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Evaluating Batsman using Survival Analysis

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Abstract

Batsman has always dominated the cricket arena. Lot of research has been done to measure the performance of a batsman. The performance of a batsman has been usually measured using batting average or strike rate. Some researchers have suggested a constant-hazard model to obtain the probability of a batsman being dismissed on their current score. There are studies that tries to examine the survival ability of batsman using a probabilistic model. We propose generalized exponential distribution as the best fit to the runs scored by a batsman. Survival probabilities and conditional survival probability of a batsman using this distribution gives the more accurate chance of a batsman to survive on crease. We have calculated these survival probabilities and conditional survival probabilities for ICC top 10 batsman against top cricket playing nation. This study can be used by team managements to pick up the team, decide batting order as per the opponent team and match situation. It can also be beneficial to the betting industry as individual batsman score can be predicted using these survival probabilities.

Key words: Conditional survival probability exponential distribution; generalized exponential distribution; survival probability; Weibull distribution.

AMS Subject Classifications: 62K05, 05B05

1. Introduction

Cricket is becoming one of the most popular sports of the today's world. Given the data-rich nature of the sport, numerous studies have used metrics to measure the performance of batsman, bowler, fielder and captain. During the past few years or more lot of work and research papers have been published which measured the performance of the players and their predictions. Many researchers have focussed their study on the most entertaining element and key factor of cricket *i.e.*, batting.

A detail study regarding research directions in cricket was considered by Swartz (2017). The use of stochastic dominance rules demonstrated by Damodaran (2006) to analyse the batting performance of Indian cricketers in ODI cricket. Shah (2017) has defined a new batting and bowling measure. He has defined batting average considering the quality of bowler he is facing and similarly bowling average considering the quality of batsman he is

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bowling against. Shah and Patel (2018) have ranked captains based on several parameters using Principal Component Analysis. Also, they have included weighted average method to rank captains based on z score of performance of team, individual performance of captain as batsman and bowler.

Elderton and Wood (1945) shows that geometric model can be used for batsman's scores. Bracewell and Ruggiero (2009) suggested 'Ducks n runs'distribution for scores of zero to overcome inability of geometric distribution under inflated number of scores of zero.

As fall of wickets leads to the loss of resources of the batting side, so stability of a batsman on the pitch would help a team to win the match provided evidently, he should have scored runs as quickly as possible. Thus, to know how much time a batsman can survive or how many balls a batsman can face on the cricket pitch while batting might be very useful to arrange the batting order of a team in 20-20 or ODI cricket based on the match situation.

Survival analysis provides the survival ability of an individual where the outcome variable is the time until the occurrence of a particular event of interest. The survival time or time to an event of interest can be measured in hours, months, years, *etc.*, in which the objects or subjects are followed over a specified period of time to pinpoint the event of interest occurs. It is widely used in medical, clinical trial, actuarial science, *etc.*, but now a day the application of survival analysis becomes very much useful in sport (especially in cricket).

Kimber and Hansford (1993) demonstrated utility of non-parametric models for estimating hazard of player's. Stevenson and Brewer (2017) proposed Bayesian approach and hierarchical inference for player's hazard. They considered Bayesian survival analysis of batsmen.

For estimating adjusted batting average of player's a product limit estimator is also used. Das (2011) used such a method using generalized geometric distribution. A survival rate criterion is considered by van Staden (2010) for evaluating the performance of batsmen. Saikai and Bhattacharjee (2018) examined survival ability of batsmen in IPL 2012.

So, in this paper, we have examined three distributions namely: exponential, Weibull and generalised exponential for fitting the runs scored by the batsmen and found the generalised exponential distribution as a best fit. Also, the batting average of a batsman is compared with the mean of generalised exponential distribution, which almost comes out to be close to each other.Using generalised exponential distribution, we have obtained survival probabilities of the batsman. This probability will give the chance that a batsman remains on the crease and scores particular runs. This survival probabilities can be used by team managements or captains to decide the batting order as per the match situations and opposition team. We have also computed conditional probabilities for each batsman for surviving for b runs given that he has survived for a runs. This will be useful to make prediction of scores of the batsman and team scores during the live match.

