Dealing with uncertainty in predicting the flows of visitors in Romanian museums

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Abstract. *Understanding museum visitors' behavioral patterns may help in predicting their number of visits. The aim of the research is to identify the trend models associated with the number of visitors, in 2012-2019, in 2 national museums in the top of the most visited museums in Romania: the National Museum of Natural History "Grigore Antipa" in Bucharest and the National Museum "Peles" in Sinaia and forecast the number of visitors to these objects in 2020 and 2021. Subsequently the same methods were used to analyze the total number of visitors to museums in Romania in 2012-2019 and to forecast the number of visitors for the years 2020 and 2021. The research method used was that of coefficients of variation, which aimed to determine the forecasts for the number of visitors through three types of models: linear, quadratic and exponential. However, Covid-19 pandemic dramatically changed the forecasts of visitor flows in the museums and the managers of these cultural heritage institutions had to cope with this situation.*

Keywords: museum management, knowledge management, predictive analytics, museum tourism demand, cultural supply.

Introduction

The most active stakeholders of a museum are clearly the visitors, closely followed by the internal staff, funding bodies, and various partners. The key to a good collaboration between the museum and its stakeholders is to understand the behavior of visitors, which paves the way for adapting museum programs according to requirements, forecasting visits, streamlining spending and staffing. Discovering the pattern of visitor / tourist behavior is extremely important, as it is the central pillar in a thriving industry over the past 30 years: museum tourism. According to Freedman (2000), people visit museums to gain and share knowledge and to confirm what they believe they already know about the cultural heritage. Added to this current cultural circumstance is the fact that the main challenge in today's changing world is digital transformation, where knowledge is shared globally. Individual attractions (tourist attractions) are an important segment for tourism, many consider them the focal point of tourism and very often the reason why a destination is visited. Understanding the predilection for individual tourist attractions was analyzed in the study conducted by Richards et al. (2002) in the Netherlands, and the findings show that it is based on the visitor's own motivations to visit, rather than the attraction marketing

efforts. Among the individual tourist attractions, the museum as destination attraction plays an extremely important role.

Understanding the patterns of visitors' behavior and the predictability of visitor flows allows optimizing the value proposition of museum, human resources involvement and various facilities (advertisements, souvenir shops, information points for visitors) to meet the growing demand from museum tourism.

Although research in the field of museums has increased significantly in the last 20 years, few of the published studies are predictive, the vast majority being evaluative or descriptive.

This research aims to forecast the number of visitors for the period 2020 -2021 within 2 national museums in the top of the most visited museums in Romania: the National Museum of Natural History "Grigore Antipa" in Bucharest and the National Museum "Peles" in Sinaia and the number of visitors to all Romanian museums.

The structure of the paper is a traditional one: the first step was to synthesize the most relevant information in the literature review; then we established the working methodology: statistical modeling to exemplify and test the methods by which forecasts can be made using regression coefficients; establishing and presenting a set of relevant data on the number of visitors from the two chosen museums, as well as from the total number of visitors to museums in Romania; testing three working hypotheses; and finally, drawing conclusions.

Literature review

Although extremely important, studies evaluating the flow of visitors to museums using traditional research methods (observation, interview, questionnaire, evaluation form etc.) are very expensive, and museum management teams usually decide to refuse such studies due to high costs. Modern methods use technology to save significant funds, but also to increase the scale of application of various research. The technology was widely used until now in museums, to facilitate interactivity between visitors and exhibits. Using technology to understand how museum visitors behave, how they distribute their time, choose their exhibition route, galleries to visit, can have serious implications on the impact of the exhibition and on the interpretation of the exhibition content (Richards et al., 2002).

Among the empirical studies that used modern research tools is the one conducted by Martella et al. (2017) at the Museum of Modern Art - Cobra (Netherlands) where they analyzed the behavior of 180 visitors who voluntarily wore proximity sensors; the data retrieved in the process were visualized and extracted (an x-ray of their behavior - the time spent in front of a work of art is representative for the visitor) for the museum staff, in the activity of designing and evaluating the exhibitions. The survey conducted by Yoshimura et al. (2012) at the Louvre Museum in Paris, reflects spatial and temporal patterns that were evaluated for visitors' behavior, route, visit duration, visiting profile and some interconnections, providing insights about their behavior using data collected from Bluetooth-enabled devices to understand visitor behavior.

In the year when Yoshimura et al. (2012) conducted their research, the Louvre was the most visited museum in the world with 8.5 million visitors and over 40,000 visitors on peak day. The study's findings indicate that technology has a high potential to analyze the characteristics of space and its use by the visitor on a small spatial and temporal scale, with unprecedented accuracy - between 5.9% -8.7% of daily visitors for 101 days. Although the percentage of data seems to correspond to a small sample of visitors, in fact, the actual number, taking into account the number of daily visitors, is much higher than could have been obtained by classical methods.

Predictability of visitor flow and analysis of their behavior are topics that have aroused interest, especially on the American continent. In a study conducted at the Florida Museum of Natural History (Falk et al., 1985) - 69 subjects, who spent at least 3 minutes in the museum, were analyzed while visiting the museum, in an attempt to establish how predictable their behavior is from 3 orientation perspectives: a. the exhibition perspective - the dominant factors that determine the visitor's behavior are the quality and content of the exhibition; b. the visitor's perspective - suggests that, although exhibits are important in determining the visitor's behavior, his past experiences and direct interests are more important; c. formative perspective - involves a more holistic view in which behavior is determined more by a wide range of social and environmental factors than by individual differences or the quality of any exhibit.

