

# ECONOMICS OF OPEN SOURCE TOOLS FOR OPEN DATA AND OPEN SCIENCE IN THE DIGITAL MOLDOVA

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## **Abstract**

*The research results data in the Internet era have become a valuable resource, similar to natural mineral resources in Industrial era. In a tendency to save resources (financial, human, time, etc.), academia, governments and businesses around the world are increasingly adopting Open Source solutions.*

*In Moldova there is a range of academic research institutions that have been collecting large amounts of data in their many years of research. On one hand, there is lack of tools able to process and reuse such data; on the other hand, it is very unlikely that research institutions will acquire modern and performing tools for using this data. Collaboration between academia, business and government should be a “must” principle in this synergic process. The governance of all these aspects is the key in thriving the potential of an open digital society through the collaboration with all stakeholders.*

*This paper explores the opportunities of the use of open source software for the re-evaluation of the open research data in Moldova. We will address this issue in the context of the ongoing State program on scientific data infrastructure, examine benefits of open source Economics and finally, analyze incentives that could contribute to the Open Data commitment for Open Science in the Digital Moldova environment.*

## **1. Introduction**

Nowadays, more than half of the world is online [8], and open source software (OSS) has attracted the attention of not only hobbyists and academia, but also that of the proprietary software companies and Venture Capitalists (VC). Much of this interest is due to the network effect of the Internet that allows users to generate and share data (and innovation). Mankind now has the opportunity to use the principle of openness, especially in the field of innovation and science, by using open source tools and open data for a better future. Openness is a better solution especially for developing countries, if they aspire to foster the status of more economically advanced countries. In the context of the EU vision of building an European data economy, the estimates underline that a free flow of data holds for a tremendous economic growth potential. This growth potential is even more significant, knowing that the value of the EU *data economy* is expected to rise up to EUR 739 billion by 2020 (4% of the EU GDP) as estimated by the European Data Market Study in May

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2017. However, the 2017 report shows a relatively modest development in terms of the economic impact of Open Data from 51% in 2016 to 54% in 2017 [7].

Along with other data, the *research results data* in the Internet era have become a valuable resource, similar to natural mineral resources from old mines that are now becoming valuable again, with the invention of modern extracting technologies. Opening the existing research data creates new opportunities for their mining, reuse and interpretation, as well as obtaining new results due to modern technologies. Open Research Data (ORD) is a type of open data focusing on making the results and the observations of research activities public and available to anyone for analysis and reuse. The ORD pool has been actively promoted since the 1950s, and with the development of the Internet network has significantly reduced the cost and time needed to publish or obtain the data.

ORD refers to scientific data freely available for reuse beyond the purpose for which it was originally collected. Open research data contributes to new findings, making research much more cost-effective and reliable. Open research data is a part of a wider change: data-based science as the foundation of open science. Data are distinct parts of information, usually obtained in a specific way. Research data is data collected, observed, or created for analysis purposes to produce original research results. Open data (especially in the era of data revolution) must be discoverable, and there should be sufficient tools for such data to be (re)used. International practices in use of open standards and open source software for the research data provide an opportunity to minimize costs, which is of major importance for countries with insufficient financial resources for research. A wider use of these instruments in the Republic of Moldova would be an important incentive in implementing the Open science concept, which may catalyze the development of the emerging digital economy and society.

The easy access to research data creates new opportunities for obtaining new results reusing the collected data. For obtaining new results the new tools for research data analysis are being developed all over the world.

Over the past 5 years, there has been a significant increase in the use of OSS and interest in open source tools for research data analysis. Growth rates and search volumes are much higher than those of proprietary software vendors. This is a convincing sign about the future of the open source software market for processing research data.

Open Source Software is a type of software for which the source code is provided and which under certain conditions (licenses) can be studied, modified and improved by the user. OSS is usually developed in a public manner and anyone who wants can contribute to the development and improvement of software [13].

The study *The economic and social impact of software & services on competitiveness and innovation (SMART 2015/0015)* states „**Open source** has become a relevant part of the software industry and a number of software ecosystems. It has become an alternative to commercial software in various areas and is already included in many commercial software products. The relevance of open source software has also increased since 2010 due to the rise of Linux, Apache and open source middleware as well as the use of open source software for the creation of cloud computing environments (private and public cloud), Big Data usage (Hadoop) and mobile devices proliferation (Android)”[5].

