

Measuring The Degree of Spatial Interaction and the Impact Scope of the First City within the Urban System of the Province Region of Batna-Algeria

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Abstract

All regions have spatial dimensions; containing cities that have different population sizes and are separated from each other by various distances, forming an urban system that is based on the interaction of functional relations. This study examines the subject of spatial interaction and the impact scope of the first city within the province region of Batna. Famous methods used in regional geography were adopted, including the Predominance Index of Mehta, the Law of General Attraction, Reilly Law, and the Population Centre of Gravity Model. The results of the study indicate the presence of a strong dominance of the first city of Batna over other cities, a distortion in the pyramid of size distribution of the urban centres, the presence of a strong interaction between the city of Batna and Tazoult, a difference in distances of the breaking-point between the first and second city, the presence of an impact scope and wide power of the first city of Batna, with a radius of 55.4 km.

Key words: Spatial interaction, Urban system, Province region, Impact scope, Batna city.

INTRODUCTION

Cities grow and develop due to many factors, including natural, human, economic and political. However, their growth and development are not isolated from the rest of other cities (Abu Qurain, 2014, pp. 397-426). But rather they grow due to their location and the size of the relationships and connections that they form with a group of other urban centres. These relationships and interactions between elements of the urban system are represented in all trends of population movement, employment and capital flows in which the transport factor plays an effective role to achieve the viability of this interaction. Market forces on their part have an effect on these interactions, by virtue of the fact that cities, which produce the most goods and services are more attracting to population and grow rapidly more than those cities lacking such advantages.

Hence, the total of these cities constitutes a complex interactive system of connections and movements between people and their activities allocated within the region, regardless of the distribution patterns of their urban centres, be it dispersed or concentrated. Both the location and the size that characterize a particular city can be a stimulus or an obstacle to the form and size of relationships and links that occur among cities. These interactions differ in their degree and strength due to factors led by the decision-makers and their adopted policies or unguided factors controlled by distance, transportation cost, location and many other factors. Each of the trends of population movement, labour and capital flow constitute the main engine in the emergence of all relationships, which are organized in place following movement networks.

From the above and given the importance of the subject of spatial interaction in regional and urban studies in forming a hierarchical structure of the urban system. Such structure achieves functional integration among cities via the distribution of activities and services. As well as spatial regularity through which the interrelationships between the urban centres of a region are organized. In Addition, given the statue of the province of Batna, which is characterized by an urban dynamism that touches many vital development sectors; it is very important to examine the extent of the interaction occurring between its major cities, and the power and influence of the first city within its province, based on the following questions:

What is the degree of interaction between the main cities of the province region of Batna?

What is the impact scope of the first city within the rest of the main cities of Batna province region?

It is aimed through this research:

To measure the degree of interaction between the main cities of the province region of Batna.

METHODS

To identify the extent of influence of the first city within the province region of Batna.

In order to identify these statements, this study rely on the quantitative approach and the statistical method. Through monitoring and analyzing the situation of the province of Batna in terms of the degree of spatial interaction and the strength of the first city's influence, using famous analytical models represented in:

- Predomination Index of Mehta.
- Law of General Attraction (theory of mutual influence).
- Breaking-point Law (Reilly law).
- Population Centre of Gravity Law.

KEY CONCEPTS IN THE RESEARCH

City Size

(Al-Jukhaidib, 2007, pp. 1-38).

"It is the number of residents living within the boundaries of the city, according to population censuses and estimates".

Hierarchy of Cities: (Al-Jukhaidib, 2007, pp. 1-38).

"It is meant by it, the size grading of a variety of cities, so that the base of the pyramid includes cities of small sizes, while at the top of the pyramid is the first city in the province or state"

Polarization

"It is a meaning that refers to unilateralism in attraction, Brad Barry (1982) called it 'centres that are characterized by a large production of services and goods, and whose environments are desirable for living in.' These privileges through which such centres attract the total population depend on the compatibility between the size and distance between the polarized urban centres and the lesser points of stability" (Al-Jukhaidib, 2007, pp. 1 -33).

Region: (Diab, 2012, p. 462).

"A spatial unit constitutes an integrated whole characterized by a common origin and interconnectedness of its components. The internal interconnections and interaction differ from the external ones in terms of their stability and strength. It is an organically integrated place, where the components of the territory and the potential of self-development and control meet".

