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ORIGINAL

Design and validation of an instrument to measure e-governance through factor analysis

Diseño y validación de un instrumento para medir la gobernabilidad electrónica a través del análisis factorial

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ABSTRACT

E-governance combines the use of electronic means in interaction between government and citizens, government and business, and within government operations to enhance democratic, governmental, and business aspects of governance. Thus, e-governance is built on a paradigmatic dimension such as e-democracy (relationship between government and citizens) and an operational dimension such as e-governance. The objective was to design and validate an instrument to measure e-governance based on three factors: a) e-administration, b) e-services, and c) e-democracy.
Method: based on the level of importance given to each factor (sample of 2042 Latin American citizens), as well as the relationships between them, an analysis of the importance of each factor is carried out.
Results: after the confirmatory analysis, the definitive instrument with which e-governance can be measured by other researchers and future research is obtained, considering the three selection factors, namely: e-administration, e-services and e-democracy.
Conclusions: this research contributes to political science through the design and validation of an instrument consisting of 39 items that can be used to measure e-governance according to the dimensions proposed by the United Nations Educational, Scientific and Cultural Organization.

Keywords: Public Administration; E-Governance; Validation of Instruments.

RESUMEN

La gobernanza electrónica combina el uso de medios electrónicos en la interacción entre el gobierno y los ciudadanos, el gobierno y las empresas, y dentro de las operaciones gubernamentales para mejorar los aspectos democráticos, gubernamentales y comerciales de la gobernanza. De este modo, la gobernabilidad electrónica se basa en una dimensión paradigmática como la democracia electrónica (relación entre el gobierno y los ciudadanos) y una dimensión operativa como el gobierno electrónico. Así, el gobierno electrónico se construye a partir de una dimensión paradigmática como es la e-democracia (relación entre gobierno y ciudadanos) y operativa como es el gobierno electrónico. El objetivo fue diseñar y validar un instrumento para medir el gobierno electrónico basado en tres factores: a) administración electrónica, b) servicios electrónicos y c) democracia electrónica.
Métodos: a partir del nivel de importancia otorgado a cada factor (muestra de 2042 ciudadanos latinoamericanos), así como de las relaciones entre ellos, se realiza un análisis de la importancia de cada factor.
Resultados: tras el análisis confirmatorio, se obtiene el instrumento definitivo con el que se puede medir el gobierno electrónico por parte de otros investigadores y futuras investigaciones, considerando los tres factores de selección, a saber: e-administración, e-servicios y e-democracia.
Conclusiones: esta investigación contribuye a la ciencia política a través del diseño y validación de un instrumento compuesto por 39 ítems que pueden ser utilizados para medir la gobernanza electrónica según las dimensiones propuestas por la Organización de las Naciones Unidas para la Educación, la Ciencia y la Cultura.

Palabras clave: Administración Pública; Gobernanza Electrónica; Validación de Instrumentos.

INTRODUCTION

E-governance is not new. In fact, it appeared in the 1930s, but it was limited to the realm of business administration.[1] In the 1990s, the report of the High Level Group of Experts,[2] prepared by the European Union, concluded that "States must be key players in the Knowledge Society, as articulators (institutional and intersectoral) and producers of high-value content".[3]

As a result, e-government would become an ideal model to facilitate knowledge transfer and insertion in a wide range of sectors. E-government has been identified as a mechanism for developing the Knowledge Society in the report.[2,3] Between the two dimensions of e-government,[4] identifies e-government as one, and e-democracy as the other. The concept of e-governance refers to the use of electronic means in government interactions with citizens and businesses, as well as in internal government operations, to simplify and improve democratic, governmental, and business aspects. An e-governance system derives from a paradigmatic dimension such as e-democracy (relationship between government and citizens) and an operational dimension such as e-government.

