical skills, students become more creative and develop essential soft skills like problem solving, critical thinking, and working in teams. More then 200 teachers were trained in robotics education.

Future Classroom

Future Classroom is based on the Future Classroom Lab (FCL) initiative created by European Schoolnet - the largest EU initiative to innovate K12 education through technology. Future Classroom equips Moldovan schools with inspirational learning environment coupled with market driven, transformative learning technologies, such as coding platforms, SMART interactive screens, robotics sets, 3D printers, digital laboratories, sensors, microcircuits, VR headsets, panoramic cameras, smart home devices and systems, etc. It was piloted in 11 schools together with Orange Moldova Foundation, and pilot schools used the technology to organize integrated lessons involving teachers of various subjects and using digital equipment, enabling students to experiment with hands-on activities. After the successful pilot, additional 20 schools were involved in the program, totaling 31 schools benefiting from the program. The National Future Classroom Center was developed at the Ion Creangă Pedagogical University, which aims to inspire teachers in the application of new technologies in the process of training students and train over 1,000 current and future teachers annually.

Impact: 31 Moldovan schools are implementing Future Classroom, innovative learning scenarios, using digital equipment. More than 3500 students and 175 teachers from 31 schools across Moldova have tested the approach in more than 618 integrated lessons, with outstanding results.

Tekwill in Every School

This Tekwill initiative aims to provide every school in Moldova the opportunity to access a free eLearning platform with high quality and interactive online courses allowing them to acquire the necessary knowledge and skills required by the future jobs' workplace. The initiative is starting with the development of the Tekwill in Every School courses and then adding to the platform information related to all opportunities and resources available for K12 education powered by Tekwill. The online courses will be on the following subjects: (i) Algorithms Programming in C/C++, (ii) Artificial Intelligence; (iii) Web Design & Development, (iv) Mobile Apps Design & Development, (v) Graphic Design, (vi) Video Storytelling, (vii) Entrepreneurship (viii) Emotional Intelligence. The deployment of the platform is expected to take place as a pilot at Tekwill. Online groups of students will be created in order to test the technicalities of the platform. Learners will have a first-hand experience of the platform and its innovative learning process. Following the pilot phase, the project will be launching the platform and its content to every school in Moldova.

Impact: The project is in its initial stage of starting. The online courses are already developed. About 80,000 students are expected to receive education through the platform by 2021. TwentyTu will provide free extra-curricular classes for 80,000 pupils - children (7-12 years) and adolescents (13-19 years) and will train 2200 teachers. 77 schools are selected for the pilot, almost 20,000 beneficiaries, aged 13-19 are expected during the 1st year.

Tekwill Academy Kids

Tekwill Academy Kids is the Educational initiative within Tekwill for children and youngsters, developed as a need to equip the new generations with critical skills (creativity, algorithmic thinking, problem solving, communication and collaboration skills). There are 14 courses developed under the program and provided on a fee basis to interested beneficiaries. An average 500 children attend the courses on a monthly basis in the areas of Robotics, Arduino, Web Development, Design, etc.

Impact: Since June 2017, over 5000 students graduated from 14 unique programs in the field of: robotics, game development, web-design, 3D printing, etc. The success of this pilot project has prompted to significantly expand the Tekwill Academy Kids Program, in order to harness the potential of children and teenagers.

Digital Education for first grade students

On September 7, 2018, ATIC in partnership with Tekwill and Government of Moldova has launched the initiative of digital education in every first grade, by providing access to equipment and curricula to all first grade students, while the Government of Moldova has introduced the curricula as mandatory under the Technological Education module and made it available to apr. 30,000 children in its first year.

Impact: Impact: The initiative had a big success and continued for 2nd grade as a Government program. Meanwhile, ATIC and Tekwill will still continue to support the government of Moldova for the 3rd grade and it will eventually cover all elementary school – from grades 1-4.

Coder Dojo Moldova

CoderDojo is an international movement and aims to initiate children in programming outside of a school program through informal methods such as training, games and regular sessions. These trainings are facilitated by volunteering mentors, willing to engage in the project and is free for participants. Under the program, children aged between 7-17 years learn how to develop mobile applications, websites and games. IN Moldova, the project is implemented together with Moldovan software Development company YOPESO since 2014.

Impact: More than 160 youth learned to code, build websites and create games by attending the regular weekend class led by 24 professional-volunteers.

Novoteca

The project transformed public libraries into vibrant community centers that serve as gateways to social and economic opportunities and provide access to the information needed to benefit from them. It is implemented by IREX in Moldova, with the support of the Bill and Melinda Gates Foundation and USAID.

Impact: 1,082 modernized public libraries countrywide; 1,200 children improved their science and technology capacities through program-sponsored robotics clubs; 1,606 librarians received training in modern library concepts and IT; it sereves about 763,000 patrons per year, of which 75% are mainly youth.

FabLab

FabLab is a global initiative lead by Massachusetts Institute of Technology and is located at Technical University of Moldova. Fablab enables rapid fabrication and digital prototyping, being endowed with 3D printing, wood, plastic and metal processing equipment for innovators. It supplements the existing ICT Center of Excellence, Tekwill, to develop education, technical prototyping, and innovation in key growth industries like electronics, robotics, furniture and lifestyle, and automotive engineering. Three regional mini-FabLabs were launched in partnership with USAID Novateca in community libraries of Cahul, Ungheni and Drochia to inspire local innovation among youth.

Impact: Since its launch in spring 2018, FabLab started its educational and skills development programs, reaching more than 500 students and emerging professionals particularly in engineering fields. Several partnerships with global software companies were established to conducts specific training programs. Besides supporting the students at the University, Fablab also provides some services to the industry by using the available equipment.

CIRCLE IT&Engineering Labs

In partnership with Technical University of Moldova (UTM), Siemens and Bitdefender, the CIRCLE laboratory was established at UTM premises. It replaced the outdated labs at the Faculty of Computers, Informatics and Microelectronics and aims to support the development of market-driven curriculum to ensure the employability of tech graduates. CIRCLE benefits more than 750 students from 25 TUM departments, covering fundamental technological areas including control engineering and cyber security.

Tekwill Academy

Tekwill Academy is an educational component under Tekwill project, that provides regular courses and technical training on specific topics taught by trainers and top specialists form the sector in Moldova. The courses are targeted to people, who want to change their profile and move to the tech field or who want to update/acquire new skills or receive a certification. Through viable partnerships with leading world education providers such as Oracle, IBM, Microsoft, Cisco, PMI, ISTQB, it identifies training subject areas and delivers courses based on the market demand. The representatives of the private sector participate as mentors, trainers or supervisor during the courses. The courses are paid, with available discounts and scholarships.

Impact: There is already established partnership with ISD for conducting Java Fundamentals training and Endava for SQL trainings. Several successful training programs have been conducted in cooperation with IT companies, such as C# and PHP Fundamentals course in partnership with Amdaris and Pentalog respectively.

Tekwill Ambassador Program

The program is another initiative by Tekwill and is mainly targeted towards university professors and aims to update and enhance their knowledge in IT related disciplines. It has 3 main initiatives - UTeach, Scholarships and Community. "Scholarships" initiative provided training courses and certification in Java Fundamentals, SQL Fundamentals to 23 academic professors from 4 Moldovan universities and 50 students from TUM. 12 professors have also participated in Project Management Course. "UTeach" enrolled 22 university [IO1] professors with innovative ideas for adjusting the ICT curriculum to current industry requirements and trends. Most active leaders from the sector joined to the
Tekwill Ambassadors Community program.

ProDidactica & ATIC joint initiative

A joint project was implemented during December 2015- December 2018 by ATIC and ProDidactica addressing the improvement of the quality of vocational education in Moldova. The activities coordinated by ATIC were focused on addressing the skills of the teachers, adjusting the existing curricula to market needs, provide and improve internship programs, raising the capacity of VET teachers by organizing ToT trainings, Soft Skills trainings, etc; developing electronic tools for the management of the institutions, increasing awareness of VET specialties, involve students in ICT Career orientation campaigns, etc.

Impact: During the program the Center for Excellence in IT (Colegiul de Informatica) has been endowed with new relevant for the studies and meeting market needs equipment. Support has been provided in the following training areas: Java, Cisco, Project Management, Communication, Web Development, etc. Overall around 1500 VET students and over 200 VET teachers benefited from the support during the program.

OPTIM

Optim is a project funded by Swiss Agency for Development and Cooperation (SDC) and implemented by Helvetas Swiss Intercooperation. It aims to stimulate Moldova's market systems and generate more economic opportunities for its citizens. Currently, they are working with training providers to improve ICT courses and match them with the needs of the sector. They are also expanding the services of training centers to rural youth and women, who are now largely excluded from opportunities. In partnership with a Moldovan IT consulting company – IUCOSOFT, they conduct Java training to people interested in a programming career in the second-largest city in Moldova Balti, where no one was offering Java training. They conduct the training on the paid basis in order to ensure further sustainability of the project.

Impact: Impact: Tekwill and OPTIM have piloted 3 courses in the regions starting May 2020 as online courses: Full Stack Developer, Arduino and Graphic Design.

Scholarships for vocational training

The project implemented by Orange Moldova Foundation is providing scholarships for young people to study at the vocational and technical education institutions at regions of the country. The project is implemented by the University Information Center, with the full financial support of the Orange Moldova Foundation and in partnership with the Ministry of Education, Culture and Research of the Republic of Moldova and the Ministry of Health, Labor and Social Protection of the Republic of Moldova.

Impact: It has started in 2010, in the last 9 years supported 737 young people with the total budget of USD 492,000.

Scholarships for Excellence

Orange Moldova Foundation implements the project since 2015 provides scholarships worth 25,000 lei per year to teachers of computer science, mathematics and physics, who work in rural institutions in Moldova. The project aims to encourage the employment and retention of STEM teachers in regional educational institutions that have an acute shortage of teachers, as well as to improve the quality of the educational process, by using digital tools in the teaching process.

Impact: 120 teachers of computer science, mathematics and physics, as well as their students have benefited from the project.

3.1.2. FORMAL EDUCATION INSTITUTIONS WITH IT DISCIPLINES

Moldova State University (USM) was established in 1946. It has 11 faculties covering almost all the fields. One of the faculties is the Faculty of Mathematics and Computer Science. Together with Physics and engineering, these departments prepare tech specialists in spheres such as data analytics, cybernetics, engineering, software development etc. About 600 students are enrolled in the of Mathematics and Computer Science with different specializations. The faculty collaborates with some IT companies, including ALLIED TESTING, CEDACRI INTERNATIONAL, ENDAVA, which provide students with practical training in specialized IT laboratories. The graduates of this faculty are working in the leading companies either in Moldova or abroad. The Faculty of Mathematics and Mechanics has 521 students enrolled.