Region's Urban Network: (Al-Wakeel, 2006, p. 77).

"Aconnected and interrelated group of urban clusters that can extend over the entire region, thus becoming regional".

Urban Clusters: (Taameya, 2012, p. 10).

"The basic structure of the regional urban network, which usually contains a group of clusters with different urban degrees. In many cases, this structure follows a hierarchy; the base of which is a group of clusters of lesser gradations, and the top of which is an urban agglomeration with a higher degree".

URBAN SYSTEM

The urban system was defined as (Abu Qurain, 2014 pp. 397-426): "The group of cities located within a specific geographical area, whether a state, a region or a governorate, which are linked and interact with each other functionally and economically to form an integrated entity, where each of them affects and is affected by the rest of the elements of this system".

URBAN DOMINANCE (FIRST CITY)

Urban domination is the tendency of the population to concentrate in large cities, or the concentration of the largest percent of the population of a country or region in a large city or two, and their control over the rest of the cities (Maho Jamil and Qadir, 2017, pp. 1-29).

Mehta Index for Measuring the Degree of Urban Dominance

$$M_i = \frac{M_1}{M_1 + M_2 + M_3 + M_4}$$

Where it is extracted from the following equation (1)

M1: size of the first city

M2: size of the second city

M3: size of the third city

M4: size of the fourth city

If the result is limited to:

0.65-1: high dominance for the first city (extreme superiority).

0.54-0.65: the level of dominance is (superior).

0.41-0.45: the level of dominance is desirable.

Less than 0.41: the level of dominance is low for the first city.

SPATIAL INTERACTION

Special interaction is the movement of forces within an urban system, assisted by different transportation systems and development corridors that link cities, whether near or far. Such interactions between cities differ in strength; as they are strong in some cities and weak in others.

Among the concepts of spatial interaction (Bin Ghadban, 2018, p. 57) "is the outcome or result of the connections between places for economic, spatial and social purposes. From this concept of spatial interaction, it is possible to identify the reciprocal relations between the individual and his environment. The reciprocal interaction is a link between two groups of any kind, so that the effectiveness of each is partly determined by the effectiveness of the other."

SPATIAL INTERACTION MEASURES

Several measures have emerged that explain and determine the relationships between cities of a region, including:

Law of General Attraction (Theory of Mutual Influence)

The idea of the law of general attraction goes back to the famous physicist Newton, and the associated scientific development brought about by 'Quantum Theory', according to which it became possible to determine the probability distributions of objects' locations. This concept of physics corresponds in the field of regional geography, to the locations of cities and their distribution patterns within any region. Thus, spatial interaction is a consequence of the importance and potentiality of the place that stimulates interactions and what happens in terms of relations between cities (Al-Atarkji and Falih, 2014, p. 28).

Law of general attraction is one of the simplest formulas, as it represents an attempt to study two main factors that control the process of mutual influence between cities and the degree of their interaction, namely the size of population and the extent of distance (Al Sufouh, 2000, p. 182). Izard (1956) describes the power of place in any of the elements by 'the mass' that is in accordance with certain principles and elements, controls the behavior of individuals and groups, and determine their effectiveness. As the existing relationships between regions are considered a type of interaction, and from it the principles not only define behaviour, but also determine the intensity and frequency of interaction that is affected by the strength and size of the mass. The relationship is also affected negatively and positively by distance, giving the conclusion that the relationship increases with the population size and decreases with the far distance (Al-Atarkji and Falih, 2017 p. 28). Therefore, the degree of interaction and the relationship of mutual influence between two groups are proportional to their size of the population and inversely with the length of the distance between them according to the following equation (2):

$$F = \frac{G M_1 \times M_2}{D^2}$$

whereas:

- F: the force of attraction
- G: a constant representing the force of attraction
- M1 and M2: size or mass of the two cities
- D: the distance between M1 and M2

Breaking-Point Law (Reilly Law)

The first revision of the theory of reciprocal influence' is evident in the equivalence 'theory of break-point or zero gravity', which is a successful attempt to find an appropriate method that helps to predict the location of the boundaries between two cities of different size (Al Sufouh, 2000, p. 187). As when there is a sufficient set of breaking points around one of the two cities will help theoretically to define the boundaries of its region (Al-Saadi, 2007, p. 90). The breaking-point can be determined through the following equation (3):

$$\text{Breaking Point} = \frac{d_{ij}}{1 + \sqrt{P_i/P_j}}$$

whereas:

