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## A TEMPORAL-SPATIAL ANALYSIS OF THE DATES SECTOR IN THE KINGDOM OF SAUDI ARABIA

### Key Words

*Transportation; Dates; Mathematical Programming.*

### Abstract

*This paper attempts to study the optimal distribution of dates' consumption and production in the different regions of the Kingdom of Saudi Arabia (KSA). In addition, the paper divided the dates into fresh dates and stored dates. For both fresh and stored dates to be used in any region, they must incur transportation and handling costs. For stored dates to be used in the same region or in other regions, it must incur storing cost. The harvest season of dates begins from the beginning of August and ends in the end of October. However, demand for dates is continuous all the year around. As a result, some investors store the dates during the harvest season so that it can be available the year around. This paper examines the interregional and interseasonal pattern of dates. The results show an ideal balance between fresh dates and stored dates consumption and production in the thirteen different regions of the Kingdom of Saudi Arabia.*

### Introduction

The Kingdom of Saudi Arabia is one of the most important Countries in the world in producing dates. Dates are one of the most important products in food security policy in the kingdom, and thus the agricultural policy is very interested in

palm trees. The policy encourages farmers to grow palm trees by financial and non-financial support. As a result of this policy, the cultivated area of palm trees has increased from about 80,000 to 106,000 hectares during the period 1992- 1998 and during this period, production of dates increased

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from 552,000 to 648,000 tons (Table 1). However, for some reasons beyond the objective of this research, production slightly decreased in 1998. (Department of Economic Studies and Statistics, 1970-1998)

Table 1 shows the area of palm trees and production of dates in the kingdom

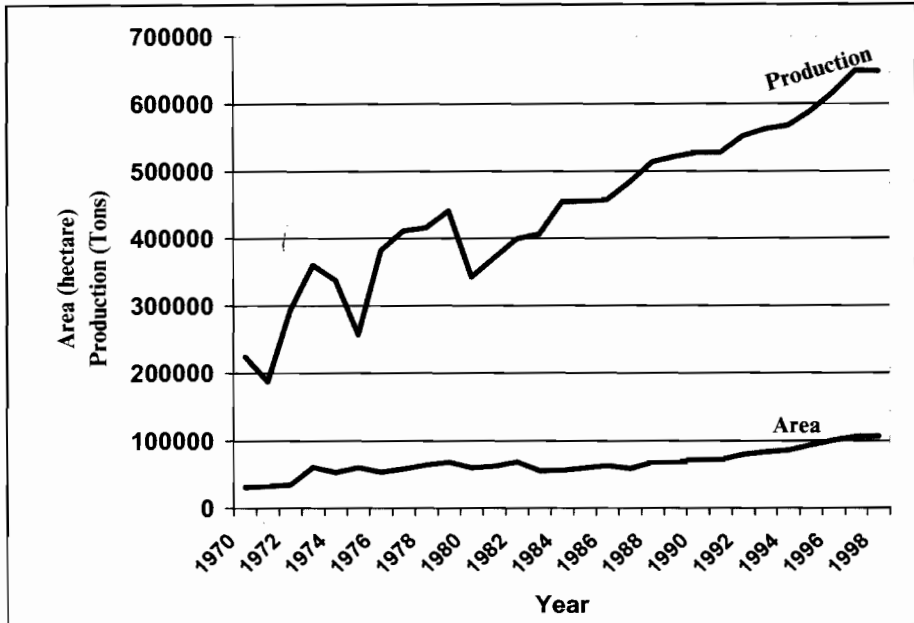
from 1970 to 1998. Furthermore, the trends of production and area planted are shown in graph 1. The Ministry of Agriculture and Water (MAW) estimated the average per capita consumption of dates to be 28.7 Kg per year, during the period 1993 to 1995. Saudi import of dates is trivial, comparing to total production, and could be disre-