Since its inception, the experiences of modernizing the State, through e-governance, have promised at least two advances: greater efficiency and better democracy. It is argued that e-governance could translate into the creation of real and virtual spaces so that citizens can exercise due social control over those in power, and a fundamental step to get there is transparency.[5]

To assess the level of development of e-governance in Latin America, this project uses the three dimensions proposed by the United Nations Educational, Scientific and Cultural Organization:[6]

- Electronic administration (e-government): refers to the improvement of government and public sector officials' processes through new ICT processes.
- Electronic services (e-services): refers to improving the ease of providing government services to citizens. Examples of online services include: requests for government documents, requests for legal documents and certificates, licenses, and permits.
- Electronic democracy (e-democracy): requires an increasingly active participation of people in the decision-making process thanks to IT.

METHOD

This is a research article in which it was applied an instrument to measure e-governance to adult citizens in Venezuela, Mexico, Argentina, Peru, Cuba and Colombia. Before answering the questions, the subjects were asked to give their consent through the following statement: "I declare that I have been informed that: my participation in this research is completely free and voluntary and I can withdraw from it at any time. I will not receive personal benefit of any kind for participating in this project/product, nor will I receive any financial retribution". The instrument was applied between the months of October and November 2023.

This is quantitative research with a cross-sectional design. For the statistical analysis it was used the SPSS program. For the purpose of validating the "Electronic Governance" questionnaire, an exploratory factor analysis was used, followed by confirmatory factor analysis. The initial instrument consisted of six items to measure e-administration, twenty-one to measure e-services and fourteen to measure e-democracy. Factor analysis is a technique used to reduce a large number of variables to a smaller number of factors. This method extracts the maximum common variance from all variables and combines them into a total score. Factor analysis is part of the General Linear Model (GLM), and this method also makes some assumptions: there is a linear relationship, there is no multicollinearity, the relevant variables are included in the analysis, and they have real correlations between variables and factors.[7]

For the purposes of this study, the principal component analysis (PCA) method was used, which is the most commonly used by the researchers. The ACP starts by extracting the maximum variance and factoring it in first. It then removes the variance explained by the first factor and begins to extract the maximum variance for the second factor. The process boils down to this last element.[7]

As this is a regional study, the main intention of the study was to apply the instrument in as many cities and regions as possible in Latin America. Of course, the limitation was the access that the researchers of this project were able to have to the people. The population consisted of 21 721 761 adults from Venezuela (Zulia state), Mexico (Nuevo León Department), Argentina (Tucumán, Salta, Misiones, Santa Cruz, Córdoba), Perú (La Libertad Department), Cuba (Habana) and Colombia (Boyacá Department). A sample of 2042 people was calculated, with a margin of error of 3 % and 99 % reliability. A quota sampling was designed, distributing the subjects as follows (Table 1):

Table 1. Sample

Countries	Regions	Population	%	p	Sample
Venezuela	Zulia	5126000	23,6	0,236	481,91
México	Nuevo León	5784442	26,63	0,2663	543,78
Argentina	Tucumán, salta, misiones, santa cruz, Córdoba	4129480	19,01	0,19	387,98
Perú	La Libertad	1778000	8,185	0,08185	167,14
Cuba	La Habana	3686839	16,97	0,1697	346,53
Colombia	Boyacá	1217000	5,603	0,05603	114,41
Total		21721761	100	0,99988	2041,8

According to this test, the variables are orthogonal, or uncorrelated. Alternately, the variables may not be orthogonal, in which case the correlation matrix is significantly different from the identity matrix.

To reinforce the study, a systematic review was conducted. A search in Scopus in 2013 yields 47 documents using the string “e-governance” AND “measurement”. Of these 47 documents, 11 are open access and provide useful results for this research (Table 2):