- d_{ij} : the distance between two cities i and j
- P_i : population of the large city in size
- P_j : population of the small city in size

Law of the Population Centre of Gravity

It is a formula to calculate the extent of population concentration around a certain point, that point is often the first city. As it depends on finding the distance between the population centre of gravity and the surrounding cities with their population numbers based on the following equation (4): (Al-Jaafari and Samha, 2017, p. 110).

$$R = \sqrt{\frac{\sum D M^2}{\sum M}}$$

- R: the radius
- M: the number of inhabitants in each city
- D: the distance between these centres and other cities

THE ROLE OF SPATIAL INTERACTION IN BRINGING ABOUT SPATIAL ORGANIZATION

The concept of spatial organization appeared in the seventies of the last century, by geographers in their studies and writings, as "the spatial organization of society is the relationship (interconnection) of spatial-functional structures (labour, production, and investment in nature) and infrastructures that aim to achieve a necessary production for societal living conditions; by aligning with the objectives on the basis of economic laws, which in its turn affect the formation of a specific social organisation (Al-Dibs, 2015, p. 261). Therefore, spatial organization based on its concept will help in the optimal distribution of production, services and comprehensive development.

However, to clarify this, we need to study and analyse the status of the spatial functional and administrative functional structures, as according to (Al-Dibs, 2015, p. 265):

The spatial functional structure: it expresses all the relationships and mutual distribution of the various forms of spatial concentration of human activity. The spatial functional structure is the geographical distribution and the spatial relationships of the productive and service of human activity.

The administrative functional structure: it is a hierarchically controlled system (descending) by the administrative bodies associated with human-vital activities in a particular place.

Since cities are linked by spatial relations, these relationships have a fundamental and important role in the continuation of functional relations (Al-Jabri 2013, p. 35). Dickinson (1930) points out that city's ties fall into four categories: mutual

trade, social ties, population relations, and city impact on land use. Smails (1947) adds that services represent the most important link between a city and its region.

THE TIME DIMENSION OF THE RESEARCH

In this research, the timeframe was set by the population census at the end of 2017, since it is determined as the last census by the Directorate of Programming and Planning in the province of Batna.

Geographical Location and Situation

The province of Batna is located in the eastern centre of Algeria, capital of the highlands, situated between the Tell Atlas in the north and the Saharan Atlas in the south, which are the main features of the province's surface. The province covers an area of 1203,383.76 Km², and it is located between the longitudes 4° and 7° east, and the latitude 35° and 36° north. The province of Batna is bordered by the provinces of Umm El Bouaghi, Mela and Setif to the north, Khenchela province to the east, Biskra province to the south and M'sila province to the west

Administrative Division

The province of Batna has known many administrative divisions after the independence, as it included six departments in 1966 that are Batna, Biskra, Khenchela, Arris, Barika and Merouana. It was re-divided in 1974 and both the districts of Khenchela and Biskra were promoted to provinces. Then came the new administrative division, according to which new districts and municipalities were created and some were transferred to some neighbouring provinces. Now, the province of Batna includes 21 districts(Dairas)and 61 municipalities (communes), as shown in Figure (1).



Figure 1. Map of the administrative division of Batna
Source:(Monograph Batna 2017, p. 26)

SIWE DISTRIBUTION OF URBAN CENTRES IN THE PROVINCE OF BATNA IN 2017

Through size distribution of urban centres in the province of Batna, a representation of the hierarchical structure of these urban centres that constitute the region was obtained. This hierarchy is based on the population of these urban centres and the degree of their functional and service attractiveness, which is reflected in their level of urban concentration. These urban centres occupy specific positions within the hierarchical representation. The statistical data recorded during the year (2017) is adopted, to find the size of distribution pattern of the various urban centres in the province of Batna, as in Table (1).