The study recommends „supporting open source software in all sectors of the economy and public administration. OSS has the potential to become a unique force of the European software industry if it is properly supported. Although open source software is well suited for applications including commercial, European companies, public administrations, and users, they do not yet know enough of its benefits. Thus, the study recommends focusing on policy actions that strengthen the OSS knowledge base and the exchange of good practices between private and public organizations [5].

In a tendency to save resources, but also based on the clear IT development strategies of local IT companies, governments around the world are increasingly adopting Open Source solutions.

In 2017, the European Commission stated that „EU institutions should become themselves OSS users to a greater extent than at present” and OSS is listed as one of the 9 key innovation drivers together with Big Data, Mobility, Cloud computing, and Internet of Things (IoT) [5].

## 2. Open Source Software for Open Research Data: Challenges for Moldova

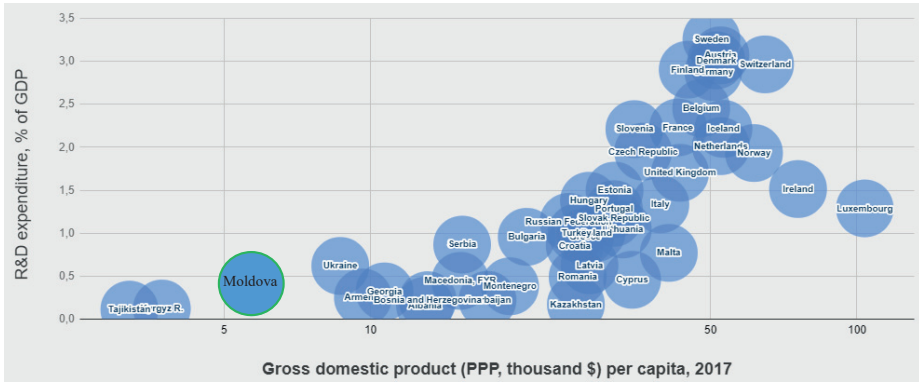
In the Republic of Moldova, the National Strategy „Digital Moldova 2020” states for „promoting the use of open software and free tools for creation, dissemination and use of digital content” [5], and the Interoperability Framework, as a part of e-government program states for „a simple, understandable, accessible, easy-to-use solution based on open standards and a uniform interface”, and „wide use of open standards will simplify and optimize the process to connect to the platform and ensure a sustainable platform development”[9].

Republic of Moldova has joined UN Agenda 2030 which provides „the dissemination of relevant open access to scientific publications generated around the world”. To use the opportunities for the access to research data, the relevant tools are required for capture, processing, and analysis, and one of these could be open-source software.

The importance of promoting the openness is reflected in the „Declaration on Open Science in the Republic of Moldova” adopted in November 2018 in which the research community „...recognize the strategic importance of Open Science. ... want to contribute to ..., address the challenges of openness throughout the entire research cycle: Open Access; Open scientific data; Open Methodology; Open Education; Open rating; Open licences; *Open source software*; Open and Shared Infrastructures; Citizen's science; Open, reusable and reproducible research” [10].

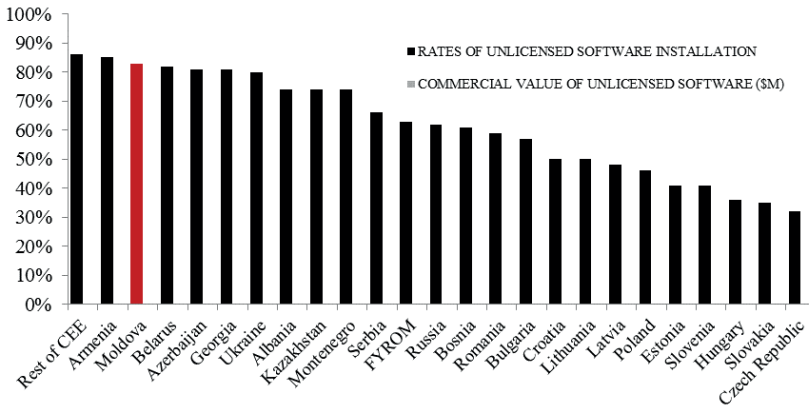
However, within the research, innovation and development institutions as well as in the governmental and non-governmental institutions of the Republic of Moldova, although some emphasis is on the use of OSS, the reality is slightly different.

