Societal Technological Megatrends

Subjects: Social Issues | Others

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Researchers was to obtain an overview of the evolution of the research on the subject of technological megatrends from the perspective of interest, domains, geographical areas, sources, authors and cocitation networks, research clusters of countries, and cluster-related concepts.

forecasting | societal changes | digital transformations | megatrends | technological wave | technological changes

1. Introduction

Change is the essential characteristic [1][2] of the actual economy. As suggested by Taylor [3] in his attempt to formulate a theory of change, the rapid changes of global society generate opportunities and threats that can be managed properly only if they are approached from a predictive perspective. These concerns, which have been highlighted for thousands of years in China through books and guides dedicated to change [4], have reached a high level of accuracy over time and constitute the basis for numerous academic studies, as well as numerous special reports of renowned consulting firms, such as PricewaterhouseCoopers [5], Deloitte [6], McKinsey [7], and Gartner [8]. researchers would like to highlight the fact that some concerns in this field were meant to shape an increasingly dynamic reality [9], including the creation of certain intelligent learning algorithms for change impact prediction [10]. It is believed that changes at the global society level (societal changes, also known as megatrends [11]) are generated by macroeconomic forces that manifest themselves in cycles ranging between 20 and 50 years and that act on extended geographical areas by generating an important shift in the progress of a society.

The objective of this study consists in the accomplishment of a bibliometric analysis of megatrends as an effect of technological evolution at the societal level, in order to clearly highlight the main directions and characteristics of the research in this field. Following Aria and Cuccurullo [12], who consider that in a bibliometric analysis researchers find questions related to the identification of the knowledge base, the examination of the research fund, and the revelation of the social networks, with reference to the scientific community, and in corroboration with the methodologies described by Schepers and Wetzel [13] and Stopar and Bartol [14], corresponding to the assumed objective, researchers established the following research questions: (Q1) How has the research interest in this topic evolved over time? (Q2) What are the main research areas? (Q3) Which are the countries that pay more attention to research in the field of megatrends? (Q4) What are the main sources in the field of megatrends? (Q5) What are the main papers and the main authors in the field of megatrends? (Q6) What are the source and the

author cocitation networks? (Q7) What are the coauthorship clusters by country? and (Q8) What are the clusters of megatrend-related concepts?

2. Technological Megatrends in Society

Although *The Oxford English Dictionary* [11] attributes the earliest use of the concept of Megatrends to *The Christian Science Monitor* (CSM) in the early 1980s, current searches in the CSM article database led to the identification of the use of the term, for the first time, in the article “Where America is rehearsing for the 21st century”, published by Ruth Walker on 23 March 1983 [15], given that John Naisbitt’s book “Megatrends. The new directions transforming current lives” had already been published in October 1982. Researchers acknowledge that after 1982, megatrends became a concept established by Naisbitt [16], which referred to the “general changes in thinking or approach, which affect countries, industries and organizations”, given that *The Oxford English Dictionary* defined it as “an important shift in the progress of a society or of any other particular field or activity; any major movement” [11].

The last decade abounds with authors [17][18] who paid special attention to the concept of megatrends from a scientific perspective. Megatrends are essentially considered to be either global changes in individual, social, and technological structures, which are expected to have a major impact in the future on the markets as a whole [19], on society, the economy, and the natural world in the long run [20]; or macroeconomic and geostrategic forces [21], transformative on the global level [22] and sustainable from the synergistic development perspective [23], which shape current world and current collective future in profound ways associated with both opportunities and significant risks and which have a significant impact on business, the economy industry, society, individuals, culture, and even technology (including information and communication technology). Munters and Marx [24] comprehend megatrends in time and space by reference to key areas of society, such as politics, economics, technology, social values, and relations at all levels of society, and Chism [25] even sees them as solutions available to governments to solve emerging problems. From a unique perspective, it is intriguing to observe the opinion of the authors Vidyasekar, Kolhapur, and Amarnath [26], who examine the impact of transformative forces on the global level and also on the personal lives of individuals, as components of society, enterprises, economies, and cultures.

