

Assessment of Digital Infrastructure Maturity in Bulgarian Scholarly Libraries: Empirical Study of Automation and AI Adoption

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Abstract: Scholarly libraries play central role in providing services for introduction and management of scientific data, including infrastructures for institutional repositories and metadata support. In the context of complex digital research activities, scholarly libraries support access, preservation and distribution of digital resources. AI supported services give new perspectives to information sciences and widen opportunities for innovations and cooperation. Purpose of the article is to assess the digital infrastructure maturity in Bulgarian scholarly libraries and to perform empirical study of automation and AI adoption. For achieving this goal, a survey is carried out among Bulgarian scholarly libraries. It outlines the infrastructural capacity and the basic parameters, necessary for the introduction of a measurement model. The Curation Lifestyle Model is adapted to perform quantity measurement of parameters and calculate a Digital maturity index (DIMI). After that, Pearson chi-square test is performed to check the correlation between the size of the university and the DIMI. Finally, Spearman correlation formula is used to establish a relation between DIMI and AI adoption.

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1. Introduction

Scholarly libraries are the main repositories for scientific data and technological evolution turned them into innovative digital hubs. They develop virtual collections in online environments and integrate intelligent systems in every aspect of their operation. Strategic plans and management policies of research libraries include digital transformation, innovation of services, and remodeling to meet the demands of higher education institutions [1].

The rising importance of technology and data sharing has pushed research libraries to develop digital services in order to serve their communities best [2]. They constantly upgrade their technological infrastructures, enrich online resources, improve cataloguing services, and, at the same time provide user-friendly interfaces and continuous access to information. An integral prerequisite for the development of contemporary scholarly libraries is IT infrastructures, which support digital services and digital management. Next steps are automation of cataloguing, user analysis, discovery services, and statistics. Inevitable parts of the well-developed scholarly library are also electronic references, research data support, digitization services, etc. Open science frameworks and affirmed legislation policies regulate standards for metadata and support interoperability – Open AIRE, FAIR, OAIS [3]. For a better understanding of data and its proper use and interpretations, metadata standards are implied.

Depending on the structure, value, contents and interchange models, there are different types of metadata standards – MARC, MODS, Dublin Core, etc. [4].

Currently, science is in a position where digital data, automation of services, and AI-support systems determine its level of excellence. More recently, artificial intelligence technologies have begun to influence library services by enabling automated metadata enrichment, intelligent discovery systems, and advanced analytics [5].

In the near future automated systems will turn into expert systems, reference services will transform into Chatbots and voice assistants. Traditional classification schemes will be converted to text classification and semantic indexing [6].

When digital resources are managed properly, the institutions widen their opportunities for productivity and community cooperation. A variety of digital curation techniques are offered in scientific literature for better storage and maintenance of digital collections [7]. In this context, scholarly libraries are starting to implement digital management policies and strategies, which support them in the archiving and curation of educational and scientific data [8].

The Curation Lifestyle Model, developed by the Digital Curation Center, provides an overview of the stages of data preservation. The model serves as a basis for creating a framework of requirements and technological infrastructures for maintaining, preserving, and adding value to digital research data throughout its lifecycle [9]. Evaluation of the implementation of DCC Curation Lifestyle Model is possible with the use of the Digital Maturity Model (DMM). It performs a quantity measurement of parameters to determine the technological



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infrastructure, identifies possible improvements and underlines development opportunities [10].

Bulgarian scholarly libraries, as part of the European and World scientific area, are expected to develop with high intensity and to introduce modern digital infrastructures and services. These activities ensure the affirmation of Bulgarian scientists in the international scientific community and create a wide range of cooperation opportunities, and innovation, and knowledge exchange.