Technical University of Moldova (UTM) was founded in 1964. The university is one of Moldova's leading sources of IT specialists. Currently, it has 9520 students (of whom 6095 full-time students), who study in 64 specialties and specializations, in 9 faculties -Energetics and Electrical Engineering, Mechanical and Industrial Engineering, and Transport, Computers, Informatics and Microelectronics, Electronics and Telecommunications, Food Technology, Textiles and Polygraphy, Constructions, Geodesy and Cadastre, Urbanism and Architecture, Economic Engineering and Business. It has the Centre of Excellence for Space Sciences and Technologies (hereinafter -NCST-TUM), established by a consortium of Technical University of Moldova, academic institutions and some high-tech SMEs in order to take advantage of the benefits of space technologies and applications in Earth observation, meteorology and astrophysics.

Academy of Economic Studies of Moldova (AESM) is one of the leading universities in Management, and Economics, established in 1991 in Chisinau. It has over 4000 students annually, 6 faculties, including the tech related faculty of Economic Cybernetics, Statistics and Informatics. The faculty s has the following specializations: Economic statistics and forecasting, economic cybernetics and informatics, Informatics (informatics, applied informatics), system engineering and computers (information technology, information security).

Ion Creangă Pedagogical State University (UPS "I. Creangă") is the main pedagogical university in Chisinau, Moldova, established in 1940. Currently, 6000 students are studying in the university in over 40 specializations.

The Faculty of Education Sciences and Informatics was founded in 1986 and prepares teachers for the field of Educational Sciences, ensuring them professional qualifications, as well as the development of scientific research competence at the level of national and international standards and trends. Currently, 1274 students, master students and doctoral students are studying at the Faculty of Education and Informatics.

The Free International University of Moldova (ULIM) was established in 1992 and is a private university. Currently, ULIM has 7 faculties, where approximately 6000 students are enrolled, from which 1500 are international ones from 15 countries around the world. It is the Faculty of Computer Science, Engineering and Design with the following specializations - Information Technologies, Information Security, Informatics and Interior Design. The university cooperates with private sector companies, such as ENDAVA and IUCOSOFT to enhance its curriculum and conduct internship programs for the students.

Alecu Russo State University of Bălți (USARB) is the only provider of university level IT graduate studies in Balti and on the North of Moldova, established in 1945. In total, there are approximately 4,700 students. USARB offers three bachelor's level study programs in IT- Mathematics and Informatics, Informatics (pedagogical) Informatics (exact sciences), and two more programs at the master's level - Database administration and web technologies, Web development.

Every year USARB accepts approximately 50-60 young people for its full time and distance bachelor's IT study programs and 15-20 more people register for master's studies.

Cahul State Bogdan Petriceicu Hasdeu University (USCH) located in the South of Moldova, was established in 1999. USCH offers Informatics for bachelor's level study and Information technologies in education study program for the master's level. Annually, there are about 2200 students enrolled at the university. In 2016, the University lost accreditation of its informatics and mathematics study program having no full-time mathematics professor with scientific degree in the staff.

Comrat State University (CSU) is located Comrat, the capital of autonomous region of Gagauzia. Annually, it as about 1,700 students. CSU has 4 accredited bachelor's level study programs in IT - Informatics (pedagogical); Informatics (exact sciences); Informatics and mathematics (pedagogical sciences); Information management, and 3 more accredited IT study programs for the master's students- Applied informatics, Didactics of informatics, Didactics of mathematics.

Tiraspol State University (UST) is the 1st higher education institution in Moldova was established in 1930 and currently has 5 faculties and 40 specializations. Faculty of Physics, Mathematics and Information Technologies has 11 study programs for bachelor's study level, including computer science and mathematics, computer science and physics, mathematics and computer science, physics and computer science, mathematics, computer science and 5 for master's study level.

Centre of Excellence in Informatics and Information Technologies (CEIIT) is the major center of excellence with Technical education and has the following tech specializations: Informatics, Computers, Managing Web Applications, Programming and analysis programs, Computer Networks, Computer Operator. CEITI collaborates with the private companies and other institutions from the country, including Orange, Financial Banking College, Polytechnic College, etc.

3.1.3. OTHER EDUCATION DEVELOPMENT INITIATIVES

Moldova in support of the Education Reform Project (MERP) by World Bank (2013-2020)

The project was designed to support the government's education reform program by focusing on interventions to strengthen the quality and increase efficiency in the education sector. MERP supports five priority areas of intervention: (i) implementation of quality assurance standards in receiving schools; (ii) establishment of teachers and directors' training and remuneration programs; (iii) improvement of the student assessment system; (iv) strengthening the quality of data and the education management information system (EMIS); and (v) increasing efficiency of General Education, which covers the primary and secondary levels.

Impact: As a result of the project, 6 schools renovated & reformed to become compliant with the quality standards; trainings for about 2630 teachers and 950 school managers were done; The 4th and 9th grade national assessments in Romanian language, Russian language and mathematics were revised; Consolidation and strengthening of the Educational Management Information System (EMIS) was done, which covers primary and secondary education, as well as including a new module for preschool and VET education.

Moldova - Higher Education Project by World Bank (2020-2025)

The project includes activities to address challenges observed on both the supply and demand sides, as well as to make higher education more attractive to Moldovan students who are currently leaving the country for academic and economic reasons, as mentioned above. One of the proposed interventions is on developing and implementing a new financing mechanism that is expected to improve the internal efficiency of the system, promote more accountability, and ultimately make investments from the State budget more targeted to improvements in the quality of services.

Impact (expected): The following key results are expected by the end of the Project: (i) each beneficiary university has at least one curriculum in its main academic area revised in accordance with the qualification standards developed under the Project; (ii) increase in the number of programs with national and international accreditation; (iii) higher education financing mechanism supported by the Project is adopted by the government; (iv) increase in the number of partnerships between public universities and firms.

Enhancing the quality and effectiveness of VET system in Republic of Moldova by European Union (2019-2021)

The overall Project objective is to support the Ministry of Education, Culture and Research and related VET bodies/institutions and actors in further implementation of VET Strategy 2013-2020 by improving capacity of key institutions in charge to assure quality with the special focus on teachers' competences and collaboration with private sector. In this context the project specific objectives are focusing on (i) strengthening the institutional and operational capacities and staff competences from the National Agency for Quality Assurance in Education and Research (ANACEC), (ii) supporting the further implementation of National Qualifications Framework of the Republic of Moldova, (iii) building the capacity for effective cooperation between VET providers and private sector, (iv) supporting VET teachers of Centers of Excellence to become multipliers through pedagogical training.

Orange Digital Laboratories by Orange Moldova Foundation

The project was launched in September 2015 and is aimed to contribute to facilitating the development of quality education in IT colleges in the country, as well as to removing the digital barrier in education in the Republic of Moldova. It is being implemented in all IT colleges in Moldova: the Center of Excellence in Informatics and Information Technologies, the Polytechnic College of Balti and the Polytechnic College of Chisinau. The project is setting up digital laboratories inside the institutions and equipping them with modern furniture, high-performance computers, state-of-the-art TV screens and free WiFi and 4G internet connection from Orange, the fastest internet in the Republic of Moldova.

Moldova Competitiveness project (MCP) by USAID

The Moldova Competitiveness Project (MCP) supports Moldova's efforts to promote a strong, diverse and export-oriented economy by improving competitiveness and efficiency in key industries. Within ICT cluster it is implementing various projects, mainly focusing on creation of talent pool to match the industry requirements by raising the profile of STEAM subjects, creating public-private partnerships and establishing centers of Excellence, as well as supporting the engineering and creative services sector. The Education initiatives, such as Education Robotics, Future Classroom, FabLab, CIRCLE IT & Engineering Labs, are supported by USAID within MCP project.

Dual Vocational Education and Training (VET)

Dual Vocational Education and Training (VET) by GiZ (2018-2021) The project supports the Ministry of Education, Culture and Research, as well as several private sector actors, social partners and training institutions, in identifying common approaches to improving the framework for dual VET. It is built upon the previous project - "Structural Reform in VET", that managed to have a good impact, - dual VET was mainstreamed into the existing VET system, as a viable alternative to the traditional, school-based VET. It also strengthened role of private enterprises in driving dual VET and almost 70 companies provided over 1,500 apprenticeship places in the school year 2018-2019 - almost twice as many as in the previous school year.

4. ASSESSMENT OF THE EXISTING INITIATIVES

4.1. IT EDUCATION FRAMEWORK

For the purpose of this report, the following education pyramid framework is developed in order to map and asses the existing educational initiatives in IT sector as well as propose the development strategy for the IT education in Moldova.

FRAMEWORK: THE EDUCATION PYRAMID

World Class Specialists
architects, scientists, data architects.
PhD, Doctorate, Scientists, Startups, Innovations, Ips.

Level 1

Working Skills
ensuring job, salary, outsourcing contract.
Colleges, Universities, Training Centers, Certification Programs.

Level 2

Basic Skills
Computer Science Principles, STEAM at schools.
K12, TVET.

Level 3

INFRASTRUCTURE

CONTENT & CURRICULA

TEACHING

EDUCATION GOVERNANCE

Enablers

The proposed framework implies, that the IT Education is based in the 3 main levels- that are built on each other in order to ensure getting the workforce of the future while filling in the current industry gap.

- **Level 3 -** Basic Skills implies providing basic computer science knowledge to the school pupils, together with a necessary environment and methodology, that can boost the interest in STEAM related professions in the future. The goal is goal to motivate & engage the students learn. The main educational institutions responsible for this level are primary education institutions -K12, lyceums and TVETs. As an outcome, everyone knows the basics of Computer Science and kids can do some meaningful activity.
- **Level 2 -** Working Skills imply the skillsets that are necessary to find a job in the sector. These are usually people working on outsourcing contract or junior and middle level specialists. Basic coders and technical specialists are also in this segment. The skillset demanded is not very sophisticated and can be obtained within existing trainings. The educational institutions providing these skillsets include colleges, Universities, IT training centers and certification program providers.
- **Level 1 –** Advanced Skills implies the skillset necessary to become a world class specialist in the sector, including software architect, data architect, system engineer, etc as well as for becoming a scientist, obtaining a PhD, and developing innovative solutions and product, establishing own Startups. The institutions responsible for these skillsets are mainly universities and research institutions.

Private sector cooperation with education sector is important to drive the specialists to this direction. The skillset is mainly obtained through work experience and self-learning. The main challenge of education system is to ensure that there is a big portion of students/ specialist at this level, which will ensure the country's competitiveness.