For the research activities and for obtaining valuable research data it is important to have enough funding. Unfortunately, Moldova, with GDP \$2,289 [15] (PPP \$5,698) [16] per capita in 2017 and only 0,37% allocated for R&D doesn't have a favorable position compared to the developed and neighboring countries (Figure 1). Moreover, only 0,6% of the R&D expenditures are allocated for software procurement [1].



**Figure 1. R&D expenditures depending on GDP**  
 Source: Authors, based on World Bank Group data [15,16]

The lack of money for research activities and relevant instruments for procurement is pushing researchers to find other alternatives and cheaper solutions for necessary software tools - i.e. some of them use Open Source, or - since many of them are not aware about the relevant open source solutions, or are not prepared to use them - (in Moldova more than 41% of researchers are older than 55 [1]) are using the unlicensed solutions. The rate of unlicensed software installation in Moldova is 83%, the second position in the region (Figure 2).



**Figure 2. Rates and commercial values of unlicensed PC software installations. Central and Eastern Europe, 2017.**  
 Source: Authors, based on the 2018 BSA Global Software Survey [2]

### 3. Studies/Surveys’ Findings

Recently, the Information Society Development Institute has undertaken several studies/surveys within the research and development institutions<sup>4</sup>: Study on Open Access in Nov. 2015 -Feb. 2016 and the Survey conducted within the e-IDSM project [14] in May 2018 were focused on identifying the needs of the Research, Development and Innovation (RDI) community in the Republic of

<sup>4</sup>[3] pages 98-117

Moldova regarding the management of scientific data over their lifecycle (creation, processing / analysis, storage / preservation, sharing / access and use)<sup>5</sup>.

The first Survey, involving 39 representatives of research institutions, concluded, that in Moldova there is no culture of research data sharing and there is no specific infrastructure for data retention and sharing. The main recommendations suggested by participants:

- it is necessary to open all data funded from public money; there is a strong need for modernization of the tools used for the data creation, communication and information exchange networks;
- it is necessary to store scientific information in a way that ensures an enhanced level of data protection;
- it is important to formulate appropriate policies regarding the safe storage of the research data; and ensure public access that will preserve data authenticity and prevent intellectual theft, etc.

The second Survey (2018) gathered responses from 48 RDI institutions (92% success rate), including 13 higher education institutions. Respondents with various positions within these institutions participated in the survey, including: heads of RDI institutions (25-12.3%), project directors (42 - 20.7%), laboratory / sector managers (65) - 32%), scientists (34 - 16.7%), teachers (23 - 11.3%), doctoral students (4 - 2%), other positions (10 - 5%).

Data obtained revealed that there are different types of research data produced and generated. Most of the respondents mentioned that they produce or generate the following types of data for research: text (86.2%), images (66%), numerical data (62.6%) and tabular data (55.7%). Only 13.8% of respondents indicated that they do not produce or generate any type of research data. Other types of data have also been mentioned, including: DICOM images, archive quotes, technical drawings, nanopowders, nanocomposites, software in the equipment, teacher's praxis, protocols, algorithms, programs, maps, etc.

Regarding the format of the data generated or collected, the survey participants indicated that they use different formats for scientific data. However, research data is mainly generated and collected in the following formats: text (93.1%), presentations (83.2%), graphics (67%), spreadsheets (46.8%), databases (43.3%) and software for statistical analysis (25.6%).

Survey participants referred to the following ways of producing and generating research data: scientific publications (72.8%), outcomes of the observations (72.3%), results of experiments (69.3%), statistical sources (52%) and survey results (33.7%). For some areas of research, data can be obtained from social media, sensory data, archive files, own calculations, demographic forecasts, bilateral and international projects, media, scientific forums, weather stations data, medical imaging, etc.

Procedures for storing and preserving research data are very important not only for the long-term archiving of research results but also for ensuring the integrity of these data. Thus, 102 (50.2%) of the respondents mentioned that they are taking measures to preserve the data, 61 (30%) of respondents said they did not take measures to preserve the data, and 40 (19.7%) of them said that „I do not know if data preservation measures are being applied in the respective research projects”.