2. Material and methods

Data of runs scored by batsmen up to April 2020 was taken from www.espncricinfo.com. Also, the top teams and top batsmen as per International Cricket Council (ICC) ranking for ODI of April 2020 are considered. In this paper, we first took the innings-by-innings scores of ICC top 10 batsmen and fitted various distributions like exponential, Weibull and generalised exponential using R programming language.

3. Results and discussion

From Table 1, it can be seen that generalised exponential distribution is the best fit to the runs scored by the batsman as Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) are least compared to other two exponential and Weibull distribution.

Table 1: Fitting three distributions on runs scored by top 10 batsmen

	Exponential dist.		Weibull dist.		Generalised Exponential dist.	
Batsman	AIC	BIC	AIC	BIC	AIC	BIC
Kohli	2035.28	2038.756	1939.482	1946.435	1900.618	1907.57
Rohit	1821.798	1825.178	1693.453	1700.212	1660.305	1667.064
Babar	621.0408	623.3174	621.5612	626.1145	617.4151	620.9684
Taylor	1729.64	1733.016	1673.154	1679.905	1648.36	1655.111
Du Plessis	1129.563	1132.476	1128.508	1134.333	1122.768	1128.594
Warner	1111.585	1114.381	1104.288	1109.879	1100.065	1105.656
Williamson	1265.706	1268.675	1257.981	1263.921	1244.698	1250.638
Root	1146.419	1149.339	1135.751	1141.591	1123.992	1129.832
Finch	1123.977	1126.78	1034.221	1039.829	998.7167	1004.325
De Kock	1105.748	1108.543	1093.063	1098.654	1082.108	1087.7

The actual batting average and average (mean) as per the generalised exponential distribution were compared for all top batsmen. From Table 2, it can be seen that both averages were very close in majority of the batsmen. This again validates the suitability of the generalised exponential distribution.

The probability density function and cumulative distribution function of generalised exponential distribution is given by

$$f(x;\alpha,\lambda) = \begin{cases} \alpha\lambda(1-e^{-\lambda x})^{\alpha-1}e^{-\lambda x}, & x>0, \alpha>0, \lambda>0; \\ 0, & \text{Otherwise.} \end{cases} \tag{1}$$

and

$$F(x;\alpha,\lambda) = (1-e^{-\lambda x})^{\alpha} \tag{2}$$

Its mean and variance are given as:

$$\mu = \frac{\psi(\alpha+1)-\psi(1)}{\lambda} \tag{3}$$

Table 2: Comparison of actual batting average with the mean and sd of runs using generalised exponential distribution

Batsman	Country	Actual Bating Avg.	Mean	sd
Kohli	India	59.33	65.54	95.42
Rohit	India	49.27	53.73	81.80
Babar	Pakistan	54.17	55.50	64.68
Taylor	New Zealand	48.44	53.15	73.16
Du Plessis	South Africa	47.47	48.66	56.05
Warner	Australia	45.8	46.14	55.16
Williamson	New Zealand	47.48	48.44	59.78
Root	England	51.05	53.42	66.88
Finch	Australia	41.02	40.68	64.72
De Kock	South Africa	44.65	44.96	56.98

$$\sigma^2 = \frac{\psi'(1) - \phi'(\alpha+1)}{\lambda^2} \tag{4}$$

where,

$$\psi(\cdot) = \text{diagamma function } = \frac{d \log \Gamma(\cdot)}{d(\cdot)}$$

and

$$\psi'(\cdot) = \text{trigamma function which is derivative of diagamma function.}$$

Survival analysis is defined as a set of methods for analysing data where the outcome variable is the time until the occurrence of a particular event of interest. The event could be death due to cancer, occurrence of a disease, relief from a severe back pain, *etc.*, Let us take an example to explain mathematical definition of survival function. Suppose the actual survival time of an individual (say) t which can be regarded as the value of a variable T (*i.e.*, associated with the survival time). It can take any non-negative value. The different values that T can take have a probability distribution, so the variable T can be considered as a random variable. Now for the random variable T, the probability distribution function of T can be defined as $F(t)$ and it is given by