The framework also implies, that in order the education levels to work smoothly, there are 4 main enablers:

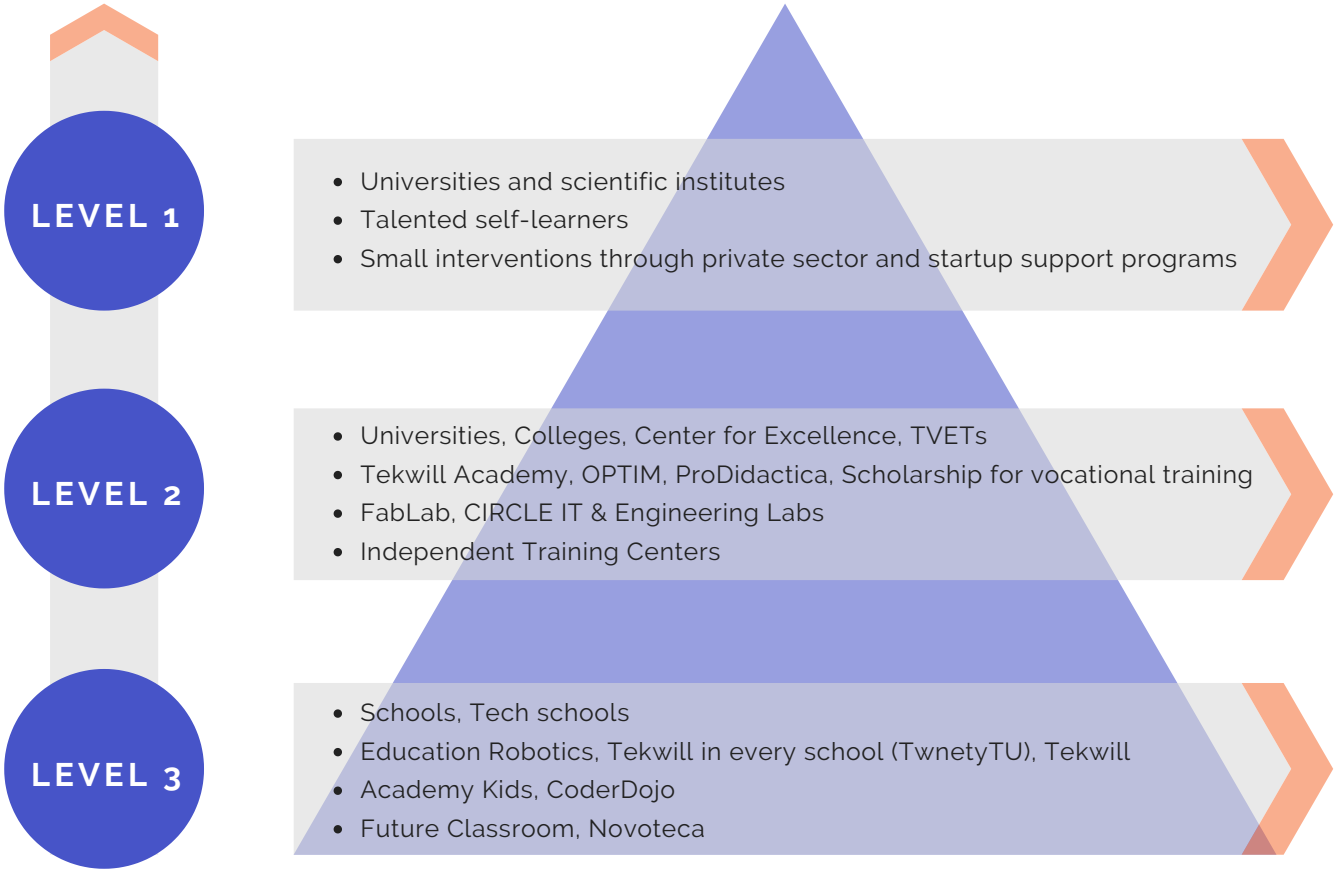
- **Infrastructure –** the physical assets necessary to organize the education process, including the space, furnishing, hardware & software, lab equipment, Internet and network access, as well as their maintenance on a systematic basis. This is especially crucial of IT and Engineering education, and STEM related disciplines, as availability of modern educational materials and equipment ensures that the education process is organized based on the latest trends in the market.
- **Curricula -** the education content provided in the educational and training institutions. Besides the fundamental knowledge, which is crucial to prepare students for the lifetime careers, all the education institutions need to ensure that their content is matching the industry needs, and that the curricula is not outdated. Particularly for IT related disciplines, where the technologies are very dynamic, it is important to be in line with industry to ensure the availability of necessary workforce.
- **Teaching -** the quality of teachers and the teaching methods. The hardest part

of all education institutions is to attract the best candidates and ensure their retention, mainly due to the low wages. Besides, the best specialists usually prefer to work in the private sector. Another issue is the teaching methodologies, which are one way and needs to be more interactive, incorporating digital tools in the teaching process.

- **Educational Governance -** the structure and management of the educational process mainly done by the various policies and government initiatives. This includes improvement of quality assurance within universities, their autonomy management, and clarification of the roles of each education institution. This also implies cooperation with universities and involvement of private sector in the curricula development, internship programs and involvement of company staff in the teaching process.

The mapping is done to understand the level of the education pyramid the initiatives contribute, and what the current situation is related to the education initiatives and their enablers. Based on the mapping of the initiatives, we can see, that the existing education initiatives target mainly the bottom of the Education pyramid and are targeted towards students studying at schools. This is very important for a long run, and for a systematic impact in the education.

4.2. WHAT WE HAVE NOW: ASSESSMENT OF INITIATIVES ON THE FRAMEWORK



		Level	Infrastructure	Curricula/ Content	Teachers	Edu Gov.
1.	Education Robotics	3	x	x	x	
2.	Future Classroom	3	x		x	
3.	TwentyTU	3		x		x
4.	Tekwill Academy Kids	3		x		
5.	Novoteca	3	x			
6.	Coder Dojo	3		x		
7.	FabLab	2	x			
8.	CIRCLE Labs	2	x			
9.	Tekwill Academy	2		x		
10	OPTIM	2		x		
11	ProDidactica	2		x	x	
12	Scholarship for vocational Training	2				
13	Tekwill Ambassador program	2			x	
14	Scholarship for excellence	2			x	
15	Orange Digital Laboratories	2	x			
16	MERP project by WB	3	x		x	x
17	Higher Education project by WB	2	x	x	x	x
18	VET system effectiveness by EU	2	x			x
19	Dual Vocational Education and Training (VET)	2		x		x

Initiatives, such as **Education Robotics, Tekwill academy Kids, Future Classroom Lab** are serving to the right purpose and motivate and engage the kids to learn in the STEAM related subjects and training the teacher for conducting classes in more interactive way. However, the enablers of this level are not well developed, particularly the infrastructure in terms of science laboratories in schools, teacher's quality, as most of them are in the retiring age and cannot embrace the new technologies in the educational process and the curricula. The computer science (CS) curricula need to be revised and replace the "informatics" subject..

Tekwill in Every School (TwnetyTU) on the other hand is an important initiative and has a potential having a big impact in terms of accelerating the shift to digital reality and enhancing the digital skills. The current post COVID-19 reality dictates, that online education and e-learning are going to be a crucial part of the primary education. This initiative needs to be more enhanced and be seen from a perspective of a changemaker in the primary education process. Relevant content updates, tools and methodologies need to be developed to ensure the engagement of kids during the online learning process. If the platform is successful, it can then be used in all subjects of the school. Teachers need to be trained to adjust their training styles for conducting the classes online.

CIRCLE IT& Engineering labs and FabLab are important initiatives for engineering education and as enabler act for infrastructure. The curricula and content part can be improved and prepare abundant ground for further sudden improvements in engineering education.

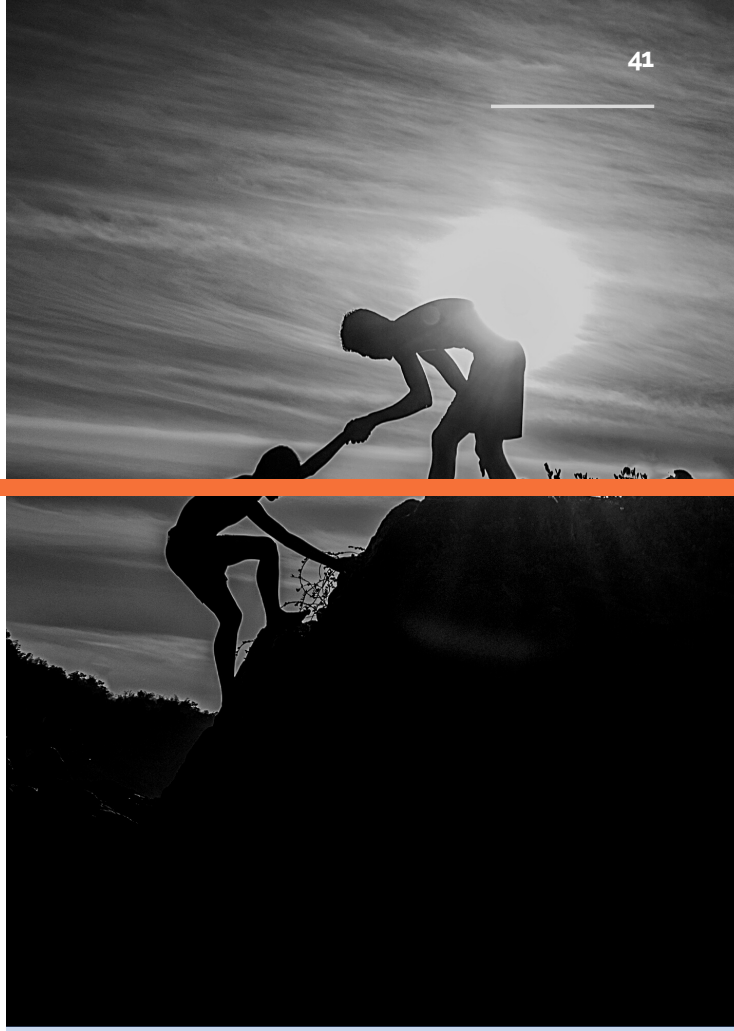
Teacher training is another important component. CIRCLE labs are good start based on which an enhanced model of engineering labs can be developed and scaled to involve the potential out of Chisinau. The availability of educational labs covering all the disciplines of the university is critical to ensure availability of graduates meeting the industry needs. Fablab has all the necessary infrastructure but lacks a content and relevant governance to have bigger impact.

The main initiatives that are targeted solving the industry academy gap are the **Tekwill Academy** program and OPTIM program. The availability of Tekwill academy like initiatives usually attract the best talents in the universities and quickly fill their knowledge gap from the university to meet the needs of job market. These bootcamp style trainings are quite efficient, as are funded by student or industry. They are also easier to attract Industry people in the training / coaching process, as require less time commitment, have direct benefits, and are more fun.

OPTIM program was one of the few initiatives targeting the regions of Moldova and providing opportunities for students in Balti to study Java trainings. This kind of short-term interventions can be very impactful in filling the industry gap. The only concern is ensuring the employment of student I their regions, and that requires a more systematic approach and environment building initiatives, including incentives for companies to move to regions. The only challenge with these initiatives is the lack of relevant status, as it is with bootcamps. So far, there is only 1 accredited coding bootcamp in Australia – Coder Academy

Various initiatives, such as **ProDidactica and Scholarship** for excellence are trying to increase the brand of TVET education and the cooperation with private sector. Repositioning of the TVETs can help to increase the impact in closing the industry gap. There many initiatives by EU and GIZ to restructure the TVET system in Moldova, and based on the best practices of EU and Germany can be very successful. There also initiatives by World Bank that acts as important enablers in terms of building necessary infrastructure, updating the curricula, teacher skills and overall education governance. We think that the implementation of these projects will result in quite an important impact for the higher education of Moldova. During the implementation process, various models can be tested and experimented, and the best ones can be scaled in the country.