The purpose of this paper is to assess the Digital Infrastructure Maturity Index (DIMI) in Bulgarian scholarly libraries and to perform an empirical study in order to evaluate if there is a correlation with size of the institution and AI adoption. Three research questions are defined:

1. Assessment of DIMI in Bulgarian scholarly libraries.
2. Test of the relationship between university size and DIMI.
3. Calculation of the correlation between DIMI and AI adoption.

2. Materials and Methods

The defined research questions and the selected methods for their investigation have been listed in Table 1, below. The first research question aims to reveal the current state of digital and technological development of Bulgarian scholarly libraries through measuring a Digital Infrastructure Maturity Index. For this purpose, the DCC Curation Lifestyle Model is adapted to the Digital Maturity Model and quantity analyses of parameters is performed. After that Chi-square test investigates if there is a relation between the size of the university and the DIMI. Finally, with a look to-wards the near future, a calculation with the Spearman correlation formula is performed in order to establish if there is a correlation between the DIMI and the AI adoption in Bulgarian scholarly libraries.

Table 1. Research questions and methods for their investigation.

Research Question	Method
1. Measurement of the DIMI in Bulgarian scholarly libraries	DIMI
2. Relationship between size of the university and Digital maturity index (DIMI)	Chi-square (χ^2) test
3. Correlation between adoption of AI and Digital infrastructure maturity (DIMI)	Spearman correlation

2.1. Digital maturity index (DIMI) in Bulgarian scholarly libraries

For determining the DIMI of Bulgarian scholarly libraries, an evaluation framework is adapted, based on the DCC Curation Lifestyle Model and the principles of the Digital Maturity Models.

The Digital Maturity Model is an instrument for establishing the level of digital maturity in organizations. It measures the extent to which a company implements digital technologies and processes through various parameters (strategy, technology, service, etc.) Each parameter is evaluated on the basis of a maturity scale (for

example, between 1 and 5). The total sum shows the current level of digitalization [11].

$$\text{DIMI} = \sum_{i=1}^N \text{Parameter}_i \quad (1)$$

The DIMI is calculated with the use of parameters based on the DCC Curation Lifestyle Model.

The DCC Curation Lifestyle Model provides overview of the stages of data preservation. It serves as a basis for creating a framework of requirements and techno-logical infrastructures. There are 8 sequential actions:

1. Conceptualize – initiate and plan the creation of data (gathering and preservation).

2. Create and receive – create data, including administrative, descriptive, structural, and technical metadata. Receive data from various sources in accordance with policies, and put the correct metadata.

3. Appraise and select – evaluate data and select for long-term preservation.

4. Ingest – transfer data to an archive, repository or other custodian.

5. Preservation action – provide long-term preservation. Data cleaning, validation, assigning preservation metadata, assigning representation information, and providing acceptable data structures and formats.

6. Store – keep the data, complying with relevant standards.

7. Access, Use, and Reuse – ensure that data is constantly accessible. In some cases, authentication and access control are applied.

8. Transform – create new data from the original (different format or subset) [12].

A questionnaire is designed for Bulgarian scholarly libraries with the title: “Digital Library Information Systems and Services”. It includes 14 questions, united under 6 sections: General university information; Core library information systems; Digital services and automation; Interoperability and standards; Intelligent and advanced services; International cooperation.

For the purposes of this research, six questions are selected and aligned with the 8 sequential actions of the DCC Curation Lifestyle Model:

1. Does your institution use an institutional repository or digital collection?

2. Which digital library services are currently automated?

3. Does your library provide any of the following digital services?

4. Which metadata standards are used?

5. Is the library aligned with any of the following frameworks or guidelines?

6. Is the library currently using or plan to use intelligent / AI-supported services?

After defining the correspondence between the DCC Curation Lifestyle Model and the selected survey questions, an evaluation framework is designed by attributing scoring points for each answer. After the aggregation of all score points, the DIMI for each Bulgarian scholarly library is calculated.

Table 2 illustrates the correspondence between the DCC Curation Lifestyle Model, the survey questions and the score attributed to each answer.

Table 2. Framework for evaluation of the DIMI.