The time spent by visitors in the museum galleries, revealing similar or different tastes and habits, can be used to predict visitor behavior. People from worldwide are more and more interested in discovering cultural heritage, values, cultural artefacts. Each of these is connected with spiritual, emotional and cognitive knowledge (Brătianu and Orzea, 2009).

At the core of the body of research that has been conducted under the stream of "contemporary museum studies" is a particular set of assumptions about the ways in which knowledge is produced and shared in the museum context (Srinivasan et al., 2009). Practices of a learning organization are integrated in the management of museums. These processes are congruent to knowledge management principles and Museum Maturity Framework, as stated by Thepthepe and Mitsufuji (2016), leading to a managerial improvement in what concern the capability to understand visitor behavior and predict their flows. Knowledge sharing depends on management styles in cultural organizations. In certain museums, managers have a strong motivation in sharing knowledge and they try to establish an organizational culture facilitating this process. Infrastructure is not perceived as supportive in many cultural organizations to knowledge sharing, especially in public-funded museums (Zbucnea and Leon, 2015).

On the European continent, in a study conducted at the Louvre Museum, Veron and Levasseur (1989), based on ethnographic observations on the behavior of a number of visitors, concluded that depending on the visits inside the exhibitions they can be classified into four categories: Visitor Ant - tends to follow a specific route and devotes a lot of time to observing each exhibit; Visitor Fish - most of the time moves in the center of the room and "usually" avoids looking at the details of the exhibits; The Butterfly Visitor - does not follow a specific route, is guided by the physical orientation of the exhibits and frequently stops to look for more information; and the Cricket Visitor - seems to have a specific preference for certain exhibits or exhibitions and spends a lot of time observing pre-selected exhibits, tending to ignore the rest.

Another classification of visiting patterns is provided by Sparacino (2002) which proposes to divide visitors into three categories: Greedy Visitor - wants to know and see as much as possible; Selective Visitor - gives time to objects of special significance and neglects the rest; The Hasty / Busy Visitor - prefers to walk around the museum to get a general idea about the exhibition, without giving much time to the exhibits.

Starting from the visiting patterns proposed by Veron and Levasseur (1989), in a study conducted at the Torre Aquila Museum - Trento, Italy, Zancanaro et al (2012) analyzes the consistency of visitor behavior during a visit, the possibility of identifying visitor types based on initial observations and the evolution of behavior patterns during a visit, by tracking various interactions using a mobile multi-media device for guidance and positioning information using infrared sensors.

Knowing the type of visitors is very important for adapting the information delivered to them and for preparing future visits (return to the museum). Repeated visits are an important phenomenon in tourism, both for the economy as a whole and for individual tourist attractions. Thus, according to a report by the UK Tourism Council, 79% of foreign visitors have repeated the visit at least once during 1994-2004 (Assaker & El-Haddad, 2012). Individuals who have visited their family or friends have the highest percentage of repeated visits - 84%, and the percentage increases for all types of visitors with increasing age (if at the age of 16-24 the percentage is 12%, over 45 another study by the same entity in 2007 (Assaker & El-Haddad, 2012) reveals that 28% of foreign visitors have visited London between 2-5 times in the last 5 years.

At the British Museum, a survey revealed that 51% of visitors had made a previous visit in June 1993 and 22% had made 6 or more visits in the last 12 months. Then, in November 1993, the percentage of visitors who had at least one previous visit increased to 69% (Darnell & Johnson, 2001).

The visit during the current period determines the possibility of a repeated visit by the same visitor at a later period. Also, a visitor in the current period may influence the likelihood that other people will schedule a visit as opinions about one's own visit shape the perception of others about the importance of repeating the visit or visiting for the first time.

The determinants of a person's likelihood of visiting a museum can be classified as follows, according to Darnell & Johnson (2001):

- Individuals: tastes, income, family size, pattern of previous visits and other relevant personal circumstances;
- Depending on the specifics of the attraction: the nature of the attraction, the type of exhibition, the frequency of important events, the entrance fee and the rest of the associated costs;
- Other determining factors: price and nature of competition, price and nature of additional costs (e.g. cost of transport to attraction).

A good knowledge of the determining factors for visiting or repeating a visit to a tourist attraction creates added value for both attraction management and decision makers, who want to influence / control the flow of visitors, especially when those who have not visited the museum must be motivated.

The potential importance of repeated visits is also underlined by research in econometric studies on the flow of international tourism and the demand for individual attractions (Assaker and El-Haddad, 2012). These studies illustrate the very important explanatory role that dependent variables play in the predictability of visits, so that a visit in the current period affects the probability of a repeated visit of the same visitor in a later period. However, econometric modeling in tourism did not identify differences between categories of visitors (e.g. those who repeated or did not repeat the visit), focusing mainly on parameters such as: income, price, exchange rate, time available or sources. income. Factors such as recent visits and their frequency have been less researched due to their complexity.

One method used to analyze the patterns and structure of the flow of tourists to a specific tourist attraction is that of Markov chains (Xia et al., 2009), which examines the dynamics between different events, such as the frequent transformation of a visitor for the first time at a tourist attraction in a visitor who will repeat the experience. Using Markov's chains, Xia et al. (2009) present a method of modeling the spatial-temporal circulation of tourists at the macro level - a technique applied to estimate the probability that tourists visit some of the attractions in the Philip Island Natural Park, located in the state of Victoria, Australia. Although studies based

on Markov's chains reveal the volume of those who have visited for the first time and will return in the future, they do not provide a tool to determine how many such revisits will be.