5. SUMMARY OF CHALLENGES IDENTIFIED



Moldova's declining demographics and high emigration rate are putting pressure on the IT labor market. The demographic trend is marked by continuing negative annual growth, with a declining average annual rate of 0.2% from 2000. Over the last two decades, the number of students enrolled in secondary and post-secondary vocational education has fallen by almost 53%. Meanwhile, many talented pupils, winning in various competitions, leave the country to pursue a better higher education abroad. Main reason is also the reputation of the university and the "power "of the diploma in terms of the name and brand. One of the ways to tackle this problem is to establish the representatives of those universities in Moldova through partnering with top universities and conducting joint degree programs.

In Georgia, Millennium Challenge Corporation (MCC) has made a major investment aimed at facilitating high quality inclusive university-level STEM education in Georgia. Through this investment, San Diego State University (SDSU) partnered with three Georgian public universities to offer Bachelor's degrees in a range of STEM disciplines to Georgian students: Chemistry /Biochemistry; Computer Engineering; Computer Science; Electrical Engineering. The project increased the capacity of the Georgian public universities to offer internationally accredited program. In Armenia,

In Armenia, Master of Science in Data Science in Business program was established at Yerevan State University (YSU), faculty of economic and management in partnership with San Jose Sate University. In the framework of the cooperation, students admitted to YSU's joint Master's program of Data Science for Business, will have a unique chance to spend one year in San Jose State University and get SJSU diploma. Moreover, the master degree itself was established with a cooperation of Enterprise Incubator Foundation, YSU and PMI R&D Armenia.

General education has problems with its teachers and curricula quality. According to the Ministry of Education, the state institutions have a shortage of 2,000 teachers. There is ample room for improvements in teacher selection, evaluation and retention policies, and strengthening incentives to stimulate performance, which also includes the wages.

In primary and secondary education, 18% of the teaching staff are over the retirement age. Teachers are normally not working in the industry, which results in mismatch between students' theoretical knowledge and hands-on, practical experience. The primary and secondary education needs to have a wholistic and systematic approach form the Government, in order to ensure the quality of teachers, as well as update the STEM related curricula and infrastructure.

In Finland, a powerful teacher union represents public school teachers, which is very influential among other stakeholders in policy discussions. The success of Finish education system is based on 2 main components- teacher's prestige, selection, training and trust in them. The teaching career is prestigious, demanding, and reserved for the most talented and hard working. Only one fifth of all applicants to primary teacher education programs in Finnish universities are admitted based not only on high academic achievements, but also on interest and passion to become a teacher. For those admitted into education faculties, the Finns invest heavily in pre-service teacher education. Since the teaching profession requires a master's degree in education, it takes approximately five years of university studies to become a qualified teacher. You can become a qualified teacher in Finland and be ready to oversee a classroom, all by yourself, only after several years of study and numerous hours of classroom hands-on practice. Once Finnish teachers are hired and in classrooms, they are given a lot of responsibility. Although Finnish teachers must follow the national core curriculum (which is student-centered and provides the overall framework and learning objectives), they have autonomy when it comes to its implementation.

In Georgia, The Training Educators for Excellence (TEE) run by Millenium Challenge Corporation (MCC) supports professional development by training and mentoring teachers to improve competencies in science, technology, engineering, and math subjects and by training principals to strengthen school management. The TEE activity aims to improve classroom instruction in the subjects of science, technology, English, geography, and math in grades 7–12, through a combination of professional development activities for teachers and school directors. The TEE activity plans to operate on a nationwide basis, including both Georgian-language schools and minority-language schools and reaching up to 18,000 Georgian-language teachers, 2,085 school directors, and 2,085 School-based Professional Development Facilitators.

School pupils still lack interest to pursue STEM related disciplines in their future career: Less kids choose technical and science professions after their school, as they are perceived as difficult and boring. On the other hand humanitarian disciplines, like law and economics are almost half of the students at the universities. One of the ways to increase the interest in this area is enhancing the school digital infrastructure and brining subjects such as computer science and robotics to the school curriculum. Although there are already big improvements in terms of incorporating robotics in schools and extracurricular activities, as well is improving the digital skills at schools, there is still a need to revise the current subject of informatics in General Education. In Primary Education it should focus more on fun, and in higher education more as having the CS and coding as a tool, rather than a knowledge, which is

used not only by Software Developers, but by specialists in other disciplines.

The **Tiger Leap initiative in Estonia** began in 1990s with the commitment of the Ministry of Education, computer companies and private persons to ensure that all students had access to computers. The Tiger Leap programme also helped to improve co-operation between the state, schools and service providers. In the field of science and engineering and technology, the Science Tiger program was launched with the objective of vitalizing and diversifying science classes in general educational schools by using ICT-based resources (e.g. Pasco and Vernier).The TigerRobotics program involved the use of programmable robots and home lab sets in teaching and learning as well as teacher training and competitions for students. In the framework of "ProgeTiiger initiative, Estonian students in grades 1 to 12 will be introduced computer programming and creating web and mobile applications. An educational portal known as SchoolLife was launched in 2001, giving teachers the opportunities to exchange ideas and ask for advice from colleagues, and allowing them to share good ideas, find educational materials, and discover useful links and electronic courseware information. By 2004, teachers' computer use had diversified tutorial work and teachers' computer skills had significantly improved. Over the next decade, the range of courses diversified considerably, and a network of teacher trainers formed to provide courses all over the country.

For talented individuals under the age of 18 there is the **Tumo Center for Creative Technologies in Armenia.** With 6 tech and design centers across Armenia, Lebanon and France, Tumo facilities have been purpose built for 19,000 students to take their initiatives and education to another level. Tumo provides in depth educational pathways in AnimationGame Development, Filmmaking, Web Development, Music, Writing, Drawing, Graphic Design, 3D Modeling, Programming, Robotics, Motion Graphics, Photography and New Media for youngsters in workshop formats, self-learning and project lab facilities.

Armenian Armath Engineering schools and laboratories comprise of approximately 220 science and technology hubs across the country. The program was launched in 2014 and currently stands with an estimated 5000 children. The education base ranges from grades 5-12 with the intention of providing education in programming, robotics, design skills and 3D-modeling. Thus, providing participants with a professional orientation towards a career in engineering and parallel sectors. It is noted that 89 percent of Armath laboratory attendees progress to university and 43 percent of those students combine tertiary education and work with an average salary of $280.

COAF KIDS is a technology hive based in one of the regions of Armenia - Debet, Lori, was launched in May 2018. The center offers free training to 150,000 young and elderly people, including music, dance, painting, active citizenship, languages, programming, robotics, information technology, art, communication, ecology, healthy lifestyle, business and civic skills. COAF SMART partners include The SAP Next-Gen Lab which brings the latest blockchain technology, iOS development and Virtual Reality design to students at the COAF SMART Center. COAF is also collaborating with PicsArt Armenia for furthering the reach of education to all.

In Kosovo, **Jcoders Academy and The Digital School** provide learning technology courses for kids from 7 up to 18 years old. Beside learning how to code computer programs, at the Digital School children also learn about computer sciences and digital culture, where they get extensive lessons over their behavior online and how it can affect them and the people around them. They also learn how to protect themselves online by taking care of their digital footprint and digital citizenship. The curriculum is developed to be suitable for ages 7 – 15 and 16 – 18 years old.

Over the period of three years, the curriculum has shown successful results as the students were able to deliver ready products on their own such as published games, mobile applications and webpages. Today Digital School operates in five locations in Kosovo, two locations in Slovenia and one location in Macedonia and it numbers more than 100 active students and 35 employees staff. They have more than 4000 submitted projects on their private knowledge-base.

Technical Vocational Education and Training institutions lack provision of specialists for ICT industry. The TVET sector is still highly centralized, with an inflexible system, unable to adjust rapidly to labor market demand. This leads to a high degree of mismatch between the educational system and the private sector. If organized, the TVET educations can a become the main supplier of the basic IT jobs in the industry, including coders, technical assistants, web developers Quality Assurance specialist, etc. The curricula can be adjusted to organize coding bootcamps and fill the gap of specialists in a very short period, as well as to increase the brand of the TVET. Other cooperation with private companies can be established with specialized courses.

Olin College (Wellesley, MA) opened its doors in 1999. Starting from the observation that STEM education is in crisis in the United States because it fails to attract the right students, because it is teaching the wrong curriculum, and because it is using methods that are known to be largely ineffective, the main purpose of Olin is to train the engineer of the 21st century, "a person who envisions what has never been and does whatever it takes to make it happen." Olin College operates with several innovative features: It recruits its students not primarily on the basis of their SAT test scores but through face-to-face interviews in multiple settings, including team exercises; learning is organized around project-based activities performed by students working in teams; Olin College has no academic departments and does not offer tenure to its faculty members; a typical program will involve several teachers from different disciplines providing integrated courses with interdisciplinary material; The curriculum combines engineering, entrepreneurship, and humanities in a unique way. Every Olin student must complete a year-long senior design project sponsored by industry; The students must also acquire leadership and ethical competencies through social sciences and humanities courses; to ensure that all Olin graduates are successful at communication in a professional setting, every student is required to present some aspect of their academic work in a public setting at the end of every semester. Olin graduates have outstanding career opportunities. According to a recent survey, 97 percent of Olin alumni were either employed—in a company or in a business they started themselves - or attending graduate school (22 percent of those at Harvard, Stanford, or MIT). Companies sponsoring senior year projects often recruit the students involved as permanent employees after they graduate.

In Kosovo, There is a private VET institution established by a prominent local IT company (Cacttus), Cacttus Education, which offers diplomas in network and system administration, and web and mobile application development. In addition to academic programmes, it also offers trainings and children's learning program. Programs developed based on the work market demands. Cacttus Education is the first associate V level professional school in the field of Information and Communication Technology. As a higher education institution, Cacttus Education provides students with a professional two-year study program in the most attractive fields of employment of the Information Technology (IT) Industry. The two study majors are: "System and Network Administration" and "Web and Mobile Application Development".

In Georgia, The Program Improvement Competitive Grants (PICG) is funding Georgian TVET providers on a competitive basis to establish new or improved training courses that reflect industry demand for skills. The 10 institutions selected to receive grants, which are located throughout Georgia, are establishing 26 new courses and seeking to improve 15 existing courses. These include courses in areas such as information technology, agriculture and veterinary services, aquaculture, maritime operations, tourism, railways, and aviation. Most of these courses are at TVET levels 4 and 5, which are training courses for upper secondary school graduates.