From Table (1), it became evident that there is a defect in the hierarchical structure through the distribution of urban clusters. This is marked by the population distribution pattern, which seemed unequal and does not take the hierarchical structure type that helps to create interactions and develop functional relationships between urban centre forming the region. It is therefore, a distorted pyramid at the top and the base, where it is observed a decrease in the proportions of the lower size categories (less than 5000) inhabitant and the category (5000-10,000) inhabitant, thus reducing their role in spreading growth as it is the cornerstone for the development process within the region. It is also recorded a severe shortage in the second development category (50,000-100,000) inhabitant, which is almost non-existent, only in a single Centre. As a result, this defected structure requires re-reforming through a regular distribution of the population, and this can only be achieved through setting up strategies and policies to reach a fair distribution of wealth and development programs in all sectors.

Table 1. Size distribution of the population categories, year 2017.

Categories size /h	Number of Centres	Percentage of Centres%	Population number of Centres	population percentage%
More than100.000	2	3.27	465.554	35.63
From50.00-100.000	1	1.60	68.520	5.25
From20.00-50.000	12	19.67	332.246	25.42
From10.000-20.000	23	37.70	305.193	23.35
Less than 5.000	10	16.39	26.076	2.00
Total	61	100.0.0	1397.000	100.00

Source: (The author, 2019), Monographic accreditation of the province of Batna, 2017.

MEASURING THE LEVEL OF URBAN DOMINANCE

To determine the level of urban dominance in the province of Batna, Mehta index mentioned earlier was applied. By using equation (1), results in the following table were achieved:

Table 2. Level of urban domination (2017).

Time period	First city Batna	Second city Barika	Third city Ain Touta	Fourth city Merouana	Mehta index
2017	339.160	126.394	68.520	42.936	0.58

Source: (The author, 2019), Monographic accreditation of the province of Batna, 2017.

The obtained result shows that the dominance level of the first city of Batna surpassed the value of 0.58, as the result is limited to the range of 0.54-0.65, meaning that there is a superiority in dominance for the first city (Batna). This outcome highlights its importance in the province region, thanks to its acquisition of services and facilities that encourage the attraction of the population.

SPATIAL INTERACTION AND THE IMPACT SCOPE OF THE MAIN CITIES OF THE PROVINCE REGION OF BATNA

The extent of influence of a city i is an evidence of the level of spatial interaction of this city and its surrounding urban centres. The magnitude of this effect is measured by the extent of spatial interaction activity, the more active and influential the interaction is, the wider the scope of influence of the city. As the scope of influence of these urban centres includes a number of residents who have a strong tendency to have access to services, trade, shopping and activities in the city, in which they belong to its influence sphere. The following analytical models were applied to study such interaction and impact:

Law of Attraction

Through the application of the 'law of attraction' of equation No. (2), and based on the results of Table No. (3), we noticed that the highest value of the interaction index was between Batna and Tazoult with a value of (58.70), due to the proximity of the two urban centres, estimated at 14 km. While the lowest value of the interaction was observed between Batna and T'Kout with a value of (0.36), due to the long distance between the two urban centres estimated at 104 km. Here, we can see the effect of the distance on the degree of spatial interaction. When making a comparison between the value of the interaction between Batna, Tazoult and Ain-Touta that was second in the interaction strength with Batna with a value of (22.69), although its population size, which is estimated at (68,520) inhabitant, is larger than the population size of the urban Centre of Tazoult. We find that the spatial interaction between Batna and Tazoult is more than four times the interaction with Ain-Touta, which is normal; given the proximity of the distance between Batna and Tazoult that has become characterized by an urban cohesion where administrative boundaries have started to disappear.

Just as distance has an effect on spatial interaction, population size also has a clear effect on the value of the interaction, where it is noticed, for example but not limited to, the interaction between Batna and El-Madher, in which the distance is closer than Ain-Touta, it is 24 km. But because the population size of Ain-Touta is greater (68,520) inhabitant compared to El-Madher (21,982) inhabitant, Ain-Touta interaction with Batna is double the interaction of El-Madher with the same urban centre. Therefore, the interpretation of the previous results suggests that the spatial interaction between two cities is affected by the distance, as well as the population size, as it is the case between cities of El-Madher, Ain Al-Touta, and Theniet El-Abed.