Table 2. Findings on e-governance measurement

#	Year	Works´s title	Findings	Proposes and validates an instrument for measuring e-governance
1	2013	E-governance in Lithuanian Municipalities: External Factors Analysis of the Websites Development.[8]	The paper focuses on the usability of public organizations’ websites, as well as on the external factors influencing the development of Lithuanian municipal websites. It measures one of the dimensions of e-governance which is e-services.	Parcial
2	2016	A QoS and Cognitive Parameters based Uncertainty Model for Selection of Semantic Web Services.[9]	The main objective of this research work is to present a model based on cognitive and quality of service parameters for the selection of semantic web services.	No
3	2016	A Toolkit for Prototype Implementation of E-Governance Service System Readiness Assessment Framework.[10]	This research paper presents a set of e-governance readiness assessment tools as a prototype application.	Parcial
4	2016	E-readiness evaluation modelling for monitoring the national e-government programme.[11]	The study aims to develop a solution to assess the progress of a national e-government program on the methodological platform of the Project Management Maturity Model (PMMM).	Partial
5	2017	Georgia on my mind: a study of the role of governance and cooperation in online service delivery in the Caucasus.[12]	E-services indicators are proposed, although the instrument is not validated. The article concludes that eGovernment is fragmented and that the use of public and private online services (eService) is limited, despite the high penetration and use of the Internet.	Parcial
6	2018	The Arrangement of the Information Technology and Communications Master Plan using PeGI Model (e-Governance Ranking Indonesia) to Improve District Government Services.[13]	E-services indicators are proposed, although the instrument is not validated.	Partial
7	2018	Who Is Measuring What and How in EGOV Domain?.[14]	This is a literature review. It does not validate an instrument, although it makes contributions by stating that assessment tools are scattered among various sources and that there is no systematized framework to support the analysis and selection of the appropriate tool for specific situations.	Partial

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8	2020	Relationship of Personal Data Protection towards the Electoral Measures: Partial Least Square Analysis.[15]	The study addresses one of the indicators of the e-democracy dimension, namely e-voting.	Partial
9	2021	E-governance and University of Ha'il institutional excellence in light of the Kingdom's Vision 2030: an Empirical Study on Faculty Member.[1]	The following dimensions are proposed and validated to measure e-governance: Transparency, Accountability, Participation, Level of e-services provided, Change management and Infrastructure.	Yes
10	2021	The Engineering of E-governance and Technology in the Management of Secondary Schools: Case of the Nouaceur Delegation. [16]	Although the instrument is not validated, several principles are proposed to measure e-governance, such as: participation, transparency, accountability and evaluation.	Partial
11	2023	Mapping the e-governance efficiency of Chinese cities.[17]	E-governance is considered an essential indicator of advanced cities, but the measurement of e-governance efficiency requires further study. Following this line of research, this article proposes an e-governance efficiency index (GEI) that is applied to Chinese cities.	Yes

The participants were informed and accepted the following statement: I understand that my participation is completely voluntary, that I can withdraw from the study whenever I want without having to give explanations and that this will not affect my medical care. I freely give my consent to participate in the Research Project entitled "E-governance in Latin America".

RESULTS

Exploratory factor analysis

In this first phase, an exploratory factor analysis was used, in which it is assumed that any indicator or variable can be associated with any factor. It is the most widely used factor analysis by researchers and is not based on any previous theory.

Several tests are needed to determine the strength of the correlation between the variables. The Kaiser-Meyer-Olkin (KMO) test was used and the result was 0,963, indicating that factor analysis can be performed (Table 1). The Kaiser-Meyer-Olkin (KMO) test determines whether the data is suitable for factor analysis. This test measures the fit of the sample for each variable in the model. This statistic is a measure of the ratio of variance between variables that are likely to share the variation. The lower the ratio, the more suitable the data will be for factor analysis.[18]

The KMO returns values between 0 and 1. A general rule of thumb for interpreting the statistic is that: KMO values between 0,8 and 1 indicate that sampling is adequate. KMO values below 0,6 indicate that sampling is inadequate and corrective action should be taken. Some authors put this value at 0,5, so use your own criteria for values between 0,5 and 0,6. KMO values close to zero mean that there are large partial correlations compared to the sum of correlations. In other words, there are generalized correlations that pose a major problem for factor analysis.[18]

Bartlett's sphericity test was also used with a result of 0,00, which also confirmed the factor analysis (Table 3). Bartlett's sphericity test compares the observed correlation matrix with the identity matrix. Basically, it checks for any redundancy between variables that can be summarized with a small number of factors. The null hypothesis of the test is that the variables are orthogonal, i.e., they are not correlated. Another hypothesis is that the variables are not orthogonal, i.e., they are so correlated that the correlation matrix is significantly different from the identity matrix. This test is often performed before applying a data reduction method, such as principal component analysis or factor analysis, to ensure that the data reduction method actually compresses the data in a meaningful way.[19]