Prediction of consumer choice for a museum was the main goal of a research conducted by Assaker and El-Haddad (2012), in the attempt to realistically assess how an initial visit to a goal induces a repeat visit and how it affects the flow of visitors in time. The conclusions showed that visitors who are visiting a museum for the first time are the most effective tool that decision makers can use to stimulate revisits (promotions, marketing, etc.). Also, the only element that affects the probability of making another visit is the time elapsed between the initial visit and the return to the museum.

Another research was conducted by Volchek et al. (2018) and investigates the relationship between the most popular search engine queries, in this case Google, about London museums and actual visits to them, as well as the opportunity to predict the number of visits to the museum based on the tourist's online search behavior. The study included 10 of the 40 most visited museums in the UK and the search engine chosen was Google because 80% of searches related to tourism in Great Britain were done on it. The evaluation tool was Google Trends. The results of the correlational analyzes show that there are strong relationships between a series of queries and the actual visits to the museums in London under investigation. The emergence of consistent relationships without a time lag between searching for information and the actual visit confirms that tourists are looking for activities and attractions for the destination just before or during the visit, which may allow museums to use online search data to estimate their demand. immediate. Google Trends has become a tool commonly used in recent years by other Coupé researchers (2018), and the advancement of technology has made the Internet the main source of travel information, with search engines becoming the primary sources of tourist information, which shapes the tourist's perception of the image of the attraction and facilitates the travel decision (Volchek et al., 2018).

Methodology

The research methodology involved identifying a trend model regarding the evolution of the number of visitors in two national museums, the National Museum of Natural History "Grigore Antipa" in Bucharest and the National Museum "Peles" in Sinaia in 2012-2019, which was based on a predictive analysis for the years 2020 and 2021.

Subsequently, the trend model was replicated on the total number of visitors to museums in Romania in the period 2012-2019, in order to predict the number of visitors for the years 2020 and 2021. As available data, we used to the "Romanian Statistical Yearbook 2018" - National Institute of Statistics, Bucharest as well as to the public reports of the 2 investigated museums.

The following three hypotheses arises:

- Null hypothesis: the existence of the trend model of the number of visitors of a museum in the form of a linear function;
- The first alternative hypothesis: - the existence of the trend model of the trend model of the number of visitors of a museum, in the form of a quadratic function;
- The second alternative hypothesis: - the existence of the trend model of the trend model of the number of visitors of a museum, in the form of an exponential function.

In order to test the hypotheses, we applied the selection coefficient method for selections to the optimal trend model. The coefficient of variation method is through the most often applied statistical tools designed to evaluate the consequences generated by the value differences of some variables over time, being focused on comparing the internal variability of research variables.

The coefficient of variation represents the index of the standard deviation from the average and ensures the comparability of the data series, even if the averages differ very much; visits to museums are influenced by many factors, and the Covid-19 pandemic has led to the closure of museums for very long periods of time. The study was conducted in April 2020 based on available data and could not take into account the impact of the Covid-19 pandemic on the considerable decrease in the number of tourists in 2020, even though most museums have tried to counteract the effects of the pandemic by offering virtual tours.

The lower the value of the coefficient of variation, the greater the homogeneity of the analyzed data.

Findings and discussions

We have distinctly tested the three hypotheses on the data available from the National Museum of Natural History "Grigore Antipa" in Bucharest and the National Museum "Peles" in Sinaia. Furthermore, we applied the same method to the total number of visitors to museums in Romania in the period 2012-2019.

The analysis of the trend model, for the number of visitors at the „Grigore Antipa” National Museum of Natural History, in 2012-2019, which has as goal the forecasting of visitors for 2020 and 2021, started from the data highlighted in Table 1.

Table 1. The number of visitors at the „Grigore Antipa” National Museum of Natural History, in the period 2012-2019

Year	Number of visitors (ξ_i)
2012	326179
2013	209181
2014	179698
2015	213800
2016	230534
2017	301684
2018	311639
2019	314286

Source: public report from „Grigore Antipa” National Museum of Natural History.

If the architecture of the ξ variable, where ξ = the number of visitors at the „Grigore Antipa” National Museum of Natural History, supposes a linear model $\xi_{t_i} = a + b \cdot t_i$, a and b will

$$\text{be: } a = \frac{\begin{vmatrix} \sum_{i=1}^n \xi_i & \sum_{i=1}^n t_i \\ \sum_{i=1}^n \xi_i t_i & \sum_{i=1}^n t_i^2 \end{vmatrix}}{\begin{vmatrix} n & \sum_{i=1}^n t_i \\ \sum_{i=1}^n t_i & \sum_{i=1}^n t_i^2 \end{vmatrix}} = \frac{\sum_{i=1}^n \xi_i \sum_{i=1}^n t_i^2 - \sum_{i=1}^n \xi_i t_i \sum_{i=1}^n t_i}{n \sum_{i=1}^n t_i^2 - \left(\sum_{i=1}^n t_i \right)^2} \quad b = \frac{\begin{vmatrix} n & \sum_{i=1}^n \xi_i \\ \sum_{i=1}^n t_i & \sum_{i=1}^n \xi_i t_i \end{vmatrix}}{\begin{vmatrix} n & \sum_{i=1}^n t_i \\ \sum_{i=1}^n t_i & \sum_{i=1}^n t_i^2 \end{vmatrix}} = \frac{n \sum_{i=1}^n \xi_i t_i - \sum_{i=1}^n t_i \sum_{i=1}^n \xi_i}{n \sum_{i=1}^n t_i^2 - \left(\sum_{i=1}^n t_i \right)^2}$$

We have presented in Table 2 the values corresponding to the test of null hypothesis (linear trend model) in the case of „Grigore Antipa” National Museum of Natural History.