Universities are not providing knowledge demanded by tech sector companies. The IT industry is struggling to get enough well-trained labor force on a yearly basis that would meet market needs. There are few reasons for this, including (i) teaching programs are not corresponding to the private sector standards; (ii) absence of effective links between university and private sector companies to organize internships and recruitment procedures; (iii) the university degree program is too long in comparison with the industry dynamics and stifles the development of students until those reach the workforce market. One of the ways to overcome this challenge is cooperation with tech sector and private partners to establish Education labs and update the curricula. There are also several interesting Models that can be used to tackle this challenge and of them is the cooperative education (Box 5.1.) and the boot camp model.

The **Armenian National Engineering Laboratories (ANEL)** aims to prepare qualified specialists in engineering who will meet the demand of the industry, increase innovativeness and competitiveness of Armenian high-tech business. A**NEL is a combination of 30 state-of-the-art education and research laboratories**, covering 6 major specializations of NPUA: Cybernetics, Radio Engineering and Communication Systems, Power Energy, Electrical Engineering. The scientific laboratories are equipped with computerized measurement and control devices. The ANEL collaborates with industry and research institutions in the country. In particular, ANEL helps those labs and institutes to solve their technical and scientific problems.

Since 2004, **Synopsys Inc.** carries out bachelor, master and research programs through SAED (Synopsys Armenia Education Department) at different universities of Armenia with a purpose to prepare qualified specialists for microelectronics field. As a result of this focus on producing high level candidates 100% of SAED graduates have found employment, 77% of those are employed directly by Synopsys and the remaining 23% by tech companies within Armenia or internationally.

350 graduates became professional engineers at Synopsys Armenia. Synopsys cooperates with The National Polytechnic University of Armenia (NPUA), Yerevan State University (YSU), Russian-Armenian (Slavonic) University (RAU), European Regional Academy (ERA), The National Research University of Electronic Technology (MIET).

Microsoft Innovation Center Armenia offers a combination of training courses covering web/mobile development, programming, QA, UI/UX, as well as coding and data science bootcamps. A summer program over 5 weeks teaches 10-14 year old the basic mechanics of technology, programming, Web Development, IT English and Life Skills called TechnoChamp for Teenagers. 800 to 1000 people are trained annually in the center. There are two main directions: training track and bootcamp track. From the bootcamp track, 90% enter the job market. Overall, about 35% out of 1000 trained students find jobs.

Cooperative education is a model that alternates academic studies with relevant work experience in a field directly related to a student's academic or career goals. The advantages of this model are considerable: it allows students to gain relevant work experience; apply theoretical knowledge gained in the classroom; and clarify career plans. It also helps students build contacts with employers and establish networks to facilitate finding employment upon graduation. Working as part of the studies program helps finance education; it is also useful for learning how to behave on a job and in general to develop the skills which employers want. The advantages for employers are also significant since they have "access to well-prepared short-term workers, flexibility to address human resource needs, cost-effective long-term recruitment and retention, partnerships with schools, and cost-effective productivity.

(The National Commission for Cooperative Education, USA).

In the **United States,** The Florida Institute of Technology offers the most condensed cooperative education program ("ProTrack") allowing engineering students to graduate in four years with three semester work terms. Drexel University in Philadelphia, PA, and the Northeastern University in Boston, MA, have two of the largest cooperative education programs in the United States. A student graduating with a five-year degree usually had a total of 18 months of internship work at up to three different companies. Source: The National Commission for Cooperative Education, USA, World Bank.

Higher Education Institutions have decreased their image as an academic institution and what value it provides. The role of higher educational system is gradually diminishing. In particular, the Master's and PhD degrees are not considered of higher value by companies, but rather additional periods spent without practical activities. Besides, many students drop out from universities by getting a decent salary and job offer, without embracing the real value university gives, such as scientific research. The integration of public research in university education can substantially enhance the role of university by outsourcing R&D projects to university groups, engaging students and gradually increasing the level of complexity. Universities are essential economic agents and can help make the local firms more innovative and productive through relevant applied research, as well as the training of highly qualified professionals.

The Philip Morris International (PMI) R&D Center in Armenia has adopted a unique approach to support the research and education ecosystem. Students and researchers are actively engaged by driving innovation in various dimensions through cooperation with industry. To increase this engagement, special funding schemes have been developed to support the PhD and research teams. Since 2018, 20 PhD students and 49 research teams from more than 15 universities and research institutions were supported both financially and technically to advance their research projects in data science, AI, machine learning, material science, industrial engineering, electronic engineering, experimental physics, mathematical modelling, etc. The converging-applied researches bring the conventional scientific research closer to the industry, thus making a scientific cluster attractive to the industry. Besides, all the teams had an opportunity to take part in different community events and access top experts for mentorship.

Molodva's competitive advantage in IT sector is quite vague: The IT sector in Moldova is growing rapidly, and with recorded growth, it can be a crucial sector for the country's economic development. However, in order to keep its competitive advantage, Moldova needs to position itself in a more niche segment of the market and leave the saturated outsourcing market. Playing in an outsourcing market, Moldova tried to build its competitive advantage around a cheap and qualified workforce.

The transformation needs to entail a shift from competitive advantage resting on low cost programmers to competitive advantage based on ability to produce high value-added products and solutions. Moldova is hardly able to compete with massive low cost off-shoring destinations, such as India, China, Vietnam, etc.

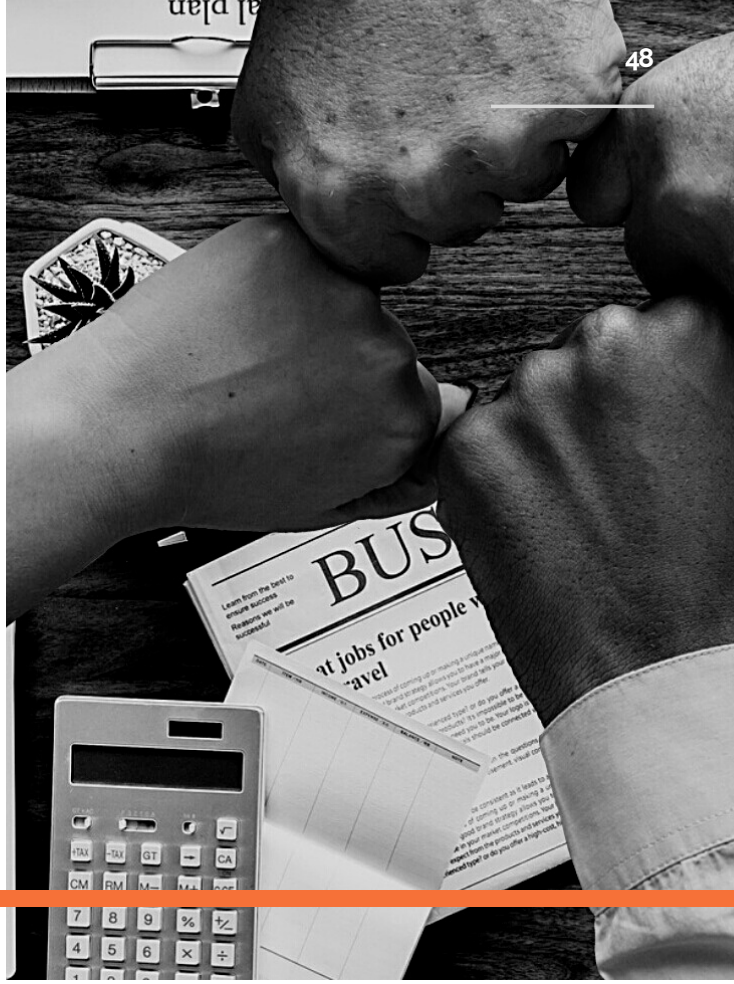
Box 5.1 Future of Engineering Education

The trend in engineering education is to move towards socially relevant and outward-facing engineering curricula. Such curricula emphasize student choice, multidisciplinary learning, and societal impact, coupled with a breadth of student experience outside the classroom, outside traditional engineering disciplines, and across the world. While many of these educational features appear within engineering programs at many "current leader" institutions, they are often "bolt-on activities" and are isolated within the curriculum. As a result, much of the benefit of these experiences remains unexploited because they are unconnected with other curricular components and students are not encouraged to reflect upon and apply what they have learned in other areas of the degree program. In contrast to the "current leaders," many institutions identified as "emerging leaders" in engineering education typically deliver distinctive, student-centered curricular experiences within an integrated and unified educational approach. In most cases, their curricula were designed from a blank slate or were the result of a recent systemic reform. Experiences such as work-based learning and societally-relevant design projects are embedded into the programs in a way that provides a solid platform for student self-reflection and a pathway for students to both contextualize and apply the knowledge and skills they have gained elsewhere in the curriculum. However, many of these "emerging leader" exemplars – such as at Olin College of Engineering and Iron Range Engineering – cater to relatively small cohort sizes. The key innovations that are likely to define the next chapter for engineering education are the mechanisms by which such features an be integrated across the curriculum at scale: delivered to large student cohorts under constrained budgets.

Source: MIT

6. IT SECTOR DEVELOPMENT MODELS & IMPLICATIONS FOR EDUCATION

6.1 THREE DEVELOPMENT MODELS FOR STRATEGIC REPOSITIONING OF MOLDOVA IN ICT



Moldova's IT sector is facing a strategic choice of a future model for development. As the industry is maturing, the future growth is becoming harder to achieve. The competitive advantage and Moldova's value proposition need to be clearly articulated. The value proposition will have to go beyond mere supply of teams of high-quality engineers and programmers who are ingrained in selected elements of global value chains of multinationals. Regardless of the choice of the model (discussed below) Moldova's positioning requires well-thought strategies, and coordination of actions among all stakeholders of the IT industry.

Moldova can strive to capture its "niche" based on an attractive positioning clearly comprehensible by global players. Based on the analyses of the experience of countries that succeeded in developing IT industries in relatively short periods of time, three competitive development models are proposed as follows:

1. **MNC Model:** Platform for accessing regional markets – EU and CEE
2. **R&D Model:** Tech Powerhouse
3. **Startup Model:** New products and services based on the demand of local and global market

These models can eventually serve as a basis for working out a competitive development model for Moldova.

Model 1 – Multinational Company (MNC) Model: Platform for accessing regional markets – EU and CEE

Positioning Moldova in the global market as platform for global players to penetrate large regional markets, by providing advantages for global companies to serve targeted regional markets more effectively. This includes creation of a favorable business environment, provision of high skilled labor force and developing

necessary infrastructure. With this model, Moldova can manage to become an attractive investment destination for mostly market-seeking FDI's in the region. Cultural and language similarities will also support the process. Targeted efforts will foster positioning of Moldova as a unique destination for MNCs based on investments in developing sophisticated skills. It will foster the entry of large global players, which could have spillover effects by attracting other companies from Eastern Europe. This may lead to growth of average company size and productivity. It will also be an attractive destination for immigration to Moldova, rather than emigrating from Moldova.