**Table 1**  
**Total Cultivated Area and Total Production of Dates In the Kingdom of Saudi Arabia, 1970-1998**

<b>Year</b>	<b>Area Hectare</b>	<b>Production 1000 Tons</b>	<b>Year</b>	<b>Area Hectare</b>	<b>Production 1000 Tons</b>
1970	31006	224.3	1984	56207	454.4
1971	32956	187.8	1985	59787	455.7
1972	34566	293	1986	63033	457.4
1973	60837	360.1	1987	58620	484.2
1974	53121	337.3	1988	67740	514
1975	60413	256.9	1989	68308	521.8
1976	53599	382.3	1990	72379	527.9
1977	58369	411.4	1991	72344	528
1978	64400	416	1992	79575	552.4
1979	68100	441	1993	83703	563
1980	60353	342.3	1994	85790	567.8
1981	62330	371	1995	93825	589.3
1982	68583	399.6	1996	100858	616.9
1983	55481	406.7	1997	106137	649.2
			1998	106960	648.1

**Source:** Department of Economic Studies and Statistics. "Agriculture Statistical Year Book " Volumes 1-12. Ministry of Agriculture & Water, Riyadh. 1970-1998.

**Figure 1**  
**Dates Production and Area in Saudi Arabia for the Period 1970-1998.**



garded. Saudi imported about 0.26 thousand ton in 1998. Saudi export is about 30.85 thousand tons in 1998. Dates waste is about 6 thousand tons in 1998 (FAO's web site: <http://www.fao.org/>).

The harvest season of dates is short, from the beginning of August to the end of October. However, demand for dates is continuous all the year around. As a result, some investors store the dates during the harvest season so that it can be available the year around. Thus, dates can be eaten either fresh during the harvest season or preserved and stored for the rest of the year.

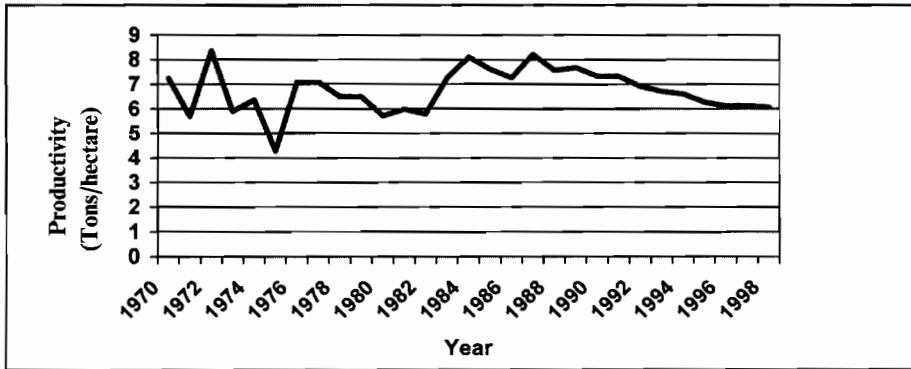
### Research Objectives

This research aimed to estimate the optimum distribution of dates around the kingdom among the different administrative regions and also to find an ideal balance between fresh dates and stored dates and the consumption and production in the thirteen different regions in Saudi Arabia. This Optimum distribution is obtained by minimizing transportation and storage cost.

### Review of Literature

Kottke (1970) studied spatial, temporal and product use allocation of milk in an imperfectly competitive

**Figure 2**  
**Dates Productivity Pattern in Saudi Arabia for the Period 1970-1998.**



dairy industry, using a set of recursive relations incorporating linear and quadratic programming formulations. The empirical results of the models traced prices, production, and consumption patterns over time.

Bivings (1992) used a seasonally and regionally disaggregated model to analyze the short-term dynamics of agricultural trade and market reform, such as Mexico's unsuccessful attempt in 1989 to completely liberalize its sorghum sector. The model highlights the interactions among seasonal storage, interregional domestic trade, and international trade in determining how a commodity market adjusts to macroeconomic disturbances as well as to change policies specific to the market. The non-linear programming model contained nine production, consumption, or import regions and

involved trade and storage in twelve monthly periods.

Motsinger, Epperson and Mizelle (1985) examined the economic feasibility of storing southeastern U.S. Red Delicious apples under various circumstances, encompassing type of storage, potential market share in the storage periods, perceived level of quality and opportunity cost of storage. Reactive programming was used to allocate shipments throughout the harvest and storage periods.

Pae (1971) investigated geographical and seasonal distribution of potato production and consumption in the United States. The study also investigated the effects of acreage control on the optimum prices and production. The study used a quadratic programming model with six interdependent areas. Each area had one or more than

one season of production, and four seasonal demand functions.