Table 3. KMO and Bartlett Test

Kaiser-Meyer-Olkin measure of sampling adequacy of sampling adequacy		**0,963**
Bartlett's test for sphericity	Aprox. Chi-cuadrado	93297,391
	gl	820
	Sig.	0,000

The results were examined in the anti-image correlation matrix as the values were not close to zero (Tables 5 and 6). The anti-image correlation matrix contains negative values of partial correlation coefficients, while the anti-image covariance matrix contains negative values of partial covariances. In a good coefficient model, most elements outside the diagonal will be small.[20] On the diagonal of the anti-image correlation matrix, a measure of sampling suitability for a variable is shown. As a result of this analysis, it was determined that item 1 (in pink) will be eliminated in the confirmatory analysis because it has a value below 0,700.

Table 4. Communalities

Item	Initial	Extraction
Item1	0,264	0,035
Item2	0,284	0,074
Item3	0,642	0,645
Item4	0,689	0,719
Item5	0,706	0,762
Item6	0,682	0,731
Item7	0,718	0,686
Item8	0,786	0,770
Item9	0,748	0,741
Item10	0,766	0,755
Item11	0,781	0,758
Item12	0,796	0,756
Item13	0,791	0,764
Item14	0,736	0,581
Item15	0,784	0,582
Item16	0,775	0,572
Item17	0,759	0,587
Item18	0,750	0,771
Item19	0,831	0,903
Item20	0,792	0,831
Item21	0,757	0,709
Item22	0,784	0,726
Item23	0,814	0,771
Item24	0,785	0,760
Item25	0,801	0,803
Item26	0,814	0,790
Item27	0,793	0,781
Item28	0,744	0,760
Item29	0,808	0,844
Item30	0,798	0,834
Item31	0,770	0,796
Item32	0,805	0,835
Item33	0,847	0,891
Item34	0,839	0,869
Item35	0,778	0,800
Item36	0,856	0,876
Item37	0,894	0,926
Item38	0,860	0,882
Item39	0,855	0,877
Item40	0,768	0,737
Item41	0,783	0,775

Extraction method: maximum likelihood

In communalities, the values closest to 1 are taken and a minimum value of 0,7 will be obtained; this is the case of Items 5 and 7 to 41 (Table 4). The commonality of the variable ranges from 0 to 1. In general, one way to understand commonality is through the proportion of the total variance found in a particular variable. A variable with no single variance (i.e., a variable whose variance is 100 % explained as a result of other variables) has a commonality of 1. A variable whose variance cannot be explained by other variables has a commonality of 0.[21] As a result of this analysis, it is determined that in the confirmatory analysis, Items 1 and 2 (in pink) will be eliminated for presenting values below 0,500.

In the total variance explained (Table 5), we can see that 73,329 % is concentrated in items 1 to 7. The total variance is the sum of the variance of all the individual principal components. The proportion of variance explained by a principal component is the ratio of the variance of that principal component to the total variance. To find the principal components, we need to add the variances and divide them by the total variance.[22]

Table 5. Total variance explained

Factor	Initial eigenvalues			Sums of squared extraction charges			Sums of loads squared by rotation		
	Total	% of variance	% accumulated	Total	% of variance	% accumulated	Total	% of variance	% accumulated
1	18,582	45,323	45,323	17,864	43,572	43,572	15,154	36,961	36,961
2	5,193	12,666	57,989	5,246	12,794	56,366	3,679	8,974	45,935
3	2,826	6,893	64,881	2,012	4,908	61,274	3,488	8,507	54,443
4	1,674	4,084	68,965	2,175	5,305	66,579	2,992	7,297	61,739
5	1,412	3,444	72,409	1,018	2,484	69,063	2,438	5,945	67,685
6	1,243	3,032	75,441	0,980	2,391	71,454	1,417	3,455	71,140
7	1,126	2,745	78,186	0,769	1,874	73,329	0,897	2,189	73,329
8	0,969	2,364	80,550						
9	0,938	2,287	82,837						
10	0,609	1,485	84,321						
11	0,502	1,224	85,545						
12	0,467	1,138	86,683						
13	0,421	1,026	87,709						
14	0,349	0,852	88,561						
15	0,297	0,723	89,285						
16	0,268	0,655	89,939						
17	0,265	0,647	90,586						
18	0,262	0,639	91,225						
19	0,249	0,607	91,832						
20	0,238	0,580	92,412						
21	0,219	0,534	92,946						
22	0,201	0,489	93,436						
23	0,193	0,471	93,906						
24	0,191	0,465	94,372						
25	0,186	0,452	94,824						
26	0,174	0,425	95,249						
27	0,169	0,412	95,661						
28	0,162	0,394	96,055						
29	0,156	0,381	96,436						
30	0,151	0,368	96,804						