Curation Lifestyle Model →	Survey Question →	Score
Conceptualize	Institutional Repository	
Create and receive data	Yes	Yes – 1
	No	No – 0
Curation Lifestyle Model →	Survey Question →	Score
Appraise and select -	Automation of library services	(0-1) services – 0
Evaluate data and select	Cataloguing and metadata management	(2-3) services – 1
for preservation	Circulation and user management	(4-5) services – 2
	Digital content ingests and workflows	
	Discovery and search services	
	Usage statistics and analytics	
	None / limited automation	
Curation Lifestyle Model →	Survey Question →	Score
Ingest - transfer data to	Digital services provided	(0-1) services – 0
an archive, repository,	Remote access to electronic resources	(2-3) services – 1
data center	Digital reference services	(4-5) services – 2
	Research data management support	
	Open access publishing support	
	Digitization services	
Curation Lifestyle Model →	Survey Question →	Score
Preservation action -	Metadata standards	Local only – 0
data cleaning, validation,	Dublin Core	One foreign standard – 1
acceptable file formats	MARC21	Two and more foreign
	MODS	standards – 2
	Local	
Curation Lifestyle Model →	Survey Question →	Score
Store - coherence	Alignment with frameworks	None – 0
with standards	Open AIRE Guidelines	At least one – 1
	FAIR principles	
	OAIS model	
	None	
Curation Lifestyle Model →	Survey Question →	Score
Access, use and reuse	AI-supported services	Yes – 2
Transform	Yes – currently implemented	Planned – 1
	Planned within 1–2 years	No – 0
	No current plans	
Total score →	Maturity Index Scale	
Total score - 11	Low maturity – 0-3	
	Moderate maturity – 4-6	
	Advanced maturity – 7-11	

2.2 Relationship between the size of the university and DIMI

A Chi-square index (χ^2) is a statistical indicator, which is used to establish whether there is a significant correlation or difference between categorical variables. It compares the observed values with the expected values, submitted in a table. If the value of χ^2 is big enough and the p-value (the calculated result) is lower from the determined level, it is concluded that there is a statistical correlation between the variables [13].

A Chi-square test of interdependence was carried out to check if there is a relationship between the size of the university and the DIMI of scholarly libraries. For this purpose, two Hypothesis were determined:

H₀: There is no interdependence between the size of the university and DIMI.

H₁: There is a relationship between the size of the university and DIMI.

The Pearson Chi-square test follows the steps:

- Creation of a table with observed and expected frequencies.
- Calculation of the chi-square value with Excel.

- Comparing the value to the critical value.
- Deciding whether to reject the null hypothesis.

2.3 Correlation between adoption of AI and DIMI formatting

The relationship between the Digital infrastructure maturity and AI adoption in academic libraries was examined with the Spearman correlation.

Spearman correlation is a statistical method that measures the strength and direction of the relation between two variables, while the data has been arranged in ranks. It is used with non-normally distributed data or ordinal data and shows if there is a monotonic relationship (the two variables change in the same direction).

The Spearman correlation is calculated not with the raw (initial) data, but instead with ranked values. The ranked values are arranged in order from lowest to highest, and a number is assigned to each value, based on its new position

Spearman correlation (ρ or r_s) formula:

$$r_s = 1 - \frac{6\sum d_i^2}{n(n^2-1)}, \quad (2)$$

where: d_i is the difference between the ranks of the two variables for each observation; n is the number of observations. The coefficients range from -1 to 1, where -1 is a perfect negative correlation, 0 indicates no correlation, and 1 is a perfect positive correlation [14].

3. Results and Discussion

3.1. Digital maturity index (DIMI) in Bulgarian scholarly libraries.

The questionnaire “Digital Library Information Systems and Services” was prepared and distributed among Bulgarian scholarly libraries in the period January-March 2026.