Successful examples for this model are Ireland and Egypt (See box 6.1). Ireland implemented a sophisticated phased policy aimed at attracting global, mostly US, multinationals that sought efficiency and access mainly to the EU markets. Seven of the 10 major software companies in the world have substantial operations in Ireland. Egypt and Jordan are positioning themselves as leaders or platforms for the MENA region (Middle East and North Africa) trying to replicate the Irish success.

The key success factors in this model are:

- free access to regional markets (in the case of software, this is not heavily complicated by transportation problems);
- availability of qualified work force;
- cultural and/or language similarities with outsourced countries and regional players;
- reliable physical infrastructure and connectivity;
- comprehensive and effective workforce development initiatives

Moldova's position allows it to benefit from the strengths of both the EU and CIS region and serve as a bridge between them. With reforms in public policy and business culture to make the business environment more attractive, businesses can use the country as a base from which to access tre¬mendous global markets, and as a destination for expansion and outsourcing. The key is to reverse some current trends that are leading to brain drain as people use international connections to leave the country, and to develop incentives that will use the diaspora community to support domestic innovation and encourage emigrants to return and build businesses in the country.

Model 2 -R&D Model: Tech Powerhouse

This model implies creation of world-class science and technology schools, improvement of quality of math and science education in public schools and heavy investments in R&D (both public and private). It requires developing advanced technologies & science-based clusters, and infrastructure. The value proposition to leading technology MNCs includes unique and sophisticated competences for their global value chains. The model to a large degree rests on creation of a highly skilled workforce pool able to develop and design innovative and sophisticated products and services. Israel represents a success story of the model (see box 6.2.). Majority of its GDP growth in recent years has been achieved due to the high-tech sector; it is the leading R&D center for Intel, IBM, Motorola, Microsoft, Boston Scientific, Oracle, Sun Microsystems, HP, Texas instruments, Cisco SAP, GE Medical Systems, etc.

The key success factors for this model are:

- Highly skilled science and technology graduates (Israel really benefited from a massive inflow of engineers and scientists from the Soviet Union in the early 1990s);
- Financial and fiscal incentives;
- R&D-oriented government programs and initiatives;
- Creation of science and technology centers promoting R&D;
- Availability of venture capital funds;

Moldova has a long history as regional center for research, learning and technology. A strong research base in **nanotechnology or in aero-space technology**, as examples, can be developed in ways that support those sectors with innovation, research and training of qualified experts. Combined with efforts to maintain and develop national infrastructure, can make the country attractive as a potential hub for certain emerging technologies.

Model 3- Startup Model: New products and services based on the demand of global market

Global market demand will drive the development of new innovative products and solutions for local ICT enabled services and products that can be exported into global markets. Government initiatives, such as fiscal and financial incentives for development of high-tech export-oriented products, coupled with business development skills through technology incubator programs, attract global venture capital to fund risky innovative start-ups.

Solid and effective financial markets (especially stock markets) should be in place to support business initiatives and, particularly, venture capital exit strategies.The key success factor is heavy investment in higher education, R&D and development of startup support mechanisms, including startup grant programs. Estonia represents the country case for this model (see box 6.3).

The key success factors for this model are:

- Government initiatives -startup support programs
- Startup-oriented government programs and initiatives;
- Creation of technology incubators;
- Fiscal and financial incentives;
- Workforce development initiatives
- Advanced financial markets;
- Culture of risk-taking and entrepreneurship.

6.2 IMPLICATIONS FOR IT EDUCATION DEVELOPMENT

Based on the strategic choice of country's IT sector development, relevant IT Education Development strategy can be developed.

Model 1 – Multinational Company (MNC) Model: Platform for accessing regional markets – EU and CEE

This model will mainly require availability of workforce, being able to deal with not very sophisticated technologies, i.e. the mainstream of tech specialists. The skillset and employee profile are similar the ones currently demanded in the local market– Software Developers, Testers, Network Administrators etc. These skills can be developed by initiating training programs for IT related graduates and build strategic alliances with companies to ensure the production of high-quality IT graduates according to business needs. There are already few initiatives in place within Tekwill Academy program and within universities, but this can be improved to bring on a more institutional level, such as a dedicated program in a college or university. The improvement of the TVET education system can also directly impact to the increase of the workforce, as the skillset demanded is possible to deliver during the education in colleges. The model will require development of Bottom and Middle levels of the Education Pyramid. As changing the whole school system is a long-term process, few short-term interventions can satisfy the possible demand of specialists.

Examples of Interventions:

IT skill Development - Fueling Specialists from unused population segment: One of the success factors for the development of the model will be involving the unutilized population segment in the workforce development process. A short-term intervention can be training programs conducted in the regions. As pilot, it can be done in selected regions, up to 5 regions and around 100 participants on the most demanded disciplines of the industry, such as Web Programing (HTML/CSS, Java Script, AngularJS, NodeJS), Mobile Programing (C, C++, Swift, QT/Graphic User Interface, IOS), Mobile Programing Android (Java Programming/Android), etc. The duration of the training can be around 8 months, with final project submission and internships with companies (around 3 months). OPTIM project has started conducting JAVA trainings in Balti.

Convergence of IT & Engineering sector - Regional specialized Tech center in Balti- convergence of IT and Automotive industry: Considering the developments of Moldovan Automotive Industry (Box 6.1) and representation of well-known automotive brands in Moldova, as well as the available education infrastructure of Balti State University, a Technology center can be established in the Balti. The center will integrate engineering, particularly Engineering with IT industry (maybe besides being a parts and component supplier, become a module or system supplier (Tier 1)). The University will be the main hub of knowledge and will serve the needs of the industry.

Box 6.1. Automotive Industry of Moldova

Moldova's modern automotive industry foundations build on its strong industrial past. The share of industry in Moldova's GDP represented 60% until the 1990s. Back then, Moldova was one of the important producers of industrial products among the CIS states and now it revives. The industry production reached 14.6% of GDP in 2017. In 2017, the industrial production registered an increase of 3.4%, mainly driven by the growth of 4.5% of the manufacturing industry. The production of electrical cable and wire harnesses has increased by 43%, followed by the production of plastic and rubber products (+16%), manufacturing of equipment for food processing beverages and tobacco (+23%), construction materials i.e. cement, gypsum (11%), textiles (+9%), etc. A significant intake was brought by the automotive industry, representing the biggest share in the increase of electrical equipment and textile.

Automotive is one of the most dynamic industries in Moldova. In 2017, the export of automotive cable and wire harnesses registered a growth of 37.1%. Nowadays, the automotive industry is a key growing sector for the Moldovan economy. This is due to an increased focus on the unused industrial potential of Moldova and the maintained industrial orientation in the education system (Technical University, technical colleges and vocational schools). The total export in the automotive industry registered a growth of 37.1%, with a share of 14% in total exports.

Up to now, large direct investors prefer to locate themselves in Moldova's Free Economic Zones (FEZ), which represents an excellent location for industrial development and production relocation oriented for exports. Production concentrates on cables, wiring harnesses for cars, car seat covers, plastic molding injection, metal processing, electronics and electronic components, and assembling. Important examples are Lear Corporation, Dräxlmaier Automotive, Gebauer & Griller, Sammy Cablaggi / Kablem, Elektromanufacturing, SUMIDA, Confezioni Andrea Covercar, LEONI, SEBN Sumitomo Electric Bordnetze, Fujikura Automotive, Coroplast Fritz Mueller, APM Automotive, Blacksea EMS, Dräxlmaier DSM and Arobs Software.

The combination of the knowledge pool, labor cost advantages, favorable tax and social security regimes, and close trade relations makes production competitive. Moldova provides exceelent opportunitiers in 2nd Tier (Component Supplier) and 3rd Tier (Part-/Raw material Supplier) of Automotive Supply Chain structure. There is a huge potential to become also destination for the development of 1st tier (System Modul Supplier).

Source: Invest Moldova

Model 2 -R&D Model: Tech Powerhouse & Model 3 -Startup Model: New products and services based on the demand of global market

These models will require developing specialists for the top level of the education pyramid, i.e. highly skilled science and technology graduates. It will require significant investment in the educational sector and particularly in the higher education, through close trilateral partnerships (government-business-academia). The positioning of the university will be provider of long-term academic education, with unique and sophisticated competences and focused on possible scientific research, rather than provider of short-term training courses to meet the labor needs of the IT industry. The universities will need to seek new ways of maintaining the talent in the country and further promoting them towards development of their own products or involvement in scientific research activities.

Examples of Interventions:

Improving the brand of HEI through international university partnerships - Establishing joint university programs with top universities in the world

Joint Bachelors / Master's degree for a specific tech and science related subject will ensure exchange of faculty staff and students and bring the international academic education and knowledge to universities. It will also provide a more "branded" Diploma to graduates and will serve as a good basis for possible joint research projects.

Bringing new MNCs to develop sophisticated industries – education, workforce, R&D.

An MNC from a sophisticated industry can carry out bachelor, master and research programs through establishing an Education Department at different universities with a purpose to prepare qualified specialists for specific field.

University Education - Setting education ground for "specializations of the future"

A partnership with MNC can also lead to the improvement of the university infrastructure and establishment of specialized laboratories, while modernizing the curricula and increasing the qualification of faculty. It will also have incubation environment and research environment for possible in-house projects. The laboratories will benefit all the country as will be accessible for interested parties from other universities, research institutions, and private sector.

University based incubators and research labs – sparking entrepreneurship within universities

To enhance the entrepreneurship, establishment of startup incubator within the university can be one of the first steps. Considering that universities usually have various disciplines including science, technology and business, these incubators can be a great place for the convergence of these disciplines and creation of startup teams / products. Various startup bootcamps, idea generation workshops can be created to boost the innovative thinking among the students.Highly skilled science and technology graduates (Israel really benefited from a massive inflow of engineers and scientists from the Soviet Union in the early 1990s).

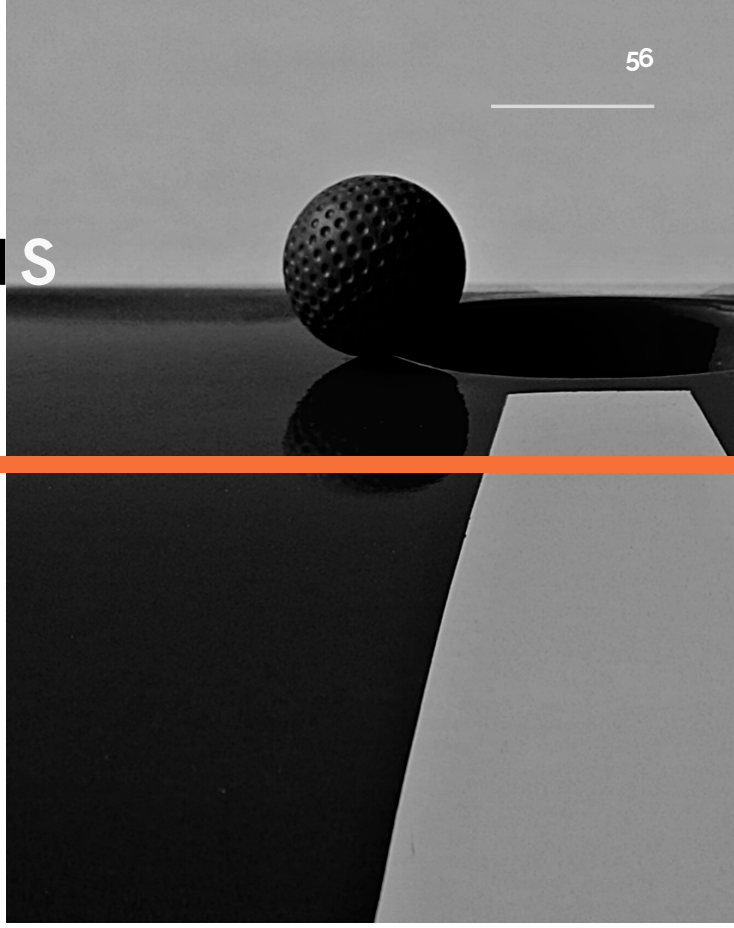
The priorities under each model are summarized in Table 6.1. below.