We point out that this rule on the interaction strength does not always give us correct results in terms of the influence of distance, due to some obstacles that can prevent any two neighbouring cities from interacting, which can be natural, related to topography, such as the mountainous region of Arris. The city of Arris is closer to Batna (36 Km) than Theniet El-Abed and its population size is greater than (36,165) inhabitant compared to the population size of Theniet El-Abed (12,421) inhabitant, however, the indicator of interaction between the city of Batna and Theniet El-Abed (13.92) is stronger than between Batna and Arris (9.46). The obstacles in this case is possibly due to the presence of certain opportunities (the presence of activity, Arris for example, with a surplus of goods and services) closer to the city of Batna would limit the possibility of connections and thus, weaken the power of spatial interaction.

Table 3. The size of the interaction between the first and second city (Law of Attraction).

First city	Major cities (districts)	distance / km	population/ thousand	interaction force $F = \frac{G M 1 \times M 2}{D^2}$
	Merouana	51	42.936	5.59
	Ain-Touta	32	68.520	22.69
	Arris	36	36.165	9.46
	Barika	94	126.394	4.85
	Al Madher	24	21.982	12.94
	Mena	85	15.305	7.18
	N'gaous	77	33.745	1.93
	Ras Al Aioun	85	27.049	1.26
Batna	Seriana	32	20.167	6.67
	Tazoult	14	33.924	58.70
	Theniet El Abed	55	12.421	13.92
	Ain Djasser	63	18.657	1.59
	Ichmoul	53	10.642	1.28
	Bouzina	69	13.700	0.97
	Chemora	57	19.343	2.01
	Ouled Si Slimane	79	13.600	0.73
	T'ikout	104	11.710	0.36
	Djezar	114	27.560	0.71
	Timgad	42	12.774	2.45
	Seggana	74	7.119	0.44

Source: (The author, 2019), Monographic accreditation of the province of Batna, 2017

Breaking-Point Law (The Reilly Law)

To measure the interaction between two clusters(a) and (b) for example, we will define the boundary between their area of influence so that they are not equal in size. Through this analysis, we aim to determine the point that separates between residents of cluster (b) who come to cluster (a) to obtain goods and services, as well as residents of cluster (a) who go to cluster (b) to obtain the same goods and services or other facilities.

Using the equation No. (3) and based on the results of Table No. (4), we noticed that the breaking distance between Batna and Barika (35.60 km) is the longest, due to the high population of Barika, as it is the second in population size

after the main city of Batna, compare with the rest of cities and urban centre of the province. While the distance of the city of Batna from the breaking-point (between Batna and Tazoult) is (3.36 km), and it is the shortest breaking distance of Batna city, this is due to the small distance (14 km) between the two Batna and Tazoult.

Both the distance and the size of the population control the degree of interaction, but when these two factors were compared and analysed, we find that:

With regard to the distance and when making a comparison between two urban centres that are at the same distance from Batna, namely Ain Touta and Syriaana (32 km), we find that the difference in the number of inhabitants in both led to a difference in the distance of the breaking-points between them and Batna. In the case of population size, in that both Tazoult and N'Gaousare characterized by roughly the same number of inhabitants and differ in the distance from Batna, but the difference in distance between each of them and the city of Batna has affected the distance of the breaking-point, so we conclude that the closer the breaking-point is to the first city Batna, the greater the interactions between this city and the second one.

Finally, we can state that all the results obtained through the application of the Reilly Law remain merely abstract numbers for theoretical boundaries that differ from the administrative ones. This calls for resorting to other data that support field studies, which includes analysis and measurement of factors such as the actual trips of the population as a real way for getting information on the interaction that occurs between cities and the movement of goods, service and other activities. We also refer to other factors that have an impact on determining the distance of the breaking-point, the most important of which are typology and technology, such as means of transportation and communication in reducing the number of trips, as well as controlling time.

Table 4. Size of the interaction between the first and second city according to Reilly's Law.

The first city	major cities (districts)	distance/ km	distance of the first city from the breaking-point	distance of the second city from the breaking-point
	Merouana	51	13.42	37.58
	Ain-Touta	32	9.93	22.07
	Arris	36	9.81	27.09
	Barika	94	35.60	58.40
	Al Madher	24	4.86	19.14
	Mena	85	14.91	70.09
	N'gaous	77	18.46	58.54
	Ras Al Aioun	85	18.72	66.28
Batna	Seriana	32	6.72	25.73
	Tazoult	14	3.36	10.64
	Theniet El Abed	55	8.84	46.16
	Ain Djasser	63	11.97	51.03
	Ichmoul	53	7.98	45.02
	Bouzina	69	11.55	57.45
	Chemora	57	11.00	46.00
	Ouled Si Slimane	79	13.16	65.84
	T'ikout	104	16.30	87.70
	Djezar	114	25.33	88.67
	Timgad	42	6.82	35.18
	Seggana	74	9.36	64.64

Source: (The author, 2019), Monographic accreditation of the province of Batna, 2017.