In 2026, the total number of scholarly libraries listed in the Register of Higher Education Institutions in Bulgaria is 51. The survey was distributed to all libraries. Participation in the survey was voluntary. Twenty-nine scholarly libraries gave their answer, which corresponds to approximately 56.9 %. The study therefore, represents a partial census of the population of scholarly libraries and provides a substantial representation.

The main purpose of the survey is to gather accurate information regarding the digital library information systems, infrastructures, and services, which are implemented in Bulgarian scholarly libraries.

The survey includes 14 questions, united under six sections: General university information; Core library information systems; Digital services and automation; Interoperability and standards; Intelligent and advanced services; International cooperation. For the purposes of the research questions, defined in this paper, six questions have been selected. Tables 3, 4, 5, 6, 7, and 8 present the answers given by the Bulgarian scholarly libraries.

From the analysis of the answers for Question 1: Does your institution use an institutional repository or digital collection, presented in Table 3, it can be summarized that 62.1 % from the scholarly libraries possess an institutional repository or digital collection. Some libraries operate an institutional repository – 20.69 %, others manage digital collections for cultural heritage – 17.24 %. The libraries, which have both – a repository and digital collections, are 24.14 %.

Table 3. Does your institution use an institutional repository or digital collection? (Question 1).

Answer	N scholarly libraries	%
Yes – both	7	24.11
Yes – digital collections for cultural heritage	5	17.24
Yes – institutional repository	6	20.69
No	11	37.93

Table 4 illustrates the answers to Question 2: Which digital library services are currently automated. Circulation and user management services have the highest percent of automation – 89.66 %, followed by discovery and search services – 82.75 % and cataloguing and metadata management – 79.31 %. Relatively low level of automation is observed in the digital content ingest and workflows, and the statistics – each with 65.52 %. There

is one scholarly library that has not automated its processes yet.

Table 4. Which digital library services are currently automated? (Question 2).

Answer	N scholarly libraries	%
Cataloguing and metadata management	23	79.31
Circulation and user management	26	89.66
Digital content ingests and workflows	19	65.52
Discovery and search services	24	82.76
Usage statistics and analytics	19	65.52
None / limited automation	1	3.45

Table 5 represents the distribution of digital services among Bulgarian scholarly libraries. The highest percent is 89.66 %, and it is for providing remote access to electronic resources, followed by digital reference services – 68.97 %, and digitization services – 58.62 %. The lowest percent is for the research data management support – 37.93 %.

Table 5. Does your library provide any of the following digital services? (Question 3).

Answer	N scholarly libraries	%
Remote access to electronic resources	26	89.66
Digital reference services	20	68.97
Research data management support	11	37.93
Open access publishing support	13	44.83
Remote access to electronic resources	17	58.62

Table 6 shows the answers to Question 4: Which metadata standards are used. Local standards are implemented in more than half of the scholarly libraries – 57.69 %. The rest are using either MARC 21 – 38.46 %, or Dublin Core – 23.08 %. None of the Bulgarian scholarly libraries has implemented MODS.

Table 6. Which metadata standards are used? (Question 4).

Answer	N scholarly libraries	%
Dublin Core	6	23.08
ARC21	10	38.46
MODS	0	0
Local	15	57.69

Table 7 shows to what extent Bulgarian scholarly libraries are aligned with the international frameworks for managing digital data – Question 5. The answers show that 79.31% are not using any international standards. Open AIRE Guidelines are used by 13.79 % and FAIR principles are implemented in 6.90 % from the libraries. The OAIS model has not been introduced in Bulgarian scholarly libraries yet.

Table 7. Is the library aligned with any of the following frameworks or guidelines? (Question 5).