$$F(t) = P(T < t) = \int_0^t f(x)\, dx$$

which represents the probability that the survival time is less than some value t. Now the survival function is defined as the probability that the survival time is greater than or equal to t. Usually, it is denoted by $S(t)$ and given by

$$S(t) = P(T \geq t) = 1 - \int_0^t f(x)\, dx$$

The survival function for generalised exponential distribution is given by

$$S(t) = 1 - (1 - e^{-\lambda x})^{\alpha}, t > 0. \tag{5}$$

Therefore, the survival function can be used to represent the probability that an individual survives from the time origin to sometime beyond t. The survival time or time to an event of interest can be measured in days, weeks, years, *etc.*, in which the objects or subjects are followed over a specified period of time to pinpoint the event of interest occurs. Though it's uses in medical, clinical trial, actuarial science, *etc.*, are hefty, but still the application of survival analysis in sport (especially in cricket) is limited.

We have calculated the survival probability of ICC top 10 batsmen using equation (5) and presented in Table 3 and its graph is shown in Fig. 1. We can say that Babar, Virat, Rohit and Taylor have the high survival probability of getting good runs. This is also depicted by their ICC rankings. Survival probabilities of Warner, du Plessis, de Kock suggest that the probability decreases compared to other batsmen, which suggest that they get a start but are unable to convert into big score. And Finch has the lowest probability which says that he gets out early. Virat and Babar have highest probability of getting half century. Similarly, Virat has the highest probability of scoring century among all other top batsmen. This also suggests that Virat converts a good start into half century and century, which is confirmed by the number of centuries he has scored.

Table 3: Survival probabilities of ICC top 10 batsmen

	Runs				
Batsman	**10**	**30**	**50**	**80**	**100**
Virat	0.6694	0.4822	0.3738	0.2678	0.218
Rohit	0.6169	0.4262	0.3205	0.2209	0.1756
Babar	0.7616	0.527	0.3796	0.2384	0.1764
Taylor	0.6686	0.4582	0.3373	0.2234	0.1725
du Plessis	0.7458	0.4945	0.3411	0.2007	0.1422
Warner	0.718	0.4681	0.3206	0.1878	0.1328
Williamson	0.7101	0.4714	0.3306	0.2014	0.1465
Root	0.7188	0.4918	0.3557	0.227	0.1704
Finch	0.5524	0.3578	0.256	0.1649	0.1256
de Kock	0.6838	0.4438	0.3065	0.1824	0.1318

Similarly, survival probability against world's top teams as per ICC ranking April 2020 is calculated in Table 4. We can see that Virat's survival chances at initial score and after that are highest against South Africa and least against England. Rohit has highest initial survival chances against England and lowest against South Africa. While the chance of getting half-century or century is highest against Australia and England and lowest against New Zealand. Babar has the lowest chance of scoring big score against India. This way we

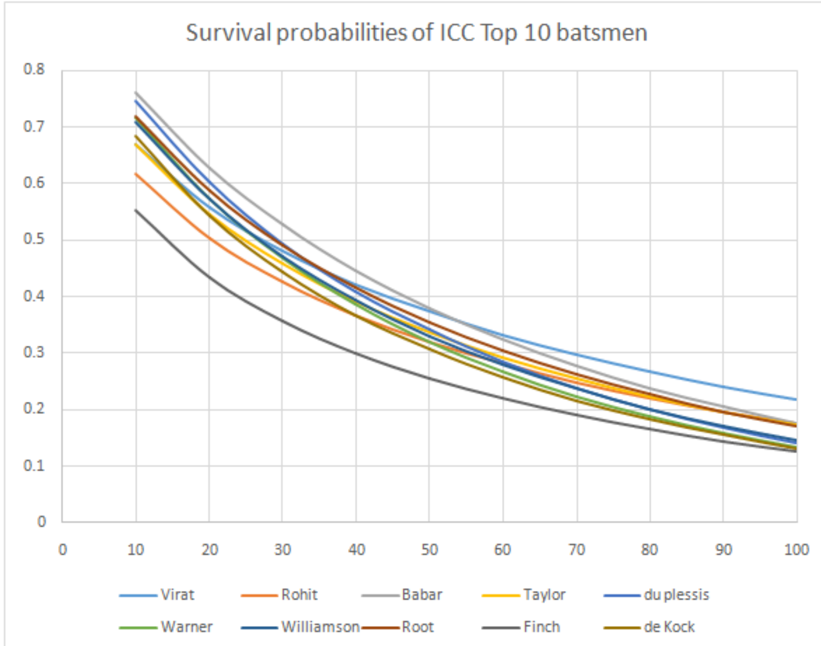

Figure 1: Graph of survival probabilities of ICC top 10 batsmen

can conclude about individual batsman scoring probabilities against specific teams. We can identify that against which team batsman gets out early or scores big after the start.