Population Centre of Gravity Law

In order to identify the size of the influence of the main city of Batna and the extent of its power, and through the application of equation No. (4) and based on the results of table No. (5), the radius of a circle was reached, which contains the area of influence of the city of Batna within the rest of the urban centres, as follows:

$$R = \sqrt{\frac{2801562}{912,873}} = 55.4 \text{ km}$$

From the result, it is concluded that the area of influence of Batna city reaches a distance of 55.4 km, which is the radius of a circle whose centre is the city of Batna. This circle contains almost 10 major cities of the province that are: Batna, Tazoult, El-Madher, Seriana, Ain-Touta, Arris, Timgad, Merouana, Ichmoul and Theniet El-Abed. That is, 65% of the population (estimated at 596.691 inhabitant) of the province region of Batna is residing in this circle, with an area of 9637.16 km², or 8% of the total area of the province region.

Table 5. Results of the population centre of gravity for the region province of Batna.

Major cities (districts)	Distance/ km (D)	Population/ thousand (M)	D ² x M
Batna		42.936	
Merouana	51	68.520	111676.53
Ain-Touta	32	36.165	70164.48
Arris	36	21.982	46869.84
Barika	94	126.394	1116817.38
Al Madher	24	15.305	12661.63
Mena	85	33.745	119761.62
N'gaous	77	27.049	200074.10
Ras Al Aioun	85	20.167	195429.02
Seriana	32	33.924	20651.00
Tazoult	14	12.421	6649.10
Theniet El Abed	55	18.657	37573.52
Ain Djasser	63	10.642	74049.63
Ichmoul	53	13.700	2983.37
Bouzina	69	19.343	65225.70
Chemora	57	13.600	62845.40
Ouled Si Slimane	79	11.710	84877.60
T'ikout	104	27.560	126655.36
Djezar	114	12.774	358169.76
Timgad	42	7.119	22533.33
Seggana	74	42.936	38983.64
Total		912.873	2801562.00

Source: (The author, 2019), Monographic accreditation of the province of Batna, 2017.

CONCLUSION

The present study has shown that spatial interaction is affected by many factors combined with each other at the same period of time. Since distance and population size cannot alone provide accurate results about the state of spatial relationships and interactions, through which the state of the urban system can be identified. Hence, the spatial interaction and the degree of influence of cities on each other require the use of field studies that take into account a number of factors; including the natural one, such as climate and landform that can be obstacles for the movement of people from one region to another. Also political and administrative factors represented in the administrative borders between cities and urban centres and their divisions, not to mention the infrastructure of roads, transportation systems, as well as modern technology of digitization and its role in limiting the movement of citizens. From this study it is concluded that:

- There is an imbalance in the hierarchical structure through the distribution of urban clusters, and this is evident through the pattern of population distribution in the size categories, which seemed unequal and does not take the hierarchical style.
- There is a superiority in the dominance of the first city Batna, which highlights its importance within the province region.

- Through the application of the Law of Attraction, it is observed that the highest value of the interaction index was between Batna and Tazoult with a value of (58.70), due to the proximity of the two urban centres, estimated at (14 km²). While the lowest value of interaction was between Batna and T'ikout with a value of (0.36), also due to the distance between the two urban centres estimated at (104 km²).
- By applying Reilly Law, it is noted that the longest breaking distance is between Batna and Barika, at 35.60 km from the city of Batna. While the shortest distance from Batna to a breaking-point was 3.36 km, this breaking distance concerns Batna and Tazoult. Hence, the disparity in the distances of the breaking-points are identified.

The area of influence of Batna reaches a distance of 55.4 km in its province region, which is the radius of a circle whose centre is the city of Batna. That is, 65% of population (estimated at 596.691 inhabitant) of the province are residing in this circle, with an area of 9637.16 km² or 8% of the total area of the province region.

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