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31	0,147	0,358	97,163
32	0,145	0,353	97,515
33	0,137	0,334	97,849
34	0,131	0,319	98,168
35	0,128	0,312	98,480
36	0,124	0,301	98,781
37	0,120	0,294	99,075
38	0,107	0,260	99,335
39	0,104	0,255	99,590
40	0,095	0,231	99,821
41	0,074	0,179	100,000

Método de extracción: máxima verosimilitud

In the matrix of rotated components, the items or components with the greatest strength according to each factor (Table 6). The items grouped in pink are the ones that have the greatest relationship with each other. In this way, the following Items are placed between factors 1 to 6.

Table 6. Rotated Component Matrix

Item	Factor						
	1	2	3	4	5	6	7
Item25	0,863						
Item26	0,854						
Item27	0,848						
Item41	0,846						
Item24	0,841						
Item23	0,841						
Item13	0,821						
Item12	0,820						
Item22	0,816						
Item11	0,814						
Item40	0,805						
Item21	0,803						
Item10	0,780						
Item8	0,767						
Item9	0,750						
Item14	0,720						
Item7	0,717						
Item16	0,715						
Item17	0,713						
Item15	0,710						
Item18	0,621					0,570	
Item37		0,918					
Item38		0,898					
Item39		0,893					
Item36		0,884					
Item33			0,848				
Item34			0,828				

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Item32		0,810		
Item35		0,785		
Item5			0,860	
Item4			0,842	
Item6			0,842	
Item3			0,796	
Item2				
Item1				
Item30	0,514		0,705	
Item29	0,541		0,697	
Item31	0,513		0,675	
Item28	0,508		0,653	
Item19	0,631			0,668
Item20	0,617			0,629

Extraction method: maximum likelihood.
Rotation method: varimax with Kaiser normalization.
a. The rotation has converged in 6 iterations.

Confirmatory factor analysis

To confirm the strength of the correlation between the variables, several tests are required. The Kaiser-Meyer-Olkin (KMO) test was applied, which gave a result of 0,964, which ratifies the factor analysis. Bartlett's sphericity test was also applied, with a result of 0,000, which also confirms the factor analysis (Table 7). In this second phase of the factor analysis, the commonalities allow us to confirm Items 3 to 41 (Table 7).

Table 7. KMO and Bartlett Test

Kaiser-Meyer-Olkin measure of sampling adequacy		**0,964**
Bartlett's test for sphericity	Approx. chi-square	92522,546
	gl	741
	Sig.	0,000

In the total variance explained, using the extraction method "principal axis factorization", it is evident that, although 6 factors could have been selected because they were closer to 1, our theoretical model is three-factor; it is observed that 65,401 % is concentrated in the first three factors (Table 8).

Table 8. Total variance explained

Factor	Initial eigenvalues			Sums of squared extraction charges			Sums of loads squared by rotation
	Total	% of variance	% accumulated	Total	% of variance	% accumulated	Total
1	18,570	47,617	47,617	18,218	46,713	46,713	17,948
2	5,135	13,167	60,783	4,830	12,384	59,096	7,408
3	2,776	7,119	67,902	2,459	6,305	65,401	3,393
4	1,668	4,277	72,179				
5	1,259	3,229	75,409				
6	1,127	2,891	78,300				
7	0,972	2,492	80,792				
8	0,938	2,405	83,197				
9	0,609	1,561	84,757				
10	0,467	1,196	85,954				
11	0,427	1,096	87,049				