**Table 2. Linear trend related to the number of visitors
at the „Grigore Antipa” National Museum of Natural History**

Year	Visitors „Grigore Antipa” National Museum of Natural History (ξ_i)	Linear trend				
		t_i	t_i^2	$t_i \xi_i$	$\xi_i = a + bt_i$	$ \xi_i - \xi_i $
2012	326179	-4	16	-1304716	226174,5917	100004
2013	209181	-3	9	-627543	234849,7250	25669
2014	179698	-2	4	-359396	243524,8583	63827
2015	213800	-1	1	-213800	252199,9917	38400
2016	230534	+1	1	+230534	269550,2583	39016
2017	301684	+2	4	+603368	278225,3917	23459
2018	311639	+3	9	+934917	286900,5250	24738
2019	314286	+4	16	+1257144	295575,6583	18710
TOTAL	2087001	0	60	520508	2087001	333823

Source: authors' own calculation.

$$a = \frac{2087001 \cdot 60}{8 \cdot 60} = 260875,125 ; \quad b = \frac{8 \cdot 520508}{8 \cdot 60} = 8675,133333$$

$$v_I = \left[\frac{\sum_{i=1}^m |\xi_i - \xi_i^I|}{n} : \frac{\sum_{i=1}^m \xi_i}{n} \right] \cdot 100 = \frac{\sum_{i=1}^m |\xi_i - \xi_i^I|}{\sum_{i=1}^m \xi_i} \cdot 100 = \frac{333823}{2087001} \cdot 100 = 15,99\%$$

If the architecture of the ξ variable, where ξ = the number of visitors at the „Grigore Antipa” National Museum of Natural History, supposes a quadratic model $\xi_i = a + b \cdot t_i + ct_i^2$, a , b and c will be:

$$a = \frac{\sum_{i=1}^n t_i^4 \sum_{i=1}^n \xi_i - \sum_{i=1}^n t_i^2 \sum_{i=1}^n t_i^2 \cdot \xi_i}{n \sum_{i=1}^n t_i^4 - \left(\sum_{i=1}^n t_i^2 \right)^2} ; \quad b = \frac{\sum_{i=1}^n \xi_i t_i}{\sum_{i=1}^n t_i^2} ; \quad c = \frac{n \cdot \sum_{i=1}^n t_i^2 \cdot \xi_i - \sum_{i=1}^n t_i^2 \cdot \sum_{i=1}^n \xi_i}{n \sum_{i=1}^n t_i^4 - \left(\sum_{i=1}^n t_i^2 \right)^2}$$

Table 3 reveals the values corresponding to the test of first alternative hypothesis (quadratic trend model) in the case of „Grigore Antipa” National Museum of Natural History.

**Table 3. Quadratic trend related to the number of visitors
at the „Grigore Antipa” National Museum of Natural History**

Year	Visitors „Grigore Antipa” National Museum of Natural History (ξ_i)	Parabolic trend					
		t_i	t_i^2	t_i^4	$t_i^2 \xi_i$	$\xi_{ti} = a + bt_i + ct_i^2$	$\left \xi_i - \xi_{ti} \right $
2012	326179	-4	16	256	5218864	280606,6973	45572
2013	209181	-3	9	81	1882629	244455,3907	35274
2014	179698	-2	4	16	718792	221111,6384	41414
2015	213800	-1	1	1	213800	210575,4403	3225
2016	230534	+1	1	1	230534	227925,7070	2608
2017	301684	+2	4	16	1206736	255812,1717	45872
2018	311639	+3	9	81	2804751	296506,1907	15133
2019	314286	+4	16	256	5028576	350007,7639	35722
TOTAL	2087001	0	60	708	17304682		224820

Source: authors' own calculation.

$$a = \frac{708 \cdot 2087001 - 60 \cdot 17304682}{8 \cdot 708 - 60^2} = 212846,7965 \quad ; \quad b = \frac{520508}{60} = 8675,133333$$

$$c = \frac{8 \cdot 17304682 - 60 \cdot 2087001}{8 \cdot 708 - 60^2} = 6403,777132$$

$$v_{II} = \left[\frac{\sum_{i=1}^m |\xi_i - \xi_{t_i}^{II}|}{n} : \frac{\sum_{i=1}^m \xi_i}{n} \right] \cdot 100 = \frac{\sum_{i=1}^m |\xi_i - \xi_{t_i}^{II}|}{\sum_{i=1}^m \xi_i} \cdot 100 = \frac{224820}{2087001} \cdot 100 = 10,77\%$$

If the architecture of the ξ variable, where ξ = the number of visitors at the „Grigore Antipa” National Museum of Natural History, supposes an exponential model $\xi_{t_i} = ab^{t_i}$, a and b will be:

$$\lg a = \frac{\left| \begin{array}{cc} \sum_{i=1}^n \lg \xi_i & \sum_{i=1}^n t_i \\ \sum_{i=1}^n t_i \lg \xi_i & \sum_{i=1}^n t_i^2 \end{array} \right|}{\left| \begin{array}{cc} n & \sum_{i=1}^n t_i \\ \sum_{i=1}^n t_i & \sum_{i=1}^n t_i^2 \end{array} \right|} = \frac{\sum_{i=1}^n \lg \xi_i \sum_{i=1}^n t_i^2 - \sum_{i=1}^n t_i \lg \xi_i \sum_{i=1}^n t_i}{n \sum_{i=1}^n t_i^2 - \left(\sum_{i=1}^n t_i \right)^2} \quad \lg b = \frac{\left| \begin{array}{cc} n & \sum_{i=1}^n \lg \xi_i \\ \sum_{i=1}^n t_i & \sum_{i=1}^n t_i \lg \xi_i \end{array} \right|}{\left| \begin{array}{cc} n & \sum_{i=1}^n t_i \\ \sum_{i=1}^n t_i & \sum_{i=1}^n t_i^2 \end{array} \right|} = \frac{n \cdot \sum_{i=1}^n t_i \lg \xi_i - \sum_{i=1}^n \lg \xi_i \sum_{i=1}^n t_i}{n \sum_{i=1}^n t_i^2 - \left(\sum_{i=1}^n t_i \right)^2}$$

Table 4 outlines the values corresponding to the test of second alternative hypothesis (quadratic trend model) in the case of „Grigore Antipa” National Museum of Natural History.