### Methods and Procedures

The linear programming technique was used in this study to minimize the costs of transporting, handling

and storing, to obtain an optimal distribution of dates among the thirteen administrative regions in the two seasons, fresh and stored dates. Total supply was obtained from the publications of Ministry of Agriculture and

**Table 2**  
**Estimation of Total Supply and Total Demand of Dates Among the Thirteen Administrative Regions in Saudi Arabia**

Region	Estimated total supply 1000 Tons *		Estimated total demand 1000 Tons **	
	From 1, Aug. To 31, Oct.	From 1, Nov. To 31, July	From 1, Aug. To 31, Oct.	From 1, Nov. To 31, July
Eastern	97.99	0	21.32	63.98
Riyadh	171.94	0	31.80	95.42
Qaseem	78.96	0	6.24	18.72
Hail	53.57	0	3.41	10.23
Tabouk	23.41	0	4.02	12.07
Medinah	58.51	0	9.00	26.78
Makkah	47.09	0	37.07	106.43
Aseer	80.21	0	11.12	33.36
Al-baha	0.98	0	2.76	8.29
Jazan	0.43	0	7.18	21.56
Najran	9.87	0	2.51	7.54
Al-jouf	25.11	0	2.23	6.70
North frontier	0.056	0	1.13	5.70

**Source:**

\* calculated by the author based on annual production.

\*\*calculated by the author based on average per capita consumption.

Water (MAW) and total demand was estimated using per capita consumption level obtained also from MAW. Total export, total import and dates waste were taken from FAO's web site (<http://www.fao.org/>). Table 2 shows the estimated quantities supplied and demanded of dates in the thirteen administrative regions in Saudi Arabia in 1997.

Annual national per capita consumption data does not show the differences in consumption levels among the seasons and the regions, this would require special food survey to determine them. However, the 1997 per capita consumption of dates was used as a scale to the total demand in each region by multiplying this number by the number of population of the region in 1997.

The costs of transporting, handling, and storing dates were estimated by collecting data from 37 dates processing plants around the kingdom. The Ordinary Least Squares (OLS) procedure was used to estimate a cost-distance equation. The OLS is considered the most common method of estimating the parameters of the linear regression model (Greene, 1990). This equation shows the relationship between the cost of transportation per ton and the number of kilometers of the road. The average unit costs of handling and storing were added to

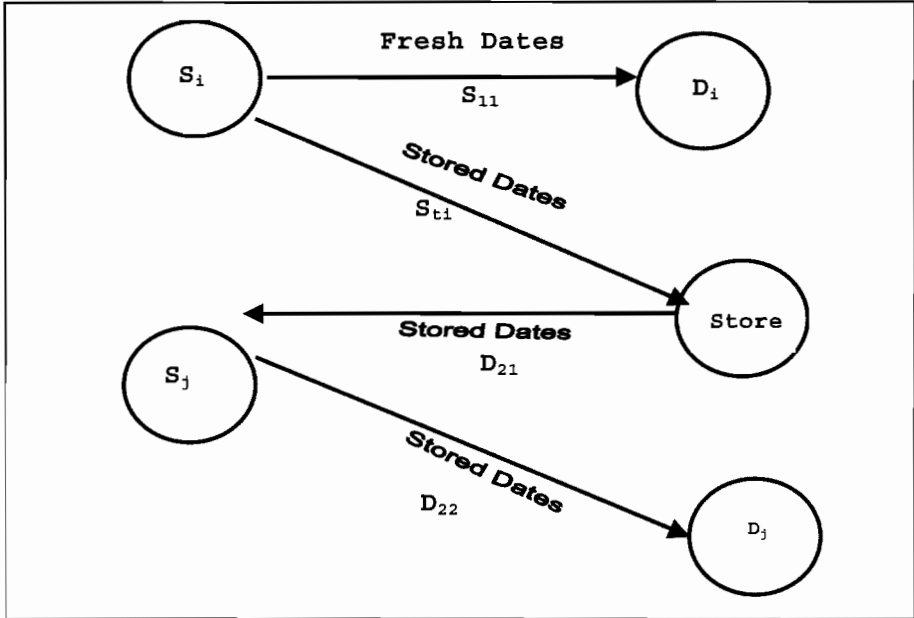
the intercept term of this equation (where relevant).