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<sup>5</sup>[3] pages 109-117

Among the specified methods of storing research data, the researchers indicated two large categories:

- locally, on the personal computer (96.6%) and / or on physical support, on paper (72.9%), on CD, USB stick, or external HDD (63.5%) etc.;
- on-line databases, specialized repositories in research institutions or laboratories (24.6%), the institution computer network (32%) and / or internationally, Dropbox, Google Drive (30.5%), etc.

Considering the data formats used by the researchers, as well as the needs indicated by them in the questionnaire replies, it can be noticed that the Moldovan researchers can be divided into two categories:

- 1) Researchers using relatively widespread proprietary software tools in the academic and research environment, such as: Microsoft Office, Windows, SPSS, Adobe FineReader, and others.
- 2) Researchers using special research-specific software solutions such as: ArGIS, Geoportal, Mathematica, FoxPro, Endnote, IC, EViews, GAMESS, Gaussian09 and others.

It is important to have data management plans in place and institutional data management policies or procedures for research projects.

The majority of researchers (177 respondents) believe it is necessary to open the data obtained from research funded by public money. 57 respondents (28.2%) opted for unconditional open access; 29 respondents (14.4%) were in favor of granted open access after an embargo, and access under certain conditions was supported by 91 survey participants (45%). Only 25 researchers (12.4%) do not support the opening of data obtained from public funded research.

In conclusion, it can be mentioned that both national research project managers and R&D institutions accept the open source concept and are ready to provide access to research data. Most researchers use digital media to access research data, but prefer to use traditional data storage formats (Word, Excel, PDF, etc.). Few researchers are using modern and innovative tools to process, access, store and archive research data. One of the main issues that discourage research data sharing is the copyright protection. There are some concerns about the loss of ownership and copyright infringement in case of sharing and open access to research data.

In the Republic of Moldova, the majority of large universities are using Moodle - online learning platform (used by 10 universities) - Table 1 [3]. The Open Educational Resources Coalition initiated in 2016 by Educational Centre PRO-DIDACTICA was signed already by 16 entities (public authorities, NGO, companies, etc.).

Name	Type of tool	Description	Web page	The institution where it is applied
Drupal	Open source content management platform	Official page Application for research Application libraries	<a href="https://idsi.md/en/home">https://idsi.md/en/home</a>	IDSi
DSpace, protocol OAI-PMH	DSpace is an OSS package used to create open access databases for scientific materials	Digital repositories for university. The catalog LibUnivCatalog	<a href="http://primo.libuniv.md/">http://primo.libuniv.md/</a>	USM, ASEM UTM, USARB UASM, UPS USMFM
Moodle	Learning Management System	Used for learning platform & plagiarism detection	<a href="https://vle.ase.md/cms/index.php/en/web-services-en/antiplag-system-en/">https://vle.ase.md/cms/index.php/en/web-services-en/antiplag-system-en/</a>	ASEM
Open-Stack middleware on Ubuntu Server 14.04 LTS	Basic Operational System for all nodes and one latest version and OpenStack release „Juno”	Federative access to Cloud Infrastructure Computing	<a href="https://slideheaven.com/scientificcomputing-infrastructure-and-servicesin-moldova.html">https://slideheaven.com/scientificcomputing-infrastructure-and-servicesin-moldova.html</a>	RENAM
GIMP	Image Editor	Similar Adobe Photoshop, can be used to create, edit and manipulate images.	<a href="https://www.gimp.org/">https://www.gimp.org/</a>	UTM
Government open data portal	Open Data	To 1000 sets of data from Moldova, collected from many governmental sources, can be freely accessible for use.	<a href="http://data.gov.md/">http://data.gov.md/</a>	Government of Moldova

**Table 1. Examples of open source software products widely used in Moldova [3]**

There has been a slight decrease in software piracy in the last years (from 90 to 83%) [1], mostly due to the awareness of the risks of using the pirated software within local business environment. However, Republic of Moldova remains one of the countries where indicators of unlicensed software installation remain high and it is important to stress that still insufficient knowledge and promotion of OSS and its benefits may be one of the key reasons of the low popularity of OSS.