In summary, researchers conclude that there is a definition of megatrends in terms of individual research interests and directions [27], which highlights three essential features [23]: the length of megatrends’ impact over a period of at least fifteen years, their influence on the global context of the business and social environment, and the transformation of socio-economic strategies. In contrast to the above, researchers argue that megatrends represent global forces which are manifested over large geographical areas; over long periods of time; with a major impact on the economy, society, and the lives of individuals; and which influence the evolution of humanity as a whole.

In this context, megatrends are manifested in human society as a result of the technology–society relationship [28] amid the changes that dominate society as a whole [2][29], with a predominant emphasis on the technological side

[30]. Thus, current attention is drawn to the study of R. Pęciak [17], entitled “Megatrends and their Implications in the Globalised World“, in which an inventory of the authors in the field is made, with references to the main socio-technological megatrends for the period of 1982–2016, starting with Naisbitt [16] and concluding with Retief et al. [31]. The study does not take into consideration the futuristic approaches highlighted by the renowned futurologists [32] of the World Future Society (WFS). researchers highlight, in the same fashion, a similar approach undertaken by Siscan [33], who insisted on the economic and social impact of megatrends.

A revision of the scientific literature is also found in the paper “Global megatrends and their implications for environmental assessment practice” published in 2016 by Retief et al. [31], which focuses on identifying the key megatrends for environmental impact assessment. Thus, the authors conclude that the term megatrends is frequently spotted in reports, periodicals, or other documents created by forecasting institutions or by specialized research centers and consulting firms, but is less incidental in the field of academic databases. Two years later, P. J. Batt [18] departed from this conclusion in the article “Responding to the challenges presented by global megatrends”, and conducted a review of the specialized literature focused on the impact of megatrends on the global food industry, having as sources of analysis mainly the reports of the experts of consulting firms. Another critical study of the specialized literature was conducted by Malik and Janowska [27] in the paper “Megatrends and their use in economic analyses of contemporary challenges in the world economy megatrendy”, in which they analyzed the use of megatrends as an analytical framework on various economic and social levels. Thus, their research highlighted the conceptual use of megatrends in the forecasting studies of different specific industries, as well as the analysis of changes produced or anticipated in the management of various socioeconomic areas.

Current research has also identified an interesting analysis of the impact of megatrends, at the level of organizations, from the perspective of the relationship between megatrends and disruptive elements, by the authors Linthorst and de Waal [34] in their study “Megatrends and Disruptors and Their Postulated Impact on Organizations”, by means of which 13 megatrends were identified, along with one disruptor mentioned in the academic literature, in relation to the topic of “the future of work”, and “the occurrence of a pandemic disease” in particular.

The conclusions of the aforementioned studies [17][18][23][27][31][33][34] fully motivate a mapping of the specialized literature assigned to megatrends, which represents an approach with a high degree of originality, being preceded only by a few revisions of the literature in the field.

3. Data Analysis

In order to obtain answers to the research questions assigned to current research objective in the field of technological megatrends and their societal manifestation, with reference to the evolution of the research interest in this topic over time (Q1), the main research areas in which the subject has been researched (Q2), the countries where more attention is paid to research in this field (Q3), the main publications in this field (Q4), and the main papers and authors in the field of megatrends (Q5), researchers organized the analysis of the data from the refined

results up to this stage into the following sections: year of publication, scientific category, corresponding authors' countries, most relevant sources/journals, and most cited articles and authors.

3.1. Year of Publication

This section is dedicated to obtaining an overview of the dynamic evolution of the research direction between 1982 and 31 October 2021. This clarification is necessary in order to ensure the replication of the research, with explicit reference to the possibility that additional papers will appear after 31 October 2021, due to the prepublication (online version) and postpublication gaps, to which the indexing delays are added. The graphical situation of the dynamic evolution of the number of papers per year is illustrated in **Figure 1**.