The average per unit storage cost was estimated on the basis of Net Present worth (NPW) as follows;

$$ST_i = (St_{nov}/(1+r)^1 + St_{Dec}/(1+r)^2 + \dots + St_{July}/(1+r)^9)_i$$

where ST refers to the average storage cost in Saudi Riyals (SR) for one thousand tons of dates,  $i$  refers to the region,  $St_{nov}$  refers to the storage cost in November (SR/1000 ton),  $St_{Dec}$  refers to the storage cost in December for (1000)(8/9) ton of dates,  $St_{July}$  refers to the storage cost in July for (1000)(1/9) ton of dates and  $r$  refers to the average discount rate in the markets. The author, on the basis of personal communications with five local commercial banks, calculated this average. The kingdom was divided into 13 regions according to the administrative distribution. This research assumed that each region has the possibility of local consumption during the fresh season ( $s_{11}$ ) or can send its dates to another region during the same season ( $s_{12}$ ). It is also possible for this region to store the available dates to another season ( $ST_2$ ). Thus, dates are either consumed in the same region in the same season ( $D_{21}$ ) or are sent to another region in the stored consumption season ( $D_{22}$ ). The following diagram shows the available possibilities for each region.

**Chart 1**  
The available possibility for each region



The following equations show the linear programming formulation for two regions  $i$  and  $j$ . Each region has its own supply in the fresh season ( $S_{if}$  for region  $i$  and  $S_{jf}$  for region  $j$ ) and its own supply in the stored season ( $S_{it}$  for region  $i$  and  $S_{jt}$  for region  $j$ ). Each region, also, has its own demand in the fresh season ( $D_{if}$  for region  $i$  and  $D_{jf}$  for region  $j$ ) and its own demand in the stored season ( $D_{it}$  for region  $i$  and  $D_{jt}$  for region  $j$ ).

The objective function is defined as follows:

$$\min \sum_{i=1}^{13} \sum_{j=1}^{13} \sum_{t=1}^{13} C_{ijt} X_{ijt} + \sum_{i=1}^{13} \sum_{t=1}^2 \alpha_{it} ST_{it}$$

subject to

$$\sum_{i=1}^{13} \sum_{t=1}^f X_{ijt} + \sum_{i=1}^{13} ST_{it} \leq S_{if}$$

$$\sum_{i=1}^{13} \sum_{t=1}^f X_{ijt} + \sum_{i=1}^{13} ST_{it} \leq S_{jf}$$

$$\sum_{i=1}^{13} \sum_{t=1}^f X_{ijt} - \sum_{i=1}^{13} ST_{it} \leq S_{it} \text{ (where } S_{it} = 0)$$

$$\sum_{i=1}^{13} \sum_{t=1}^f X_{ijt} - \sum_{i=1}^{13} ST_{it} \leq S_{jt} \text{ (where } S_{jt} = 0)$$

$$\sum_{i=1}^{13} \sum_{t=1}^f X_{ijt} \geq D_{if}$$

$$\sum_{i=1}^{13} \sum_{t=1}^f X_{ijt} \geq D_{jf}$$

$$\sum_{i=1}^{13} \sum_{t=1}^f X_{ijt} \geq D_{it}$$

$$\sum_{i=1}^{13} \sum_{t=1}^f X_{ijt} \geq D_{jt}$$

Where  $C_{ijt}$  is the handling and transporting cost between region  $i$  and region  $j$  in season  $t$ ,  $X_{ijt}$  is the Quantity transported from region  $i$  to region  $j$  in season  $t$ ,  $\alpha_{it}$  is the storage cost in region  $i$  in season  $t$ ,  $ST_{it}$  is the quantity stored in region  $i$  in season  $t$ .

The whole meaning of the constraints is that total demand equals total supply. Additionally, the explanation of the constraints are as follows: the first constraint shows that sum of the quantity demanded in fresh season in region  $i$  ( $X_{ijf}$ ) plus the quantity stored in region  $i$  must be less than or equal the amount supplied by region  $j$  in fresh season. The second constraint shows that sum of quantity demanded in fresh season in region  $j$  ( $X_{jif}$ ) added to the quantity stored in region  $j$  must be less than or equal the amount supplied by region  $i$  in fresh season.