The ongoing State Program on e-Infrastructure for Research Data is aimed at developing a Concept as well as rules and models for data handling. It is imperative that scientific data be interoperable and easy to understand, and the use of OSS could serve as a support for achieving this goal.

#### **4. The State Program on e-Infrastructure for Research Data: a step forward**

The purpose of the State Program „Development of e-Infrastructure of Data from Research, Development and Innovation in the Republic of Moldova” [4] is to carry out fundamental and applicative scientific research, to develop new concepts and models of computer data and services that will aim at the creation at a national level of a new model of infrastructure (e-Infrastructure) of scientific data that will ensure:

- the virtual integration of fragmented and heterogeneous scientific data into a unique information research space of Republic of Moldova;
- the interoperability of research data content;
- expanding the scope of scientific data through data-based research;
- deepening scientific research based on inter-institutional and interdisciplinary data;
- making research institutions more efficient.

The ongoing project „Elaboration of conceptual and methodological framework for e-data infrastructure in the field of RDI in the Republic of Moldova” undertaken by IDSI within this State Program aims at creating a new conceptual infrastructure model, based on theoretical research and best practices from European and international experience and e-Infrastructure of scientific data. This model will ensure the interoperability of data and make data exchanges more efficient through better organization and communication of scientific information. It will also facilitate interinstitutional, interdisciplinary and national efforts for preservation, management and use of research data. The project will enhance the efficiency of the research act and ease the creation of new data based research opportunities in the concept of Open Science in Moldova.

As mentioned above, the Survey identified the necessity in training the researchers in Moldova on the use of Open Source Solutions which could be implemented in the research process as well as in the special case of research data management [3], that may be an important tool for achieving the program objectives.

## **5. Economics: why OSS may be the right choice?**

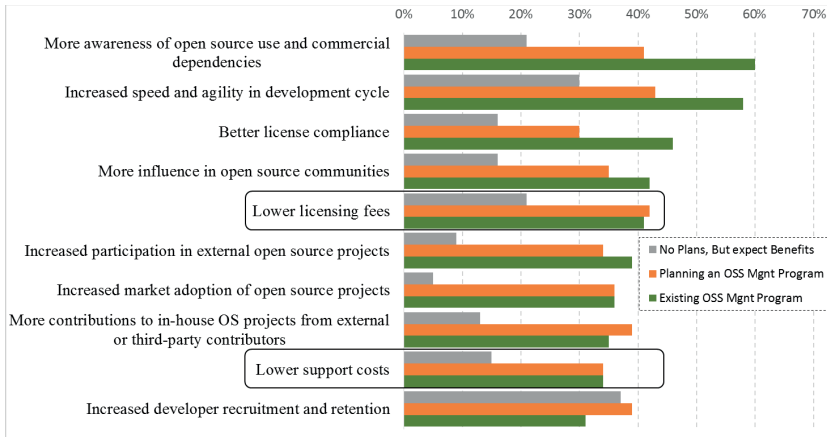
In general, the measurement of the economical impact of the openness is a very challenging task. In the digital world, open access has an impact in three major areas: academic, economic and social.

A UK case study shows that the total expenditure on research relating to cancer in the period 1970–2009 was 15 billion GBP, while the benefit (net-monetized quality-adjusted life years) was estimated at 124 billion GBP. Only 17% of the net-monetary benefit was estimated to be attributable to research performed in the UK, and the other 83% is attributable to research from non-UK sources [7].

For open source, the top three reasons for using it are innovation, cost-savings and competitiveness. With no costs for license there are considerable savings. „The average saving is £30,146 per project” stated in Rackspace report „The State of Open Source” [14]. The report informs that no respondent said that moving to open source had ended up costing them more than using commercial software, which is good news for open source proponents.

According to „The 2018 Open Source Program Management Survey”, performed by the TODO Group, more than half (53%) of the companies surveyed said their organization has an OSS program or has plans to establish one within the next year. Additionally, 1/3 of respondents which use Open Source mentioned “Lower support costs” as one of benefits to use Open Source, and 42% of the respondents mentioned also “Lower licensing costs” as a benefit (Figure 3) [11].





**Figure 3. Benefits of Open Source Programs**

Source: „The 2018 Open Source Program Management Survey” [11].