Answer	N scholarly libraries	%
Open AIRE Guidelines	4	13.79
FAIR principles	2	6.90
OAIS model	0	0
None	23	79.31

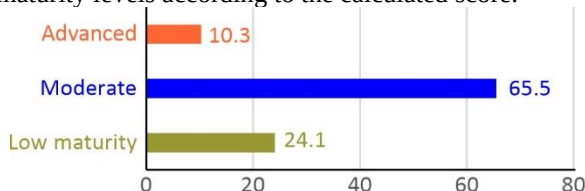
Question 6 explores the innovative services offered by scholarly libraries: Is the library currently using or plan to use intelligent / AI-supported services. Table 8 represents the answers to Question 6 – 53.57 % have either planned or already implemented AI services. The rest 46.43 % have no plans yet of introducing intelligent technologies.

Table 8. Is the library currently using or plan to use intelligent / AI-supported services? (Question 6).

Answer	N scholarly libraries	%
Currently implemented	1	3.57
Planned within 1–2 years	14	50.00
No current plans	13	46.43

The questions and answers from the survey are aggregated according to the framework in Table 2. Six indicators are formed, related to repository infrastructure, digital services, metadata standards, interoperability frameworks, and AI adoption. Each indicator was assigned a score, and the total sum was then aggregated to form a DIMI.

The index was ranked in three levels – Low, Moderate, and Advanced levels of DIMI in Bulgarian scholarly libraries. Fig. 1 illustrates the distribution of the three maturity levels according to the calculated score.

**Fig. 1.** DIMI of Bulgarian scholarly libraries.

In Bulgaria, currently 10.3 % of the scholarly libraries have reached an advanced level of DIMI. The majority – 65.5 % have reached a moderate level of digital transformation. Almost one quarter – 24.1 % are still in the position of low infrastructure maturity level.

3.2 Relationship between the size of the university and DIMI

The second research question - Test of the relationship between university size and DIMI, was investigated with the use of the Chi – square test.

Table 9 represents the distribution of universities, according to the number of their students. It is observed that the greatest number are the universities with less than 10 000 students. Universities with students between 10 000 and 20 000 are 13.79 %. Only 6.90% are the scholarly libraries in universities with a number of students over 20 000.

Table 9. Size of the University (Number of students).

Answer	N scholarly libraries	%
Below 10 000	23	79.31
10 000 – 20 000	4	13.79
Over 20 000	2	6.90

After defining the size of the universities, the data was supplied in Table 10, where the DIMI was already calculated and added. Low DIMI have seven scholarly libraries; Moderate DIMI have 19 libraries, and Advanced DIMI - 3 libraries.

Chi-square formula was applied. Two hypotheses were determined:

H0: There is no interdependence between the size of university and Digital Infra-structure Maturity Index (DIMI)

H1: There is a relationship between the size of university and DIMI.

The degrees of freedom were automatically calculated with a value 4.

The critical value (alpha is 0.05).

The result from the Chi-square test is 47.93. H_0 is rejected.

H_1 is accepted - There is a relationship between the size of university and DIMI of scholarly libraries in Bulgarian universities.

Table 10. Chi- square test algorithm.

Observed Frequencies				
University Size	Low DIMI	Moderate DIMI	Advanced DIMI	Row Total
<10k	7	14	2	23
10k–20k	0	4	0	4
>20k	0	1	1	2
Column Total	7	19	3	29
Chi-square statistic	47.93103448			
Degrees of freedom	4			
Critical value (alpha=0.05)	9.487729037			
Decision	Reject H_0 (relationship exists)			

3.3 Correlation between adoption of AI and DIMI

The Spearman correlation formula was used for solving the third research question, defined in the paper: Calculation of the correlation between DIMI and AI adoption.

Data about the DIMI of Bulgarian scholarly libraries: Low DIMI have a total of 7 scholarly libraries; Moderate DIMI have 19 libraries and Advanced DIMI - 3 libraries.

For the formula necessary results are also answers from the survey question: Is the library currently using or plan to use intelligent / AI-supported services. The number of libraries, which have already implemented AI services is one, and those, which are planning to introduce such technologies are 14. No intention yet of using intelligent/AI supported services have 13 scholarly libraries.