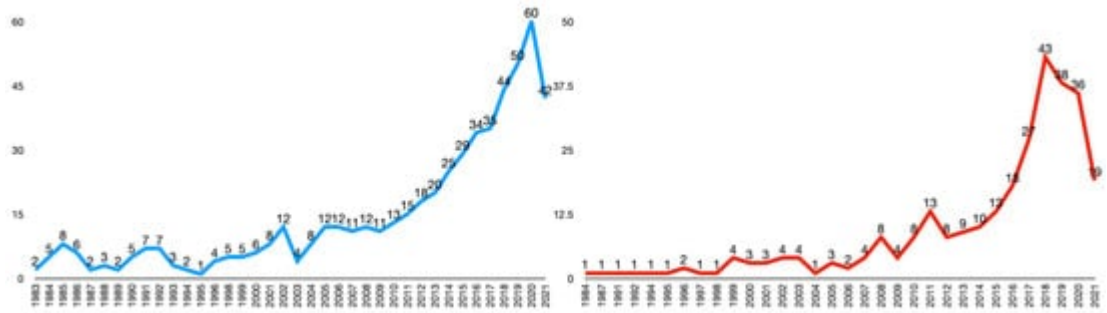

Figure 1. Dynamic evolution of Scopus (**left**) and WoS (**right**) publications between 1982 and 2021.

In Scopus, researchers noticed that the first papers on this topic were issued in 1983, when two papers were published; that until 2001, a maximum of eight papers per year were published, provided that there were years with one paper only (see 1995) but also years without any publications (see 1997); that, between 2002 and 2010, the annual number of papers on this topic ranged between 10 and 13, except for the years 2003 and 2004, when there were 4 and 8 papers, respectively; that since 2011, there has been a continuous increasing trend from 15 to 60 papers per year; and that in the first ten months of 2021, there have been 42 papers, which indicates that this year will not exceed the maximum value of 60 papers in 2020. researchers can acknowledge that 2010 was the year when the volume of papers on the megatrends topic expanded and that, after 2016, the threshold of 30 papers per year was crossed.

In WoS, researchers noticed that the first issuance of a paper on this topic was in 1984, i.e., two years after the concept was proposed; that in the period of 1984–1998 one paper per year was published or even none at all (see 1985, 1986, and 1993), except in 1996, when two papers were published; that from 1999 to 2007, three or four papers were published per year, with the specification that in 2004 only one was published and in 2006 only two; that since 2008, there has been a continuous upward trend from 8 papers to 43 papers, except in 2009, when there were only 4 papers; that after 2018, there was a slow decrease towards 36 papers in 2020, with only 19 papers in the first ten months of 2021. In addition, concerning the data in WoS, researchers can acknowledge that 2010 was the year when the volume of papers on the topic of megatrends increased, and that after 2015 the threshold of 10 articles per year was crossed.

3.2. Scientific Categories

From the perspective of the analysis by scientific categories, in **Figure 2** researchers identified that the following fields in Scopus contained over 100 papers: engineering (241), computer science (136), and social science (133). These were followed by business management and accounting (83) and environmental science (51).