The third constraint shows that sum of the quantity demanded in stored season in region  $i$  ( $X_{ijt}$ ) minus the quantity stored in region  $i$  must be less than or equal the amount supplied by region  $j$  in stored season. The forth constraint shows that sum of the quantity demanded in stored season in region  $j$  ( $X_{jit}$ ) minus the quantity

stored in region  $j$  must be less than or equal the amount supplied by region  $i$  in the stored season. The rest of constraints explain that the sum of quantity shipped to a specific region, from all supplied regions at a specific season, must be greater than or equal to the amount required (demanded) by that region at that specific season.

### Assumptions

Due to shortages in published-available data, the following assumptions are made:

- 1) The quantity available at each origin (in the two seasons) and the quantity required at each destination (in the two seasons) can be estimated.
- 2) Per capita consumption in the different regions is the same (and it has not been changed since 1995). However, one can argue about the effects of the different possible assumptions.
- 3) Per capita consumption of fresh and stored dates is the same.<sup>(1)</sup>
- 4) Consumption is assumed to be homogenous throughout the year. In fact in this study the estimated total demand in the period from August to October is

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(1) For further study, when data are available, one can deal with the fact that fresh and stored dates are different products.

equal to one third of demand in the period November to July.<sup>(2)</sup>

- 5) Dates assumed to be homogeneous products and all varieties can be stored.<sup>(3)</sup>
- 6) The unit cost of storing, handling, and shipping dates from any origin to any destination is known and fixed and not vary with the amount shipped.

## Results

The cost-distance equations were estimated using the Ordinary Least Squares (OLS) procedure. These equations show the relationship between the cost of transportation and the number of kilometers of the road. The cost of handling and storing were added to the intercept term of this equation; when relevant (Alseleem, 1994, 1998). The following equations refer to the transportation-cost-distance equations,

$$\text{Cost1}_{ij} = 16222.18 + 109.60 \text{ Distance1}_{ij}$$

$$\text{Cost2}_{ij} = 15395.73 + 107.08 \text{ Distance2}_{ij}$$

$$\text{Cost3}_{ij} = 1576221.93 + 107.08 \text{ Distance3}_{ij}$$

where  $\text{Cost1}_{ij}$  refers to the cost of handling and transporting 1000 tons of fresh dates between region  $i$  and region  $j$  in Riyals.  $\text{Cost2}_{ij}$  refers to the cost of handling and transporting

1000 tons of stored dates between region  $i$  and region  $j$  in Riyals.  $\text{Cost3}_{ij}$  refers to the cost of storing, handling, and transporting 1000 tons of stored dates between region  $i$  and region  $j$  in Riyals.  $\text{Distance1}_{ij}$ ,  $\text{Distance2}_{ij}$ , and  $\text{Distance3}_{ij}$  refer to the distance in kilometers between region  $i$  and region  $j$ .

Tables 3 and 4 indicate the optimal distribution of dates in the kingdom. With this distribution, the cost of handling, storing, and transporting are minimum at 673.9 million Saudi Ryails. It is clear from table 3 that all regions consume only their own fresh dates except Tabouk, Al-baha, Jazan, and North Frontier, Tabouk imports 4.02 thousand tons from Al-jouf, Al-baha 1.78 thousand tons of fresh dates from Aseer, Jazan 6.75 thousand tons of fresh dates from Aseer, and North Frontier 1.07 thousand tons of fresh dates from Qaseem (Table 3). Regarding stored dates, the optimal storage pattern among regions in thousand tons are 63.98, 101.28, 71.65, 10.23, 23.41, 49.51, 10.02, 60.56, 7.36, and 18.77 for Eastern, Riyadh, Qaseem, Hail, Tabouk, Medinah, Makkah, Aseer, Najran and Al-jouf, respectively (Table 4). However, Al-baha,

(2) Because of data shortages, this paper ignores the fact that during the month of Ramadan consumption increases. However, some studies have dealt with similar cases, for instant, Alseleem explored optimum distribution of table-eggs in the month of thiAlhejah as well as rest of the year (Alseleem, 1997).

(3) Some varieties, like Barhi, taste good just when consumed fresh.