TABLE 6.1: STRATEGIC CHOICE MATRIX

Model	Education & Workforce Development	Ecosystem	Interventions
MNC Model	**Very Important** - Programming skills through bootcamps - Certification programs and short courses - Specific niche technology trainings, based on the potential MNC profile **Less important** - Math and Science Education in all education levels	- Free economic Zones - **Fiscal incentives**, such as tax holidays and tax credits - Reliable network connectivity **FDI** - Efficiency and market seeking FDI	**Short-term** - IT skill development in Regions - University and industry cooperation though establishment of degree programs - Conducting Bootcamps **Long Term** - Adjusting TVET education - Dual degree programs with private companies - Synergies with other sectors, such as automotive
R&D Model	**Important** - Math and Science Education in all education levels - University positioning as academic & scientific hub - PhD education and curricula - Availability of Bs, MS and PhD programs according to current tech development trends (e.g. AI, Quantum computing, Biotech) **Less important** - Programming skills through bootcamps - Certification programs and short courses	- Intellectual Property Rights - Incubators/ Technoparks - Venture Capital - **Financial Incentives**, such as R&D grants, investments - **Fiscal incentives**, such as tax holidays and tax credits **FDI** - Strategic asset-seeking FDI	**Short-term** - Cooperation with scientific institutions, universities and industry - Joint degree programs with top international universities - Provision of R&D grants by government and private sector **Long Term** - Higher Education improvement, including update of curricula - Establishment of - Identification of niche areas and technologies, where Moldova has a competitive advantage

Startup Mode	**Important** - Math and Science Education in all education levels - Entrepreneurship and business development skills - Programming skills through bootcamps - Digital skills, computer literacy - Higher level problem solving **Less important** - Certification programs and short courses - Programming skills through bootcamps	- Incubators/ Technoparks - Venture Capital / Angel investments - Intellectual Property Rights - **Financial Incentives**, such as startup grants, investments - **Fiscal incentives**, such as tax holidays and tax credits - Reliable network connectivity - Digital society – Computer penetration - Startup-visa programs **FDI** - Strategic asset-seeking FDI	**Short-term** - Cooperation with private companies to supply real-life problems and expertise - Conducting acceleration programs in vertical industries - Provision of startup grants by government and private sector **Long Term** - Government initiatives of e-society building

7. CONCLUSION & RECOMMENDATIONS



7.1. CONCLUSION

Focusing on the Golden "middle"

Based on the provided analysis we think that the win-win situation for Moldova to develop its IT sector and IT education, is focusing on the middle level of the pyramid and the MNC model can be a good starting point. Moldova needs to improve its higher education system in tech disciplines and provide necessary incentives to keep its talent in the country. The enhancement of this level will also ensure higher percentage of people going to the top level of the pyramid and in a long run build the necessary foundation for an innovative products, scientific breakthroughs and unicorn companies, and preparing for the R&D model. Moldova has all the prerequisites for becoming the regional platform in the Europe. However, the strategy needs to be moving from simply being an outsourcing destination towards becoming a country of choice for specific niche industries, taking account the Industry 4.0 trends. MNCs can be a good trigger for this strategy, as they bring with them the culture, knowledge and know how. Meanwhile, in order to ensure that Moldova gets a lot of top specialist in the top level of the pyramid, higher education is a crucial component in the process. For a long-term sustainable development of IT industry, the strong university base is of a critical importance. While company base training can provide basic IT skills, the ever-increasing sophistication of IT products will require strong multidisciplinary educational background that can be provided only on the platform of university education at graduate and postgraduate level. We can also see that there is lack of initiatives promoting the jump from middle level to top level. The existing initiatives can be scaled, while adding the missing components, such as R&D and high-level problem solving, synergies of bootcamps, incubation / acceleration with global problems in mind, top expertise from abroad and most importantly, the existing university potential.

Importance of creation of a new entity

Considering the proposed models, a need of **establishment a new entity is needed** to be able to implement various projects, not limited only to specific industry group and expand the initiatives all over the country. It will basically take the role of industry development all over Moldova, by serving as a liaison between various

stakeholders, including private companies, donor organization and public institutions. Establishment of a new entity will give the flexibility to develop new content and strategies based on the market needs that can be out of core activities of existing organizations. This was how the sector development was done in Armenia through Enterprise Incubator Foundation (EIF). Since its establishment in 2002 with the foundation model, it managed to implement various public-private partnerships with MNCs, establish and manage technology centers in regions of Armenia and implement various projects supporting the development of the sector. The foundation model also allows establishing partnerships with existing authorities and universities, without actually owning any property or building. The important mission becomes development of the IT sector, the creation of relevant content / projects and scaling them countrywide.

7.2. PROPOSED SHORT -TERM & MID-TERM ACTIONS

A new university curriculum should be developed together with the private sector. The overall curriculum needs a revision and amendments to correspond the industry needs. For this purpose, it is recommended to establish cooperation with private sector, international universities and MNCs and adjust the curricula based on the latest trends locally and internationally.

The prestigious status in academic career and low salaries of teachers should be addressed. One of the ways to do encouraging younger professionals to involve in the teaching experience in the universities. The interest can be raised via initiating relevant R&D projects, professional trainings, guest-lecturing practices, additional bonus programs for young faculty, etc.

Creation of training centers within companies can help to close the skill gap. The skill mismatch can be addressed through enhancing the resources that smaller companies can spend on training and development. Special co-financing schemes (with matching requirements) can be developed supported by the government or international donor programs to establish special training centers and programs within the companies.

The university funding needs considerable increase as well as diversification through research grants. Currently, Moldova's IT industry is at the inflection point from where it can accelerate into rapid high value growth. Achieving next level of value addition will require significant increase in number and quality of labor force. To achieve that the government will need to provide significant investments and incentives for improving the level of IT education. Universities are essential economic agents and can help make the local firms more innovative and productive through relevant applied research, as well as the training of highly qualified professionals.

If Moldova aspires to transition from outsourcing, development center destination to one own product development model, it has to integrate fundamental, hard-core research into its university system. True innovation requires hard-core research, world-class knowledge and expertise rather than a mass of coders with basic level of proficiency. The development of innovation, R&D capabilities is easier to inculcate if students are accustomed to performing fundamental research from early years of their study.

The number of university-based laboratories, which are established with the help of multinationals, should be scaled up. The establishment of laboratories in cooperation with multinationals helps exposing students to the global best practices and latest technologies. Similar to establishment of CIRCLE Labs, more laboratories need to be established on the university premises to enable the technical environment for the students. They also provide environment for developing their own products together with incubation and acceleration programs.

Creating an alternative program to prepare software programmers in less than 3 or 4 years will help increase the supply of labor in the medium term. Taking into the consideration the rapid dynamics of the industry, 4 years of study to earn undergraduate degree is often considered too long for software programmers. By the time of the graduation the professional knowledge acquired in early student years is of little use. The educational solution to the current industry speed that can be considered is introduction of globally recognized certification programs or when applicable – associate degrees. Such programs can be university based and be provided in addition to standard degree programs.

7.3. COVID-19 IMPLICATIONS FOR SECTOR AND IT EDUCATION DEVELOPMENT

Tech companies, working on outsourcing market, lost their clients as a result of cost cutting and efficiency seeking by the companies. The COVID-19 impact analysis done in Moldova by ATIC affirmed, that companies mostly affected by the pandemic in the sector were the ones providing an outsourcing contract. On the other hand, companies who represent the core development or R&D unit of multinational company were the less impacted ones. The same applies also for companies developing own products and dealing mainly in the B2C sector, rather than in B2B sector. This once again confirms the importance of Moldova moving form the outsourcing model to own product development model.

All the non-tech sectors of economy are heavily impacted by the COVID-19, which will lead to more number of people re-profiling to tech sector. Considering that the sector will be the one in control of the current and post-pandemic reality, this implies emergence of big demand for simple coders and basic technical specialists. The supply side of education needs to consider this change and ensure availability of relevant educational programs to meet this increasing demand. Specific training programs can be developed to help people from these traditional sectors easily shift to tech, while ensuring their quick employability in the sector.

The role of science and scientific research became vital. If before science was something people would not pay much attention to, today, scientists are under the spotlight of every single person. People understood that the "hope" of solving issues caused by the pandemic is only possible through relevant scientific research, and convergence of science and tech became important factor in achieving this. This once again highlights the importance to direct education initiatives towards the top level of the pyramid, where the top scientists and world specialist can be prepared. It also dictates the need to shift to higher value-added niches for the sector, and that requires new skillset for the total sector.

The importance of the physical environment and space as a core to built content around is diminished. If before the core component of any initiative was laying around the building and physical environment in terms of co-working spaces, nice event halls and training

laboratories for human interaction and exchange of ideas, COVID-19 almost eliminated that significance. The important component of any initiative is now the content and methodologies to get educational materials to necessary audience with usage of digital tools. Software development and non-engineering related tech disciplines can be quite quickly adjusted to this reality.

The integration of information technology in education will be further accelerated and online education will eventually become an integral component of education. Online learning has been shown to increase retention of information, and take less time, meaning the changes coronavirus have caused is be here to stay. All the education levels need to develop necessary infrastructure and skills to conduct online classes and not solely limited by a zoom video call. This can also open new opportunities in terms of EdTech product development.

Annex

COUNTRIES WITH SUCCESSFUL IT SECTOR DEVELOPMENT MODELS

Box 7.1: Platform for Regional Expansion:

Ireland - Window to EU From the poor economic indicators stemming from the political and social troubles dogging the modern Republic of Ireland since its founding in 1919, the period from the mid-1990s to the early 2000s saw tremendous, unprecedented economic growth – the "Celtic Tiger". The transformation of Ireland's economy from one of the poorest in Europe to one of the richest is generally explained by governmental policies, such as low corporate taxation, a low-cost, well-educated, English-speaking labor force and advantages arising from EU membership, such as free access to the market and the receipt of subsidies. This was enhanced by the clear positioning of Ireland as a platform for expansion into the European market for competitive multinationals. Economic Incentives and the EU During the mid-to-late-1990s, taxation and public borrowing was reduced in Ireland, stimulating the economy, attracting newcomers to both the private sector and the labor market. Currently, Ireland is the 2nd most competitive economy in the EU and the 7th most competitive in the world according to IMD. OECD Figures for 2017 show Ireland as 1st in the world for labor productivity.