12	0,350	0,899	87,948
13	0,298	0,765	88,713
14	0,270	0,693	89,406
15	0,266	0,682	90,088
16	0,262	0,672	90,760
17	0,250	0,641	91,401
18	0,238	0,611	92,013
19	0,219	0,563	92,575
20	0,201	0,515	93,090
21	0,194	0,497	93,587
22	0,191	0,490	94,077
23	0,186	0,477	94,554
24	0,174	0,447	95,000
25	0,169	0,434	95,434
26	0,162	0,414	95,849
27	0,156	0,401	96,250
28	0,151	0,387	96,637
29	0,147	0,377	97,014
30	0,145	0,371	97,385
31	0,137	0,352	97,737
32	0,131	0,336	98,073
33	0,128	0,328	98,401
34	0,124	0,317	98,718
35	0,121	0,309	99,027
36	0,107	0,274	99,300
37	0,105	0,268	99,568
38	0,095	0,243	99,811
39	0,074	0,189	100,000

Extraction method: principal axis factorization.
a. When factors are correlated, the sums of the squared loadings cannot be added to obtain a total variance.

In the matrix of rotated components, the extraction method “principal axis factorization” and the rotation method “Oblimin with Kaiser normalization” have been used. You can see the items or components with the greatest strength according to each factor. The items indicated are the ones that have the greatest relationship with each other. In this way, the items are placed between factors 1 to 3 (Table 9).

Table 9. Rotated Factor Matrix

Item	Factores		
	1	2	3
Item13	0,868		
Item40	0,863		
Item12	0,863		
Item25	0,862		
Item11	0,858		
Item23	0,856		

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Item26	0,854		
Item27	0,853		
Item24	0,848		
Item41	0,847		
Item10	0,846		
Item22	0,839		
Item8	0,839		
Item21	0,831		
Item9	0,824		
Item7	0,785		
Item14	0,769		
Item15	0,758		
Item16	0,757		
Item17	0,752		
Item19	0,709		
Item18	0,702		
Item20	0,691		
Item29	0,660		
Item30	0,639		
Item28	0,630		
Item31	0,625		
Item36		0,849	
Item37		0,844	
Item39		0,827	
Item38		0,825	
Item34		0,737	
Item35		0,731	
Item33		0,726	
Item32		0,708	
Item4			0,848
Item5			0,844
Item6			0,822
Item3			0,793

Método de extracción: factorización de eje principal.
Rotation method: Oblimin with Kaiser normalization.
a. The rotation has converged in 5 iterations.

DISCUSSION

This work was based on the assumption that there were little or no applied and validated measurement instruments that considered the three dimensions of e-governance. In this sense, it coincides with other study,[10] which present a set of e-governance readiness assessment tools as an application prototype; even though it does not propose an instrument or its validation, the modified scheme of levels of commitment could be useful as a 4-stage implementation of the e-participation maturity model, namely: E-Informing, E-Collaborating,

E-Consulting, and E-Empowering. For their part, one research[11] developed a solution to assess the progress of a national e-government program on the Project Management Maturity Model (PMMM) methodological platform. One of the dimensions of e-governance, which is e-services, is measured.

It is stated that the evaluation tools are dispersed among various sources and there is no systematized framework that supports the analysis and selection of the appropriate tool for specific situations.[14] The paper aims to answer these questions by characterizing the available literature in the context of the measurement, evaluation and monitoring of the EGOV, in order to generate a knowledge base aimed at the creation of a future catalogue of tools and instruments for the evaluation of the EGOV, and to present a conceptual framework for the choice of an appropriate tool from such a catalogue. Another study support the thesis of the need to design and validate instruments to measure e-governance.[17] E-governance is considered an essential indicator of advanced cities, but measuring the effectiveness of e-governance requires further study.

CONCLUSIONS

In conclusion, this research contributes to political science through the design and validation of an instrument consisting of 39 Items that can be used to measure e-governance, namely: 1) e-government: understood as the improvement of government processes and public sector officials through new information technologies; (2) e-services, which refer to improving the delivery of public services; and (3) e-democracy, which implies greater and more active participation of citizens in decision-making processes through the use of information and communication technologies.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

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