This survival probabilities of each batsman can be useful for team selection against a particular team. It can also be useful to predict the individual batsman score and team score in on-going match. Batting order can be decided by captains considering the match situation and survival probabilities of batsmen.

Table 4: Survival probabilities of ICC top 10 against ICC top 7 teams

Batsman	Runs	India	New Zealand	Australia	England	South Africa	Sri Lanka	Pakistan
Virat	10	NA	0.6922	0.6747	0.5659	0.71	0.6923	0.5805
	30	NA	0.4948	0.4672	0.3872	0.5238	0.5019	0.4067
	50	NA	0.3784	0.3471	0.2914	0.412	0.3894	0.3123
	80	NA	0.2647	0.233	0.2023	0.3	0.2785	0.223
	100	NA	0.2118	0.1814	0.1619	0.2466	0.2263	0.1818
Rohit	10	NA	0.6955	0.6661	0.7502	0.5205	0.5369	0.6448
	30	NA	0.3932	0.472	0.5134	0.3227	0.3851	0.4082
	50	NA	0.2302	0.36	0.3669	0.2225	0.3044	0.3274
	80	NA	0.1053	0.2519	0.2282	0.1361	0.2275	0.2198
	100	NA	0.0629	0.2019	0.1679	0.1001	0.1914	0.1715
Babar	10	0.85	0.4554	0.9999	0.8866	0.9798	0.917	NA

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Table 4 – continued from previous page

Batsman	Runs	India	New Zealand	Australia	England	South Africa	Sri Lanka	Pakistan
	30	0.4254	0.3163	0.8029	0.5676	0.7803	0.6785	NA
	50	0.1839	0.2454	0.4339	0.3326	0.4531	0.4733	NA
	80	0.0484	0.1798	0.1212	0.1406	0.0999	0.2635	NA
	100	0.0195	0.1496	0.0478	0.0779	0.0218	0.1758	NA
Taylor	10	0.7133	NA	0.7744	0.6994	0.6835	0.4393	0.6253
	30	0.4786	NA	0.4516	0.4744	0.4063	0.2903	0.4881
	50	0.3393	NA	0.2613	0.3422	0.2539	0.2158	0.4115
	80	0.2101	NA	0.1145	0.2184	0.1294	0.1489	0.3346
	100	0.1545	NA	0.0659	0.1641	0.0834	0.1192	0.2967
du Plessis	10	0.8714	0.8572	0.8961	0.5054	NA	0.8521	0.918
	30	0.62	0.5255	0.6295	0.2868	NA	0.5838	0.501
	50	0.4309	0.3007	0.418	0.1813	NA	0.3922	0.2152
	80	0.2456	0.1245	0.2171	0.0973	NA	0.213	0.0531
	100	0.1678	0.0683	0.1385	0.0656	NA	0.1412	0.0204
Warner	10	0.7846	0.8116	NA	0.762	0.6217	0.7137	0.8632
	30	0.5233	0.5315	NA	0.4007	0.4023	0.4211	0.5911
	50	0.3564	0.3474	NA	0.2048	0.2825	0.257	0.3928
	80	0.2032	0.1834	NA	0.0736	0.1753	0.1252	0.2082
	100	0.1403	0.1197	NA	0.0371	0.1297	0.078	0.1355
Williamson	10	0.6784	NA	0.6155	0.7133	0.8075	0.608	0.8682
	30	0.4152	NA	0.395	0.4931	0.5323	0.3736	0.6086
	50	0.269	NA	0.2756	0.3614	0.352	0.2494	0.4157
	80	0.1453	NA	0.1693	0.236	0.1896	0.1433	0.2303
	100	0.0975	NA	0.1246	0.1799	0.1257	0.1007	0.1544
Root	10	0.7811	0.89	0.5191	NA	0.9096	0.7101	0.6775
	30	0.5495	0.6197	0.319	NA	0.6223	0.5051	0.4559
	50	0.3999	0.4093	0.2183	NA	0.3891	0.3823	0.3283
	80	0.2541	0.2116	0.1319	NA	0.1805	0.2624	0.2098
	100	0.1893	0.1346	0.0964	NA	0.1061	0.2072	0.158
Finch	10	0.6064	0.3253	NA	0.4719	0.7489	0.783	0.5939
	30	0.3993	0.1675	NA	0.3287	0.4254	0.4909	0.434
	50	0.2855	0.1003	NA	0.2551	0.2425	0.3097	0.346
	80	0.1844	0.0506	NA	0.1868	0.1046	0.1558	0.2606
	100	0.14	0.0329	NA	0.1553	0.0597	0.0987	0.22
de Kock	10	0.9299	0.5633	0.5832	0.8564	NA	0.8404	0.467