Foreign Investment

Perhaps the most significant factor in the economic boom of Ireland was the tremendous increase in FDI, particularly in the ICT sector, with money coming in especially from the US, but also from other developed economies, including investments worth billions of dollars by Microsoft, Dell, Intel, Apple, IBM, Hewlett Packard, Oracle, Xerox and Ericsson, to name a few. More than 300 foreign ICT enterprises, including nine of the world's top ten companies in the field, employ around 45,000 in the country, carrying out substantial undertakings in manufacture, software and R&D. In terms of software alone, Ireland ranks as the world's largest exporter, with more than 900 local and foreign companies employing 24,000 people in that sector. This accounts for 10% of the country's exports, generating €16 billion in revenue (2020). Besides manufacturing computer hardware, chips and components, ICT companies in Ireland also carry out marketing, sales, software development, technical support, shared services, IP management and many other related activities. Foreign investment also boosted spending in R&D and software development. Apart from access to Europe, American companies were drawn to Ireland by its attractive taxation policies, favorable time difference and skilled workers.

The Labor Market

An important factor in the Celtic Tiger was the availability of a relatively young and well-educated, English-speaking labor force. Governmental initiatives in education have prepared and continue to bring a steady supply of engineers, scientists and management personnel to the economy. Ireland has the youngest population in Europe. Ireland has one of the most educated workforces in the world. The share of 30-34 year old in Ireland with a third level qualification is 56.3%, compared to an EU average of 40.7%. Ireland's education system is amongst the best in the world and ranks in the top 10 globally as an education system that

meets the needs of a competitive economy. Ireland is implementing a comprehensive, forward looking National Skills Strategy & Action Plan for Education, which aims to make Irish education and training the best in Europe by 2026. Almost 30% of students enrolled in Science, Technology, Engineering and Math (STEM) courses. Technology Skills 2022 is Ireland's Third ICT Skills Action Plan and is a collaborative partnership with Government, the education & training system and industry to meet Ireland's ICT skills needs. Another initiative by government, Springboard+ provides over 9,000 free places on higher education courses in areas of identified skills needs to eligible applicants, whether they are employed, unemployed or re-joining the workforce. Increased employment was boosted by greater participation in the labor force as well, especially by women. Foreign workers have also been attracted to Ireland, with migrant communities from the new EU member states in Eastern Europe, and also from China and Nigeria.

The Celtic Tiger.

Challenges ahead The Irish government is taking steps to keep the economic growth sustainable. The Celtic Tiger allowed for greater public spending without significant increase in taxation, and a lot of investments in infrastructure have been carried out. Science Foundation Ireland was set up, specializing in R&D in biotechnology and information and communication technology. The International Financial Services Centre, established earlier in Dublin in 1987, ended up creating more than 10,000 jobs in the banking, finance and insurance sectors. Even so, certain issues still need to be addressed, such as further improvements still in infrastructure, healthcare and lesser dependency on fossil fuels for energy. The BrexIT will also have in impact on the economic development of the Ireland. The big fear is that the Celtic Tiger was a phenomenon that would be difficult, if not impossible, to maintain in Ireland or reproduce elsewhere, given the unique nature of the factors that led to it.

Source: IDA

Box 7.2: Tech Powerhouse – Israel:

Government policies and initiatives, such as heavy and effective investments in education, incentives favoring foreign investors, capital market reforms, high R&D spending, incubator and venture capital programs, coupled with immigration, Jewish egalitarian culture and Diasporan business links, enabled Israel to emerge as a high-tech power in the late 1990s and the beginning of 2000s. The government was encouraging and supporting the private sector to compete in international markets, ready to withdraw, however, as soon as the latter was able to continue its own. Software exports reached $2 billion in 2004, from $135 million in 992, representing about 7% of total Israeli merchandise trade (MATIMOP, 2005). The primary focus of the Israeli policymakers was on innovation and R&D to strengthen the capacities of the private sector to export highly competitive innovative goods and services, relying on the "comparative advantage" of Israel: qualified human capital, scarce natural endowments, and hostile neighbors. The birth of the Israeli R&D-based industries is attributed to the country's strong defense sector after the 1967 War and to defense R&D cooperation with the United States, Germany and France. The close synergy has another success ingredient: Israeli defense industries have traditionally focused on components, electronics, avionics, and other systems. The development of these auxiliary systems has also given the high-tech industries an edge in civilian spinoffs in security, electronics, computers, software, and the internet sectors.

Investment Incentives.

Capital Market Reforms The Law for the Encouragement of Capital Investment (LECI), adopted in 1959, was aimed at increasing exports and employment in least developed areas and to promote export-led business initiatives by granting government grants (up to 24% of tangible assets) and tax benefits depending on the percentage of foreign ownership and location. The Law deliberately introduced a bias in favor of foreign investors to attract high-tech multinationals. Capital market reforms were carried out, resulting in the increase of the efficiency of the stock market, turning it into one of the most technologically advanced stock markets in the world. As a result of these reforms, many start-ups emerged, since it became easier to get a loan. The flow of international investors to Israel increased during the 1960s and 1970s, including high-tech giants, such as IBM, Motorola and Intel, bringing significant spillovers (access to new markets, financing, and know-how, knowledge transfer).

Government Support for R&D

The first step in this direction was done in the late 1960s by establishing the Office of Chief Scientist (OCS). The Law for the Encouragement of Industrial R&D (LEIRD) was adopted in 1984 to foster science-intensive, export-oriented private industrial R&D to absorb the growing labor force by providing grants, loans and other incentives. The OCS implemented both national and international projects (pre-seed, generic and competitive R&D). The MATIMOP (national hub) was established to assist the OCS with implementing and overseeing projects aimed at the participation of Israeli industrial firms in bilateral and multilateral R&D projects. About 20-50%

of the proposed project budget was funded. On average, $300 million per year was allocated from the budget for 1,000 industrial R&D projects - the largest national program. The Magnet Program was initiated in 1993 to strengthen collaboration between the academic world, that is, Israeli universities, and private industrial firms; only a consortium of industrial companies and at least one academic institution were eligible for funding. Up to 66% of the proposed project budget was funded. In 2005, 31 consortia were operating in the Israeli market.China and Nigeria.

Technology Incubators

In 1991, the Government initiated the Incubator Program to assist start-ups and immigrants from the erstwhile Soviet Union who lacked knowledge of market economy, English and Hebrew, and did not know how to get funding. The goal of the program was "to polish the diamond", to assist those with export-oriented and innovative ideas by providing necessary investments to develop new products. The program was very successful in fostering the emergence of start-ups. In Israel, 24 technology incubators were established. Up to 85% of funding was provided by the government in the form of grants and soft loans, the remainder being given by the venture firm, the incubators or the entrepreneur. Each incubator is implementing 10 projects on average.

Venture Capital Funds

The government played a significant role in establishing the venture capital industry. In 1990, two venture capital funds worth $59 million were operating in the industry. In 1992, the OSC initiated the Yozma Program to accelerate the venture capital market by providing $100 million to attract international venture capital funds to invest in high-tech firms. Ten international venture capital funds came to be established. In 1995-2004, venture capital investments contributed to the 40% increase in GDP, 15% in employment, and comprised 50% of exports and 65% of foreign investments (Harel, 2005). In 2006, there were about 50 Israeli venture capital funds.

In 2018, the city of Tel Aviv had the most startups per capita in the world, being surpassed in 2019 only by Silicon Valley. Tel Aviv and Jerusalem are some of the best places to start a business in sectors such as AI, Big Data, Analytics, Life Sciences or Cybersecurity.

Source: World Bank

Box 7.3 Estonia:

Start-up Model A couple of decades after independence in 1918, Estonia's primarily agriculture-based economy was shaken through occupation and forced Socialization. After the fall of the USSR in 1991, the country underwent major political and economic reforms, joining the WTO in 1999, and NATO and the EU by 2004. Today, Estonia is perceived as one of the most progressive countries in the world in terms of developing information technology in the economy, and putting it to use in society as such.

"e-Stonia"

More than from investments in the information technology sector, Estonia benefits from the role that computers and telecommunication plays in the overall running of society. The government was a significant factor in promoting information technology use in the country. Another major factor in this was the country's proximity to the Nordic countries, and particularly the historical, cultural and linguistic ties with Finland. Early on after independence, Estonia acted as a base for pilot productions of especially telecom-related companies, such as Nokia and Ericsson, and this led to the development of software applications, such as, Skype Transfer Wise, Skeleton Technologies, Pipedrive and Fortumo. In the 1990s, large investments were put in place in the telecommunications infrastructure of Estonia. The state-owned Estonian Telecom Company was granted a seven-year monopoly on fixed lines in 1993, in return for committing to modernize the prevalent infrastructure. This was key to a very fast-growing telecommunications and IT clusters, outpacing the country's Baltic neighbors.
In 2000, the country's parliament passed a law that declared internet access as a fundamental human right. They also started a massive program to bring web connection to previously ignored rural areas. WiFi and broadband are widely available, and all schools and libraries have internet connections. Although nearly 50% of the country is covered by forests, 3G, and 4G networks are available everywhere. Governmental initiatives have included electronic ID cards, a Digital Signatures Act (2000) and e-government cabinet sessions following an internet-based system.

Startup scene

Now there are an estimated 450 startups in Estonia, with large number of incubator and accelerators. According to the Wall Street Journal, Estonia produces more startups per capita than any other country in Europe. The latest statistics show there are 30.6 companies per 100,000 people. And 1.6 startup employees for every 1,000 people in Estonia. Estonia has one of the most liberal tax regimes in the world. Companies only have to pay corporate income tax on their dividends. An easy company registration and taxes resulted in an increased number of startup entrepreneurs. Moreover, there are several funds that provide information and financial support to startups, most relevant being the Estonian Development Fund and Enterprise Estonia.
As a result of these opportunities, the Estonia's startup scene is booming. According to a recent World Economic Forum (WEF) report, Estonia is the most entrepreneurial country in

Europe. They include analysis of "intrapreneurs" who formulate and implement new ideas within organizations. Indeed, Estonia has become a place for developing, testing and bringing to market innovative digital solutions. 20% of total exports now are in the information and communication technology (ICT) sector. Roughly 90% of all startups in Estonia are in the very early – prototyping, seed – or early stages of development. The number of people employed in Estonian startups is growing rapidly hiring 3500 people at the end of 2016. About 3/4 of all people employed by the Estonian startups work in Estonia. 2016 turned out to be a record year with 102,5 million euros attracted by the Estonian startups.

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