Table 4. Exponential trend related to the number of visitors at the „Grigore Antipa” National Museum of Natural History

Year	Visitors „Grigore Antipa” National Museum of Natural History (ξ_i)	Exponential trend					
		t_i	$\lg \xi_i$	$t_i \lg \xi_i$	$\lg \xi_{t_i} = \lg a + t_i \lg b$	$\xi_{t_i} = ab^{t_i}$	$ \xi_i - \xi_{t_i} $
2012	326179	-4	5,51	-22,05	5,45	282454,60	43724
2013	209181	-3	5,32	-15,96	5,35	228872,52	19692
2014	179698	-2	5,25	-10,50	5,37	237257,79	57560
2015	213800	-1	5,33	-5,33	5,39	245950,28	32150
2016	230534	+1	5,36	+5,36	5,42	264302,33	33768
2017	301684	+2	5,47	+10,95	5,43	273985,65	27698
2018	311639	+3	5,49	+16,48	5,45	284023,75	27615
2019	314286	+4	5,49	+21,98	5,46	294429,62	19856
TOTAL	2087001	0	43,25	0,93			262063

Source: authors' own calculation.

$$\lg a = \frac{43,25179328 \cdot 60}{8 \cdot 60} = 5,40647416 \quad \lg b = \frac{8 \cdot 0,937610217}{8 \cdot 60} = 0,015626836$$

$$v_{\exp} = \left[\frac{\sum_{i=1}^n |\xi_i - \xi_{t_i}^{\exp}|}{n} : \frac{\sum_{i=1}^n \xi_i}{n} \right] \cdot 100 = \frac{\sum_{i=1}^n |\xi_i - \xi_{t_i}^{\exp}|}{\sum_{i=1}^n \xi_i} \cdot 100 = \frac{262063}{2087001} \cdot 100 = 12,56\%$$

$$v_{II} = 10,77\% < v_{\exp} = 12,56\% < v_I = 15,99\%$$

The values of the ξ variable, which reflects the number of visitors at the „Grigore Antipa” National Museum of Natural History, follow a quadratic trend model $\xi_{t_i} = a + b \cdot t_i + ct_i^2$

Thus, we will be able to determine the prediction of visitors for 2020 and 2021:

$$\xi_{2020}^{ANTIPA_MUSEUM} = 212846,7965 + 8675,133333 \cdot 5 + 6403,777132 \cdot 5^2 = 416316,8915 \cong 416317_visitors$$

$$\xi_{2021}^{ANTIPA_MUSEUM} = 212846,7965 + 8675,133333 \cdot 6 + 6403,777132 \cdot 6^2 = 495433,5733 \cong 495434_visitors$$

The analysis of the trend model, for the number of visitors at the „Peles” National Museum, in 2012-2019, which has as goal the forecasting of visitors for 2020 and 2021, started from the data highlighted in Table 5.

Table 5. The number of visitors at the Peles National Museum, in the period 2012-2019

Year	Number of visitors (ω_i)
2012	285520
2013	341026
2014	359040
2015	406129
2016	413474
2017	415270
2018	421210
2019	402197

Source: public report from „Peles” National Museum.

If the architecture of the (ω_i) variable, where (ω_i) = the number of visitors at the Peles National Museum of Natural History, supposes a linear model $\omega_{t_i} = a + b \cdot t_i$, a and b will be:

$$a = \frac{3043866 \cdot 60}{8 \cdot 60} = 380483,25 \quad b = \frac{8 \cdot 827065}{8 \cdot 60} = 13784,41667 \quad v_I = \frac{147752}{3043866} \cdot 100 = 4,85\%$$

We have presented in Table 6 the values corresponding to the test of null hypothesis (linear trend model) in the case of „Peles” National Museum.

Table 6. Linear trend related to the number of visitors at the „Peles” National Museum

Year	Visitors „Peles” National Museum (ω_i)	Linear trend				
		t_i	t_i^2	$t_i \xi_i$	$\xi_i = a + bt_i$	$ \xi_i - \xi_{t_i} $
2012	285520	-4	16	-1142080	325345,5833	39826
2013	341026	-3	9	-1023078	339130,0000	1896
2014	359040	-2	4	-718080	352914,4167	6126
2015	406129	-1	1	-406129	366698,8333	39430
2016	413474	+1	1	+413474	394267,6667	19206
2017	415270	+2	4	+830540	408052,0833	7218
2018	421210	+3	9	+1263630	421836,5000	626
2019	402197	+4	16	+1608788	435620,9167	33424
TOTAL	3043866	0	60	827065		147752

Source: authors’ own calculation.