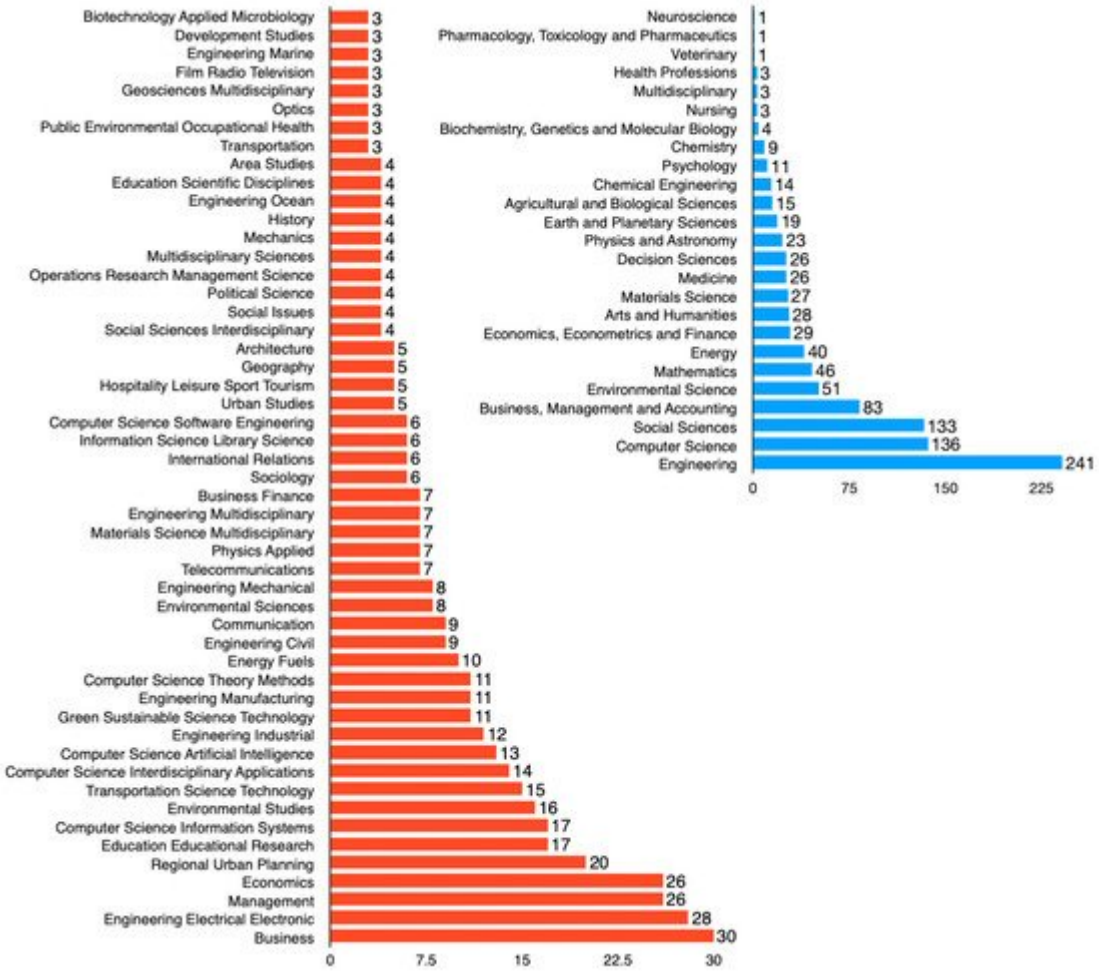

Figure 2. Scopus (**right**) and WoS (**left**) scientific categories between 1982 and 2021.

Between 20 and 50 papers were represented by the fields of mathematics (46), energy (40), economics, econometrics and finance (29), arts and humanities (28), materials science (27), decision sciences (26), medicine (26), and physics and astronomy (23). Between 10 and 19 papers were listed in such fields as Earth and planetary sciences (19), agriculture and biological sciences (15), chemical engineering (14), and psychology (11). Less than 9 papers were itemized in the fields of chemistry (9) and biochemistry, genetics, and molecular biology (4). The studies that were poorly represented in this field, in other words, those included in fewer than three papers, were: nursing (3); health professions (3); multidisciplinary (3); veterinary (1); pharmacology, toxicology, and pharmaceutics (1); and neuroscience (1).

The analysis by category for the WoS database showed the fact that the fields were much more detailed compared to the Scopus database, and that no field exceeded the limit of 30 papers. Thus, with 30 papers researchers had

the field of business; with 28 papers, the field of electrical and electronic engineering; with 26 papers each, the fields of economics and management; with 20 papers, the field of regional urban planning; with 17 papers each, the fields of education, educational research, and computer science information systems; with 16 papers, the field of environmental studies; with 15 papers, the field of transportation science technology; with 14 papers, the field of computer science—interdisciplinary applications; with 13 papers, the field of computer science—artificial intelligence; with 12 papers, the field of industrial engineering; with 11 papers each, the fields of green sustainable science technology, engineering manufacturing, and computer science theory and methods; and with 10 papers, the field of energy fuels. The other 35 fields, each comprising less than 10 papers, were represented by: civil engineering (9), communication (9), environmental sciences (8), mechanical engineering (8), telecommunications (7), applied physics (7), multidisciplinary materials science (7), multidisciplinary engineering (7), business finance (7), sociology (6), international relations (6), information science—library science (6), and computer science—software engineering (6).

3.3. Corresponding Authors' Countries

researchers acknowledge that obtaining an overview of the countries where more attention is paid to research in the field of technological megatrends at the societal level, based on the metadata provided by the two databases, Scopus and WoS, was possible by targeting the research using the criterion of the country of origin of the corresponding author. Of course, there may be changes in the affiliation of the corresponding author over time, including the country of affiliation, but current research had as a reference date the date on which the paper was submitted and/or accepted for publication, which was mostly related to the funding of that research.