**Table 3**  
**Optimum distribution of fresh dates among the administrative regions, 1000 Tons**

Supply Demmand	Eastern	Riyadh	Qaseem	Hail	Tabouk	Mednah	Makkah	Aseer	Al-baha	Jazan	Najran	Al-jouf	North frontier	Total In-shipments
Eastern	21.32													21.32
Riyadh		31.8												31.80
Qaseem			6.24											6.24
Hail				3.41										3.41
Tabouk												4.02		4.02
Medinah						9.00								9.00
Makkah							37.07							37.07
Aseer								11.12						11.12
Al-baha								1.78	0.89					2.67
Jazan								6.75		0.43				7.18
Najran											2.51			2.51
Al-jouf												2.23		2.23
North Frontier													0.05	1.12
Total Out-shipments	21.32	31.80	7.31	3.41	0.00	9.00	37.07	19.65	0.89	0.43	2.51	6.25	0.05	139.69

**Source:** results of the linear programming model, Solved by LINGO computer software.

Table 4  
Optimum distribution of stored dates among the administrative regions, 1000Tons

Supply Demand	Eastern	Riyadh	Qaseem	Hail	Tabouk	Mednah	Makkah	Aseer	Al-baha	Jazan	Najran	Al-jouf	North frontier	Total In-shipments
Eastern	63.98													63.98
Riyadh		95.42												95.42
Qaseem			18.72											18.72
Hail				10.23										10.23
Tabouk												12.07		12.07
Medinah						26.78								26.78
Makkah		3.04	47.23		23.41	22.73	10.02							106.43
Aseer								33.36						33.36
Al-baha		2.64						5.65						8.29
Jazan								21.55						21.55
Najran		0.18								7.36				7.54
Al-jouf											6.7			6.70
North Frontier			5.7											5.70
Total/Out-shipments	63.98	101.28	71.65	10.23	23.41	49.51	10.02	60.56	0.00	0.00	7.36	18.77	0.0	416.77

Source: results of the linear programming model, Solved by LINGO computer software.

Jazan and North frontier do not keep any dates in storage. They rather import stored dates from other regions: Al-baha 2.64 thousand tons from Riyadh, Jazan 21.55 thousand tons of stored dates from Aseer, and North frontier 5.70 thousand tons stored dates from Qaseem (Table 4).

Riyadh is the largest exporting region of stored dates. Riyadh exports stored dates to Riyadh (own supply) 95.42 thousand tons, Makkah 3.04 thousand tons, and Al-baha 2.64 thousand tons, and Najran 0.18 thousand tons (Table 4).

Makkah is the largest importing region of stored dates. Makkah imports from Riyadh, Qaseem, Tabouk, Medinah, And Makkah 3.04, 47.23,

23.41, 22.73 and 10.02 respectively (Table 4).

Total dates shipment inside Saudi regions is 556.46 thousand tons. This permits about 91.64 as a surplus. This is less than actual export out of the country, 30.85 Thousand tons in 1998.

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## الملخص

### تحليل زمني-مناطقى لقطاع التمور بالمملكة العربية السعودية

يوسف عبدالله السليم

جامعة الملك سعود

يهدف هذا البحث إلى دراسة التوزيع الأمثل لإنتاج واستهلاك التمور بين مختلف مناطق المملكة العربية السعودية. وفي هذا البحث، تقسم التمور إلى نوعين: تمور طازجة وتمور مخزنة. ولكي يمكن استخدام أي من هذين النوعين فإنه يجب تحمل تكاليف النقل والمناولة. وتضاف تكلفة التخزين في حالة استهلاك التمور المخزنة. يبدأ موسم جني الثمار للتمور مع بداية شهر أغسطس وينتهي بنهاية شهر أكتوبر. بينما الطلب على التمور مستمر على مدار العام، وكنتيجة لهذا، فإن بعض المستثمرين يقومون بتخزين التمر وقت جني الثمار لكي يكون استهلاكها على مدار العام. هذا البحث يبحث النمط المناطقى والزمانى للتمور. النتائج تبين التوازن الأمثل بين إنتاج التمور واستهلاك التمور الطازجة والمخزنة في ثلاث عشرة منطقة في المملكة العربية السعودية.

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