If the architecture of the (ω_i) variable, where (ω_i) = the number of visitors at the „Peles” National Museum, supposes a quadratic model $\omega_i = a + b \cdot t_i + ct_i^2$, a , b and c will be:

$$a = \frac{708 \cdot 3043866 - 60 \cdot 21780439}{8 \cdot 708 - 60^2} = 410964,5291 ; \quad b = \frac{827065}{60} = 13784,41667$$

$$c = \frac{8 \cdot 21780439 - 60 \cdot 3043866}{8 \cdot 708 - 60^2} = -4064,170543 ; \quad v_{II} = \frac{55194}{3043866} \cdot 100 = 1,81\%$$

Table 7 reveals the values corresponding to the test of first alternative hypothesis (quadratic trend model) in the case of „Peles” National Museum.

Table 7. Quadratic trend related to the number of visitors at the „Peles” National Museum

Year	Visitors „Peles” National Museum (ω_i)	Parabolic trend					
		t_i	t_i^2	t_i^4	$t_i^2 \xi_i$	$\xi_i = a + bt_i + ct_i^2$	$ \xi_i - \xi_{t_i} $
2012	285520	-4	16	256	4568320	290800,1337	5280
2013	341026	-3	9	81	3069234	333033,7442	7992
2014	359040	-2	4	16	1436160	367139,0136	8099
2015	406129	-1	1	1	406129	393115,9419	13013
2016	413474	+1	1	1	413474	420684,7752	7211
2017	415270	+2	4	16	1661080	422276,6803	7007
2018	421210	+3	9	81	3790890	415740,2442	5470
2019	402197	+4	16	256	6435152	401075,4671	1122
TOTAL	3043866	0	60	708	21780439		55194

Source: authors’ own calculation.

If the architecture of the (ω_i) variable, where (ω_i) = the number of visitors at the „Peles” National Museum, supposes an exponential model $\omega_i = ab^{t_i}$, a and b will be:

$$\lg a = \frac{44,61594713 \cdot 60}{8 \cdot 60} = 5,576993391 \quad \lg b = \frac{8 \cdot 1,004502371}{8 \cdot 60} = 0,016741706 ; \quad v_{\exp} = \frac{164590}{3043866} \cdot 100 = 5,41\%$$

Table 8 outlines the values corresponding to the test of second alternative hypothesis (quadratic trend model) in the case of „Peles” National Museum.

Table 8. Exponential trend related to the number of visitors at the Peles National Museum

Year	Visitors „Peles” National Museum (ω_i)	Exponential trend					
		t_i	$\lg \xi_i$	$t_i \lg \xi_i$	$\lg \xi_i = \lg a + t_i \lg b$	$\xi_i = ab^{t_i}$	$ \xi_i - \xi_{t_i} $
2012	285520	-4	5,45	-21,82	5,51	323613,45	38093
2013	341026	-3	5,53	-16,59	5,52	336332,06	4694
2014	359040	-2	5,55	-11,11	5,54	349550,54	9489
2015	406129	-1	5,60	-5,60	5,56	363288,52	42840
2016	413474	+1	5,61	+5,61	5,59	392405,51	21068
2017	415270	+2	5,61	+11,23	5,61	407827,77	7442
2018	421210	+3	5,62	+16,87	5,62	423856,16	2646
2019	402197	+4	5,60	+22,41	5,64	440514,50	38318
TOTAL	3043866	0	44,61	1,00			164590

Source: authors’ own calculation.

$$v_{II} = 1,81\% < v_I = 4,85\% < v_{\text{exp}} = 5,41\%$$

The values of the characteristic, which expresses **the number of visitors at the „Peles” National Museum**, display an exponential trend model $\omega_{t_i} = a + b \cdot t_i + ct_i^2$.

Thus, we will be able to determine the prediction of visitors for 2020 and 2021:

$$\omega_{2020}^{PELES_MUSEUM} = 410964,5291 + 13784,41667 \cdot 5 + (-4064,170543) \cdot 5^2 = 378282,3489 \cong 378282_visitors$$

$$\omega_{2021}^{PELES_MUSEUM} = 410964,5291 + 13784,41667 \cdot 6 + (-4064,170543) \cdot 6^2 = 347360,8896 \cong 347361_visitors$$

The analysis of the trend model, for the number of visitors at for the total number of visitors at the Romanian museums, which aims at forecasting the visitors for 2020 and 2021, started from the data highlighted in Table 9.

Table 9. The number of visitors at all the Romanian Museums, in the period 2012-2019

Year	Number of visitors (thousands persons) ($\wp_i$)
2012	10076
2013	10928
2014	10824
2015	13052
2016	14197
2017	15941
2018	17686
2019	18198

Source: „2019 Romanian Statistic Yearbook” - National Institute of Statistics, Bucharest.

If the architecture of the ($\wp_i$) variable, where ($\wp_i$) = the number of visitors at all the Romanian museums, supposes a linear model $\wp_{t_i} = a + b \cdot t_i$, a and b will be:

$$a = \frac{110902 \cdot 60}{8 \cdot 60} = 13862,75 \quad b = \frac{8 \cdot 64141}{8 \cdot 60} = 1069,016667 \quad v_I = \frac{3390}{110902} \cdot 100 = 3,06\%$$

We have displayed in Table 10 the values corresponding to the test of null hypothesis (linear trend model) in the case of all the Romanian museums.

Table 10. Linear trend related to the number of visitors at all the Romanian museums

Year	Number of visitors at all the Romanian museums (thousands persons) ($\wp_i$)	Linear trend				
		t_i	t_i^2	$t_i \xi_i$	$\xi_{t_i} = a + bt_i$	$ \xi_i - \xi_{t_i} $
2012	10076	-4	16	-40304	9586,683332	489
2013	10928	-3	9	-32784	10655,70000	272
2014	10824	-2	4	-21648	11724,71667	901
2015	13052	-1	1	-13052	12793,73333	258
2016	14197	+1	1	+14197	14931,76667	735
2017	15941	+2	4	+31882	16000,78333	60
2018	17686	+3	9	+53058	17069,80000	616
2019	18198	+4	16	+72792	18138,81667	59
TOTAL	110902	0	60	64141		3390

Source: authors' own calculation.