Therefore, from the perspective of analyzing the country of the corresponding author criterion (**Figure 3**), researchers noticed that in Scopus, the ranking of the first 15 countries was led by the United States of America with 116 papers, followed by Germany (87), Italy (30), the United Kingdom (29), Australia (20), and Finland (20). With less than 20 papers were: South Korea (19), China (19), Canada (17), Austria (16), the Netherlands (16), the Russian Federation (16), France (15), Spain (15), and Poland (11).

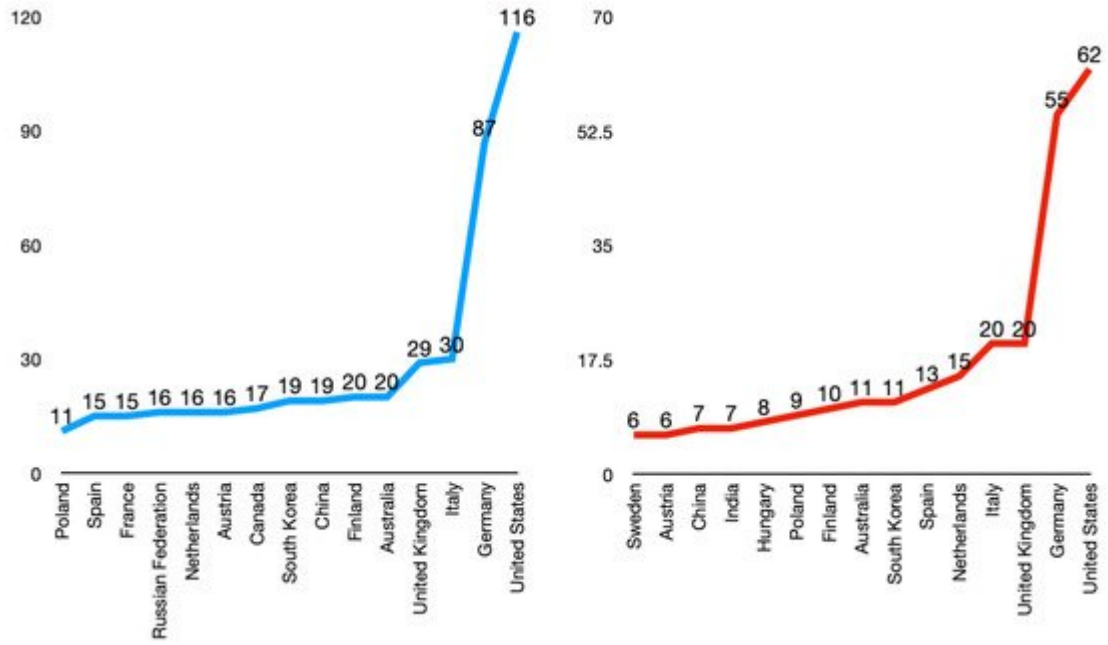

Figure 3. Distribution of publications by country, Scopus (**left**) and WoS (**right**), between 1982 and 2021.

The analysis of the country of the corresponding author criterion detected that in WoS, the ranking of the first 15 countries was also led by the United States of America with 62 papers, followed by Germany (55), the United Kingdom (20), and Italy (20). The ranking continued with the Netherlands (15), Spain (13), South Korea (11), Australia (11), Finland (10), Poland (9), Hungary (8), India (7), China (7), Austria (6), and Sweden (6).

3.4. The Most Relevant Sources

The criteria established through the selection and filtering of the results helped us to establish the most relevant journals in which articles on the topic of megatrends were published. In order to obtain an overview of the journals with a high degree of relevance to current research topic, researchers proceeded to make a top-10 list of the journals with the most numerous publications in the field. The top 10 journals indexed in Scopus and WoS are presented in **Table 1**.

Table 1. Top 10 most relevant sources between 1982 and 2021.