Table 11 displays the results from the Spearman correlation calculation – 0.51. According to the given scale, it is established that there is a Moderate correlation between the DIMI and the adoption of AI-supported services.

Table 11. Spearman Correlation (DIMI vs AI).

Spearman rho:	0.51
Interpretation Guide	
0 – 0.19	Very weak
0.20 – 0.39	Weak
0.40 – 0.59	Moderate
0.60 – 0.79	Strong
0.80 – 1.00	Very strong

3.4 Discussion

The paper investigates three research questions regarding the digital transformation in Bulgarian scholarly libraries. The results show that the majority of libraries have reached a moderate level of Digital technological infrastructure maturity. They operate institutional repositories and digital collections, and most of the processes are automated. Access, preservation and distribution of digital data are managed in a proper way, according to either national or international rules. Bulgarian scholarly libraries assist researchers in their scientific work and support collaboration in international academic communities. Intelligent/AI instruments are acknowledged and their adoption is planned for the near future. These results show good understanding of the future of the scholarly library – continuous development and service variety.

Additional support from authorities and institutions can be directed towards the full automation of library services. The basis for development of digital and AI services is technological infrastructure and complete automation.

Results also indicate that the level of research services in scholarly libraries can be improved by hiring additional experts or introducing training. The implementation of international metadata standards and regulations is

mandatory for interoperability of information, and for expanding of the cooperation.

The research established relationship between the size of the university and the DIMI. The higher the number of students in one university, the higher the demand for contemporary data in multiple formats. More funding and expertise are transferred to larger universities, which leads to advanced technological structures, automation of workflow, and digitalization of services. Important for conducting research and developing innovations is also smaller specialized scholarly libraries. Cutting-edge science requires funding and new investigations; therefore, smaller, but boutique libraries should also participate in the technological transformation in Bulgarian universities.

The Spearman correlation revealed a Moderate level of interdependence between DIMI and AI adoption. The well-developed digital infrastructure in scholarly libraries supports the introduction of AI-supported services. Although intelligent services require certain technological parameters, infrastructure is not the only factor. Introduction of AI technologies in university operations are also connected with the decision of the management and an implementation plan, aligned with international laws and regulations.

4. Conclusion

This study measures the DIMI in Bulgarian scholarly libraries and evaluates its correlation with size of the institution and AI adoption. The results can be summarized as follows:

1. Digital Infrastructure Maturity Index in Bulgarian scholarly libraries. The majority – 65.5 % have moderate level of digital infrastructure maturity; almost one quarter – 24.1 % have low level and 10.3 % show advanced level of DIMI.

2. Test of the relationship between university size and DIMI. Chi – square test is performed and it reveals that there is a relationship between the size of the institution and DIMI.

3. Calculation of the correlation between DIMI and AI adoption. The Spearman correlation shows that there is a moderate correlation between the Digital Infrastructure Maturity Index and the adoption of AI-supported services.

The internationalization of science requires alignment of the infrastructures for data storage and exchange. Technological infrastructures, information systems, and metadata standards should be interoperable.

The survey “Digital Library Information Systems and Services”, distributed among Bulgarian scholarly libraries reveals very good technological capacity, well developed digital services and relatively modern library information systems. A step forward internationalization would be the development of shared infrastructures and the building of compatible systems on national and European level. The results after the calculation of the Digital Infrastructure Maturity Index also show that Bulgarian scholarly libraries can offer a stable infrastructural basis for further development and international data exchange.

Bigger and multidisciplinary institutions are more competitive, possess larger amount of funding and invest more in innovations. They should play the role of leaders in the adoption of international practices and policies. At

the same time, AI instruments allow smaller and not so technologically advanced scholarly libraries to maintain good position and modernize their services.

Further research about the Digital technological infrastructure index among European scholarly libraries will expand the knowledge and provide data for planning future recommendations and actions.

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