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Table 4 – continued from previous page

Batsman	Runs	India	New Zealand	Australia	England	South Africa	Sri Lanka	Pakistan
	30	0.6939	0.346	0.3389	0.6303	NA	0.5579	0.2943
	50	0.4805	0.2338	0.2147	0.4641	NA	0.3628	0.2084
	80	0.2611	0.1379	0.1141	0.2936	NA	0.1876	0.1335
	100	0.1706	0.0989	0.0762	0.2164	NA	0.1204	0.1017

4. Conditional survival analysis

In this section we have considered the conditional survival probability of batsman.

Suppose that the batsman has survived at score a then the probability of surviving at score b, $b > a$ is called conditional survival probability.

Mathematically it is defined as

$$S(b|a) = P(X > b|X > a) = \frac{P(X > b)}{P(X > a)}.$$

In case of generalised exponential distribution, it is given by

$$S(b|a) = \frac{1 - (1 - e^{-\lambda b})^{\alpha}}{1 - (1 - e^{-\lambda a})^{\alpha}} \tag{6}$$

Conditional survival probabilities using generalised exponential distribution are calculated using equation (6) for ICC top 10 batsmen as per ICC ranking April 2020 and given in Table 5. This probability describes the ability of batsman to survive for some additional scores during the on-going play. We can observe that when Virat scores 10 runs, the probability of scoring a century is highest among all the players. This shows that when Virat gets his eye set, the chance of converting it into big score is highest. The probability of scoring a century once the batsmen has scored 50 runs is quite high for Rohit, followed closely by Virat, Taylor, Finch and Root. This is also reflected in the number of centuries these batsmen have scored. Once they spend some time on crease, they score high in the match. Low probabilities for a batsman also reflect that the batsman throws away his wicket after getting his eye set. This can be a good point for the coaches to guide the player to play long. These probabilities will be more useful for predicting individual scores and team scores. This is very important probabilities for the team and also for the betting industry.

Table 5: Conditional probabilities $P(\text{score} > b/\text{score} > a)$ of ICC top 10 batsmen

Batsman	a	b				
		10	30	50	80	100
Virat	10	1	0.7204	0.5584	0.4	0.3257
	30		1	0.743	0.4987	0.3884
	50			1	0.6711	0.5227

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Table 5 – continued from previous page

Batsman	a	b				
		10	30	50	80	100
	80				1	0.7789
Rohit	10	1	0.6908	0.5957	0.358	0.2846
	30		1	0.752	0.5182	0.412
	50			1	0.6891	0.5479
	80				1	0.795
Babar	10	1	0.692	0.4984	0.313	0.2317
	30		1	0.7202	0.4523	0.3348
	50			1	0.628	0.4648
	80				1	0.7401
Taylor	10	1	0.6827	0.5045	0.3342	0.258
	30		1	0.7363	0.4877	0.3766
	50			1	0.6624	0.5114
	80				1	0.7722
du Plessis	10	1	0.663	0.4574	0.2691	0.1906
	30		1	0.6899	0.4059	0.2875
	50			1	0.5884	0.4168
	80				1	0.7083
Warner	10	1	0.6519	0.4466	0.2615	0.185
	30		1	0.685	0.4011	0.2837
	50			1	0.5856	0.4142
	80				1	0.7074
Williamson	10	1	0.6638	0.4655	0.2836	0.2063
	30		1	0.7014	0.4272	0.3107
	50			1	0.6091	0.443
	80				1	0.7273
Root	10	1	0.6842	0.4948	0.3158	0.2371
	30		1	0.7232	0.4617	0.3466
	50			1	0.6383	0.4792
	80				1	0.7507