Scopus		Web of Science	
SAE Technical Papers	11	*VDI Berichte*	7
Advances in Intelligent Systems and Computing	10	*Technological Forecasting and Social Change*	6
VDI Berichte	9	*Advances in Intelligent Systems and Computing*	4
Lecture Notes in Computer Science, including the subseries Lecture Notes in Artificial Intelligence and	5	*International Conference on Traffic and Transport Engineering* (ICTTE) 2018	3

Scopus		Web of Science	
Lecture Notes in Bioinformatics			
Technological Forecasting and Social Change	5	*Lecture Notes in Computer Science*	3
Campus-Wide Information Systems	4	*Procedia CIRP*	3
Sustainability	4	*Sustainability*	3
AIP Conference Proceedings	3	*2019 IEEE 23rd International Conference on Intelligent Engineering Systems* (INES) *2019*	2
Aistech Iron and Steel Technology Conference Proceedings	3	*Acta Horticulturae*	2
Communications in Computer and Information Science	3	*Communications in Computer and Information Science*	2

1 papers,
9 papers.

Additionally, with 5 papers each, researchers acknowledge the journals Lecture Notes in Computer Science, including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics, and Technological Forecasting and Social Change. The journals Campus-Wide Information Systems and Sustainability were also included in the Scopus top 10, with 4 papers each. The next group was formed by AIP Conference Proceedings, Aistech Iron and Steel Technology Conference Proceedings, and Communications in Computer and Information Science, with 3 papers each.

Regarding the top 10 journals in WoS, the first position was held by VDI Berichte, with 7 papers, followed by Technological Forecasting and Social Change with 6 papers and Advances in Intelligent Systems and Computing with 4 papers. The top 10 was continued by International Conference on Traffic and Transport Engineering (ICTTE) 2018, Lecture Notes in Computer Science, Procedia CIRP, and Sustainability, with 3 papers each. Finally, with 2 papers each, the last group was formed by the 2019 IEEE 23rd International Conference on Intelligent Engineering Systems (INES) 2019, Acta Horticulturae, and Communications in Computer and Information Science.

3.5. Most Cited Articles and Authors

The credibility and prestige of the journals have a considerable impact on how researchers appreciate and use articles published in a particular field [35]. Thus, in order to carry out this component of the bibliometric analysis, researchers created a top-15 list of the most cited articles for each of the databases: Scopus and Web of Science.

From current queries in the Scopus database using the criteria established in consensus with the objective of current research, as previously defined, on the topic of technological megatrends at the societal level, researchers notice that the first three positions in the top 15 presented in **Table A1** were held by the paper Environment and policy factors shaping global e-commerce diffusion: A cross-country comparison by J. Gibbs, K.L. Kraemer, and J. Dedrick [36] in Information Society (2003), with 234 citations, followed by Cloud computing: Today and Tomorrow by W. Kim [37], in The Journal of Object Technology (2009) with 212 citations and Towards exact molecular dynamics simulations with machine-learned force fields by S. Chmiela, H.E. Sauceda, K.R. Müller, and A. Tkatchenko [38], in

Nature Communications (2018), with 195 citations. In this list of the top 15 most cited papers and authors, researchers discovered that the most cited sources were Information Society (234), The Journal of Object Technology (212), and Nature Communications (195). From the perspective of corroborating the importance of the journals included in the top 15 most cited papers in Scopus, researchers detected that only two journals appeared in the top 10 most relevant sources, namely, Technological Forecasting and Social Change, with five papers, and Sustainability, with four papers.

From current queries in the WoS database using the criteria established in consensus with the objective of current research, as previously defined, on the topic of technological megatrends at the societal level, researchers noticed that the first two positions in the top 15 presented in **Table A2**, were held by the paper The implications of megatrends in information and communication technology and transportation for changes in global physical activity by M. Pratt, O.L. Sarmiento, F. Montes, D. Ogilvie, B.H. Marcus, L.G. Perez, and R.C. Brownson [39], in The Lancet (2012), with 165 citations, followed by Environment and policy factors shaping global e-commerce diffusion: A cross-country comparison by J. Gibbs, K.L. Kraemer, and J. Dedrick [36] in Information Society (2003), with 157 citations, and by Simulation in Manufacturing: Review and Challenges by D. Mourtzis, M. Doukas, and D. Bernidaki [40], in Procedia CIRP (2014), with 124 citations. In this top-15 list of the most cited papers and authors, researchers discovered that the most cited sources were The Lancet (165), Information Society (157), and Procedia CIRP (124). From the perspective of corroborating the importance of the journals included in the top 15 most cited papers in WoS, researchers detected that only two journals appeared in the top 10 most relevant sources, namely, Technological Forecasting and Social Change, with 6 papers, and Procedia CIRP, with 3 papers.

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