If the architecture of the $(\wp_i)$ variable, where $(\wp_i)$ = the number of visitors at all the Romanian museums, supposes a quadratic model $\wp_{t_i} = a + b \cdot t_i + ct_i^2$, a , b and c will be:

$$a = \frac{708 \cdot 110902 - 60 \cdot 700219}{8 \cdot 708 - 60^2} = 17686,76163 \quad b = \frac{64141}{60} = 1069,016667 \quad c = \frac{8 \cdot 700219 - 60 \cdot 110902}{8 \cdot 708 - 60^2} = -509,8682171$$

$$v_{II} = \frac{23268}{110902} \cdot 100 = 20,98\%$$

Table 11 highlights the values corresponding to the test of first alternative hypothesis (quadratic trend model) in the case of all the Romanian museums.

Table 11. Quadratic trend related to the number of visitors at all the Romanian museums

Year	Number of visitors at all the Romanian museums (thousands persons) ($\wp_i$)	Parabolic trend					
		t_i	t_i^2	t_i^4	$t_i^2 \xi_i$	$\xi_{t_i} = a + bt_i + ct_i^2$	$ \xi_i - \xi_{t_i} $
2012	10076	-4	16	256	161216	5252,803489	4823
2013	10928	-3	9	81	98352	9890,897675	1037
2014	10824	-2	4	16	43296	13509,25543	2685
2015	13052	-1	1	1	13052	16107,87675	3056
2016	14197	+1	1	1	14197	18245,91008	4049
2017	15941	+2	4	16	63764	17785,32210	1844
2018	17686	+3	9	81	159174	16304,99768	1381
2019	18198	+4	16	256	291168	13804,93682	4393
TOTAL	110902	0	60	708	700219		23268

Source: authors' own calculation.

If the architecture of the $(\wp_i)$ variable, where $(\wp_i)$ = the number of visitors at all the Romanian museums, supposes an exponential model $\wp_{t_i} = ab^{t_i}$, a and b will be:

$$\lg a = \frac{33,05425912 \cdot 60}{8 \cdot 60} = 4,13178239 \quad \lg b = \frac{8 \cdot 2,0269838748}{8 \cdot 60} = 0,033783064$$

$$v_{\exp} = \frac{3078}{110902} \cdot 100 = 2,78\%$$

Table 12 outlines the values corresponding to the test of second alternative hypothesis (quadratic trend model) in the case of all the Romanian museums.

Table 12. Exponential trend related to the number of visitors at all the Romanian museums

Year	Number of visitors at all the Romanian museums (thousands persons) ($\wp_i$)	Exponential trend					
		t_i	$\lg \xi_i$	$t_i \lg \xi_i$	$\lg \xi_{t_i} = \lg a + t_i \lg b$	$\xi_{t_i} = ab^{t_i}$	$ \xi_i - \xi_{t_i} $
2012	10076	-4	4,00	-16,01	3,996650134	9923,16	153
2013	10928	-3	4,03	-12,11	4,030433198	10725,88	202
2014	10824	-2	4,03	-8,06	4,064216262	11593,54	770
2015	13052	-1	4,11	-4,11	4,097999326	12531,39	521
2016	14197	+1	4,15	+4,15	4,165565454	14640,82	444
2017	15941	+2	4,20	+8,40	4,199348518	15825,17	116
2018	17686	+3	4,24	+12,74	4,233131582	17105,33	581
2019	18198	+4	4,26	+17,04	4,266914646	18489,05	291
TOTAL	110902	0	33,05	2,02			3078

Source: authors' own calculation.

$$v_{\text{exp}} = \frac{3078}{110902} \cdot 100 = 2,78\%$$

$$v_{\text{exp}} = 2,78\% < v_I = 3,06\% < v_{II} = 20,98\%$$

The values of the variable, which focuses **the number of visitors in all the Romanian museums**, pursues an exponential trend model $\phi_{t_i} = ab^{t_i}$

Thus, we will be able to determine the prediction of visitors for 2020 and 2021:

$$\phi_{2020}^{\text{ROMANIAN_MUSEUMS}} = 13545,10544 \cdot 1,080893895^5 = 19984,70354 \cong 19985 \text{ _thousands_ of _visitors}$$

$$\phi_{2021}^{\text{ROMANIAN_MUSEUMS}} = 13545,10544 \cdot 1,080893895^6 = 21601,34402 \cong 21601 \text{ _thousands_ of _visitors}$$

Conclusions

The research topic is a very rich one. As we move forward in the study, more and more options, solutions, questions and correlations open up. The main challenge in understanding and streamlining the relationship between the museum and its stakeholders is the visitor and the key to forecast visitor flows is understanding behavior patterns. Based on the understanding of the visitor's behavior, the entire activity of the museum can be adapted (scientific, administrative, educational and social) to their requirements and needs, saving important resources (economic, human and time). The behavioral pattern of visitors can help, through statistical modeling, the behavioral prediction and the forecast of the number of visitors. Predicting the number of visitors is a golden resource for the management of the institution.