But fundamentally, OSS is not free. Usually, many people want software to be free and continuously developed by highly skilled professional developers, but only a few of them are ready to pay for it. The economics of this situation is unsustainable and broken. And the right question will be: “who pays for OSS, who motivates the volunteer’s workforce?” And we can see three huge stakeholders:

- Hobbyists – what pay with their time;
- Internet mega-companies are subsidizing OSS with their primary revenue;
- Infrastructure computing startups – financed by Venture Capitalists.

It is important to note that other than hobbyist and true altruists, the Internet companies and VCs all have ulterior motives for releasing OSS [12].

If there are in-house capabilities and technical expertise to maintain the software, and resources to implement, train and provide support to staff, then open source may be most cost-effective for the scientific organization. However, the long-term costs of implementation, innovation, providing support, and investing in infrastructure as the institution evolves, technology changes, and the needs grow involve additional costs. For Moldova, research institutions under the umbrella of the Ministry of Education, Culture and Research (19 institutions), the existing "Academica” infrastructure, can serve as starting point for the implementation of relevant OSS tools for research data. This approach could help avoid charging for extras like add-ons, integration, and additional services, which can negate any cost-saving advantages of OSS.

Nowadays, the economic impact research could be obtained by applying approaches used for the Circular Economy (production, consumption and reuse) or the platform economy as a standard in online economy.

Finally, the emerging research area for the economics of Open Source for Open Science will improve understanding of all benefits for stakeholders.

For the Republic of Moldova, when it will try to understand or to estimate the economics of openness the national aspects should be taken into consideration:

- Business does not invest in Research & Development;
- The only source for R&D and software tools implementation is public financing;
- There is a lack of resources allocated for R&D and especially for software procurement (0,37% of GDP allocated for R&D and only 0,6% of these expenditures are spent for software);

## 6. Conclusions and recommendations

Moldova has embarked in the process of implementation of Open Science approach: The „Declaration on Open Science in the Republic of Moldova” adopted by the first Conference on Open Science in 2018 is supporting the Open Science, Open Data, Open Source Software, etc. by the research community [10].

The State Program on „Development of e-Infrastructure of Data from Research, Development and Innovation in the Republic of Moldova” is in the process of implementation [4].

Although several policies and other documents are emphasizing the importance of the use of Open Source Software in Moldova [9], in our opinion, OSS is supported and promoted at insufficient level.

In the authors’ opinion, among the causes of high level of the unlicensed software installation and low use of OSS in the country are:

- low level of R&D funding;
- insufficient funding for software procurement;
- insufficient level of awareness on existing OSS tools for research data discovering, analysis, storing, sharing;
- high percentage of aged researchers, which are not ready to use new software tools and especially OSS;
- in the case of low-GDP countries (such as the Republic of Moldova), the use of proprietary software for the research data is may not be feasible, being too expensive reported to the amount of undertaken research. Finally, the relative costs (ROI) are very high for low-GDP countries (ex.Moldova) compared to developed countries, for example the UK - for which relative costs are lower.

Based on international experience and findings for the Republic of Moldova, related to Open Tools for Open Data and Open Science, we consider relevant the following:

- Open source shall be the preferred solution for choosing the software;
- Develop and establish policies for the management of research data in research projects and / or research institutions;
- Establish rules / procedures / customs for research data management; motivate researchers to know these rules, adopt them and address all stages of research data management;
- Create awareness and train the researchers in the Republic of Moldova on open source solutions/tools;
- Organize activities presenting and promoting solutions and best practices used in the field, as well as exchange of views and experience in the field of research data management etc.;
- Include open source subjects in the curricula.

Further, suggestions on the use of OSS at national level are:

- Enhance adoption of OSS by public and research institutions; promote initiatives to reduce the level of piracy and offer open source incentives;
- Develop the local IT industry and increase competitiveness of national companies through their intensive involvement in public research projects;
- Stimulate the legal use of computer programs (as stated in the National Intellectual Property Strategy 2020);
- Develop public information systems, preferably based on OSS platforms;
- Conduct periodical national surveys on the use and benefits of Open Source in public institutions (central and local public authorities, educational, research, health, culture, institutions, etc.).

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