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Table 5 – continued from previous page

Batsman	a	b				
		10	30	50	80	100
Finch	10	1	0.6478	0.4633	0.2985	0.2273
	30		1	0.7153	0.4607	0.3509
	50			1	0.6441	0.4906
	80				1	0.7616
de Kock	10	1	0.649	0.4483	0.268	0.1927
	30		1	0.6907	0.4129	0.2969
	50			1	0.5978	0.4299
	80				1	0.7192

We have also calculated conditional probabilities of ICC top 10 batsmen against ICC top teams. These probabilities will evaluate the performance of a batsman against a particular team. In Table 6, we have presented conditional probabilities of 5 batsmen against top 5 teams for particular runs only.

From Table 6, we can see that Virat has the highest probability of scoring a half-century or a century given that he scores 10 runs *i.e.* gets a start against South Africa followed by New Zealand, England and Australia. Also, Virat has capability of converting half-century into huge score like century is highest among all other batsmen. Rohit loves to score big against Australia and then England compared to other countries once he gets the start, which is reflected in the conditional probabilities. Babar loves to play against New Zealand compared to other countries with more than 50% chance of making half-century or even century from a start he gets. But he has the lowest probability of scoring against India. So, even if he gets a start, he is not able to convert into big scores against India. Taylor's probabilities suggest that once he gets his eye on the ball, he loves to score big against England and India. Du Plessis has the highest scoring probability against India compared to other teams.

5. Conclusion

Survival probabilities and conditional probabilities using generalised exponential distribution gives more accurate chance of survival compared to exponential and Weibull distributions. These probabilities can be used as a new measure for evaluating batsman as it gives the ability of a batsman to survive on crease. This is the measure that evaluates batsman during the live match and at every run he scores. Conditional survival probabilities can be advantageous to the team managements to decide the batting order or change it during match depending on the match situations and the opponent team. From our study we conclude that among all top batsmen, Virat and Rohit have higher survival rate and even potential of making big scores like half-century and century.

Table 6: Conditional probabilities $P(\text{score} > b|\text{score} > a)$ of top 5 batsmen against top 5 teams

a	b	Country	Batsman				
			Virat	Rohit	Babar	Taylor	du Plessis
10	50	India	NA	NA	0.2163	0.4756	0.4945
		New Zealand	0.5466	0.3309	0.5389	NA	0.3508
		Australia	0.5145	0.5405	0.4352	0.3374	0.4665
		England	0.515	0.4891	0.3751	0.4894	0.3588
		South Africa	0.5802	0.3582	0.4624	0.3714	NA
10	100	India	NA	NA	0.023	0.2166	0.1926
		New Zealand	0.306	0.0904	0.3285	NA	0.0797
		Australia	0.2689	0.3031	0.0479	0.0151	0.1545
		England	0.2861	0.2239	0.0879	0.2347	0.1297
		South Africa	0.3473	0.1613	0.0223	0.122	NA
50	100	India	NA	NA	0.1062	0.4554	0.3895
		New Zealand	0.5598	0.2733	0.6097	NA	0.2272
		Australia	0.5227	0.5607	0.1101	0.2523	0.3312
		England	0.5556	0.4577	0.2342	0.4796	0.3616
		South Africa	0.5985	0.4504	0.0482	0.3284	NA

6. Future scope

This study can be applied for test match cricket and T20 cricket. It can be also be used in football, hockey to calculate survival probabilities and conditional survival probabilities of goals by a team or a goal-keeper. Also, various other multivariate techniques like logistic regression, principal component analysis can be applied to the data.

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