The statistical modeling performed was intended to exemplify and test the methods by which forecasts can be made, using regression coefficients. As the official data about the number of visitors in Romanian museums is not published at this moment, we are aware that the forecasts that we made will be invalidated by the Covid-19 pandemic, which led to lockdowns and the global decrease of visits to cultural heritage institutions. In a survey conducted by ICOM, it has been found that almost all museums around the world (95%) were closed because of the COVID-19 pandemic and museums' managers focused on digital activities. About 15% of museums have increased digital communication activities. In another survey done by UNESCO, it has been reported that around 90% of museums or more than 85,000 institutions have closed their doors during the crisis (Antara and Shuvro, 2020).

This research also has limitations. The statistical modeling in this research is not meant to give us an accurate forecast, but to make us aware of the existence of such tools, the benefits of using them and the importance they can have in streamlining the management of a cultural institution.

References

- Antara, N., & Shuvro, S.E.N. (2020). The Impact of COVID-19 on Museum and The Way Forward to be Resilience, *Uluslararası Müze Eğitimi Dergisi*, 2(1), 54-61.
- Assaker, G., & El-Haddad, R. (2012). *Predicting repeat and total visits to a destination using simulation modeling through time*.
- Brătianu, C., & Orzea, I. (2009). Emergence of the cognitive-emotional knowledge dyad, *Review of International Comparative Management*, 10(5), 893-902.

- Coupé, T. (2018). Replicating "Predicting the present with Google trends" by Hyunyoung Choi and Hal Varian (The Economic Record, 2012), *Economics: The Open-Access, Open-Assessment E-Journal*, 12(2018-34), 1-8.
- Darnell, A. C., & Johnson, P. S. (2001). Repeat visits to attractions: a preliminary economic analysis, *Tourism management*, 22(2), 119-126.
- Falk, J. H., Koran Jr, J. J., Dierking, L. D., & Dreblow, L. (1985). Predicting visitor behavior. *Curator: The Museum Journal*, 28(4), 249-258.
- Freedman, G. (2000). The changing nature of museums. *Curator: The Museum Journal*, 43(4), 295-306.
- Martella, C., Miraglia, A., Frost, J., Cattani, M., & van Steen, M. (2017). Visualizing, clustering, and predicting the behavior of museum visitors, *Pervasive and Mobile Computing*, 38, 430-443.
- Richards, G. (2002). Tourism attraction systems: Exploring cultural behavior, *Annals of tourism research*, 29(4), 1048-1064.
- Sparacino, F. (2002). *The Museum Wearable: Real-Time Sensor-Driven Understanding of Visitors' Interests for Personalized Visually-Augmented Museum Experiences*.
- Srinivasan, R., Boast, R., Furner, J., & Becvar, K. M. (2009). Digital museums and diverse cultural knowledges: Moving past the traditional catalog, *The Information Society*, 25(4), 265-278.
- Statistical Yearbook of Romania (2018). National Institute of Statistics, Bucharest 2019, retrieved from <https://insse.ro/cms/ro/tags/anuarul-statistic-al-romaniei>, accessed at 10.08.2020.
- The activity of cultural and artistic units in 2018*, National Institute of Statistics, Bucharest 2019, retrieved from https://insse.ro/cms/sites/default/files/field/publicatii/activitatea_unitatilor_culturalar_artistice_anul_2018.pdf, accessed at 16.08.2020.
- The activity of cultural and artistic units in 2019*, National Institute of Statistics, Bucharest, 2020 retrieved from https://insse.ro/cms/sites/default/files/com_presa/com_pdf/activunitcultart_19r.pdf, accessed at 16.08.2020.
- Thepthea, N., & Mitsufuji, T. (2016). Knowledge process and learning organization development in science museums, *Procedia Computer Science*, 99, 157-170.
- Véron, E., & Levasseur, M. (1989). *Ethnographie de l'exposition: l'espace, le corps et le sens*. Bibliothèque publique d'information du Centre Pompidou.
- Volchek, E., Song, H., Law, R., & Buhalis, D. (2018). Forecasting London museum visitors using Google trends data, *e-Review of Tourism Research*.
- World Tourism Barometer (2020, N°18 January). *Growth in international tourist arrivals continues to outpace the economy*, retrieved from https://webunwto.s3.eu-west-1.amazonaws.com/s3fs-public/2020-01/UNWTO_Barom20_01Januaryexcerpt0.pdf, accessed at 15.05.2020.
- World Tourism Barometer and Statistical Annex (2019). *2018: International tourist arrivals worldwide reach 1.4 billion two years ahead of forecasts*, retrieved from <https://www.e-unwto.org/doi/epdf/10.18111/wtobarometereng.2019.17.1.1>, accessed at 15.05.2020.
- Xia, J. C., Zeephongsekul, P., & Arrowsmith, C. (2009). Modelling spatio-temporal movement of tourists using finite Markov chains, *Mathematics and Computers in Simulation*, 79(5), 1544-1553.
- Yoshimura, Y., Girardin, F., Carrascal, J. P., Ratti, C., & Blat, J. (2012). *New tools for studying visitor behaviours in museums: a case study at the Louvre*. Springer-Verlag.

- Zancanaro, M., Stock, O., Eisikovits, Z., Koren, C., & Weiss, P. (2012). Co-narrating a conflict: An interactive tabletop to facilitate attitudinal shifts, *ACM Transactions on Computer-Human Interaction*, 19(3), October 2012, Article No. 24, 1-30, <https://doi.org/10.1145/2362364.2362372>.
- Zbucnea, A., & Leon, R. (2015). Knowledge sharing barriers in cultural organizations. Culture, Innovation and Entrepreneurship: connecting the knowledge dots, *Proceedings IFKAD*, 1716-1727.