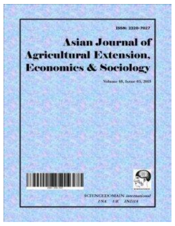

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An Economic Analysis of Cointegration for Potato Market in Tamil Nadu, India

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Authors' contributions

This work was carried out in collaboration between all authors. Author VV designed the study, managed the literature searches, wrote the protocol, collected data, analyzed the data and wrote the first draft of the manuscript. Authors KMS, AR and BS finalized the design, protocol and checked the draft report. All authors read and approved the final manuscript.

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ABSTRACT

The present study aimed to analyze the potato market integration in India, specifically how the Tamil Nadu market behaves with respect to the behavior of other potato markets across India. Major potato markets, such as Madhya Pradesh, Uttar Pradesh and Gujarat, which have a majority share in the total supply potato to Tamil Nadu were selected for market integration analysis. Since price data for Tamil Nadu market was non-stationary and other market prices were stationary in level form, Autoregressive Distributed Lag Model (ARDL) was used to estimate cointegration (long run equilibrium) among these markets. Month wise potato price data from January 2005 to September 2016 were collected from different sources and used for analysis. Results revealed that long run equilibrium existed among the potato markets in Tamil Nadu, Madhya Pradesh, Uttar Pradesh and Gujarat but the speed of adjustment of equilibrium level is very less in the long run. Change in the potato price of Gujarat market was the key determinant of shocks in the potato market of Tamil Nadu.

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Keywords: Integration; long run equilibrium; VEC; ARDL; bounds test; price.

1. INTRODUCTION

Demand for food items, particularly nutritious oriented food like potato has been continuously increasing in recent periods. There is an increasing demand for potato from the fast food and processing sectors across the globe. This demand has met out through the production and import from neighboring markets/countries. Potato is a highly nutritious, easily digestible, wholesome food and rich in carbohydrates, proteins, minerals, vitamins and high-quality dietary fibre. Potato provides more nutrients than cereals and vegetables. It is the fourth most popular food in the world after wheat, rice, and maize. It overthrew the banana in India as the primary source of starch many centuries ago.

India is the second largest producer of potato, after China, with 437 lakh tons of potatoes produced by engaging 21.34 lakh hectares in 2015-16 and Indians consume one lakh tonnes of potatoes daily. The major potato growing states are Punjab, Haryana, Uttar Pradesh, Bihar, West Bengal, Gujarat and Madhya Pradesh. In Tamil Nadu, the potato is cultivated only in small areas, specifically in the Nilgiris and Palani hills. The crop is grown round the year in both irrigated and rain-fed areas. Potato is grown in 6000 hectares with a production of 1.3 lakh tons in 2014-2015 in Tamil Nadu. It is observed that two varieties, Kufri Jyoti and Kufri Giriraj, are grown majorly in the state. A major supplier of potato to Tamil Nadu state are Gujarat, Madhya Pradesh and Uttar Pradesh. The supply is highly fluctuating nature and is stable during the month of October - December. Both intra-state and inter-state supply side constraints are uneven rainfall distribution in recent decades and the hoarding of potato during the off-season. Unexpected volatility in potato price can be overcome when the markets are integrated that perhaps bridge demand and supply gap in the existing markets of Tamil Nadu. Thus, an amount of potato supply and its price are determined by production and price situation in the markets of major supplying states such as Gujarat and Uttar Pradesh. It is important to find spatial market integration to derive appropriate policy measure regarding the price and supply of potato.

The existence of integration in the markets influences the conduct of the firms of the markets and consequently the marketing efficiency. The behavior of a highly integrated market is different from that of the disintegrated market. The concept of market integration has retained and increased importance over recent year, particularly in developing countries where it has potential application to policy questions regarding government intervention in the markets [1]. Unless agricultural product markets are spatially integrated, any local food scarcity will tend to persist, as distant markets (with no scarcity) will not be able to respond to the price signals of such isolated markets [2]. Lack of integration can often lead to localized food scarcity, even famines [3]. Besides, when the markets are not integrated, there will not be correct price signals transmitted through the marketing channels and the farmers will not be able to specialize according to long-term comparative advantage. An integrated market is synonymous with pricing efficiency, i.e., prices, "should always reflect all information". Testing for such integration is, therefore, central to determine the level at which agricultural price policy should be targeted.

Empirical testing of market integration has evolved over time from the early stages of using bivariate correlation coefficients to the more recent techniques that take into account non-stationarity, common trends and endogeneity of prices [4]. The usual definition in the literature is that integrated markets are those where prices are determined interdependently. This has generally been assumed to mean that the price change in one market is fully transmitted to other markets [5]. In making inferences about market efficiency from data on prices, the concept of integration has been central [6]. Spatial market integration refers to a situation in which prices of a commodity in spatially separated markets move together and price signals and information are transmitted smoothly across the markets [7]. Previously, the measurements of pricing efficiency in agricultural commodity markets were done through pairwise comparison or bivariate correlation of price series data. However, it is not a convenient indicator of market integration and found to have methodological flaws. These fail to recognize the possibility of spurious integration in the process of the common exogenous trend (e.g., general inflation), common periodicity (e.g., agricultural seasonality) or auto-correlated and heteroscedastic residuals in the regression with non-stationarity price data [6].

In India, cointegration methodology was widely used by many researchers [4,5,8,9,10]. [5] use Engle–Granger cointegration for fish prices in 6 markets in the state of Orissa. [8] used the monthly wholesale prices of wheat, jowar, paddy rice, groundnut and rapeseed-mustard to analyze the degree of integration among different markets both before and after liberalization using the Johansen cointegration method. Hitherto, studies on the market integration of potato have been limited in India. On the basis of the Johansen cointegration test, [11] has revealed that there was a long run relationship between wholesale and retail prices of potato in the selected markets in West Bengal, India, indicating the existence of efficiency in transmitting prices of potato crop quickly between wholesale and retail markets. [12] analyzed the spatial integration of potato markets in Uttarakhand using monthly wholesale price for ten years and found that five potato markets reacted on the long-run cointegrating equations while the speed of price adjustment in the short-run was almost absent and they revealed there was the weaker integration if the markets are situated in longer distance. [13] examined cointegration among selected regulated wholesale markets for potato in West Bengal, India and showed that major potato markets are well integrated while less important markets are weakly integrated. However, no empirical work has been done to evaluate potato market integration in Tamil Nadu with the help of advanced cointegration tests. With this backdrop, the present study aimed to evaluate the impact of shocks in the other potato markets in India on Tamil Nadu potato market.

2. METHODOLOGY

2.1 ARDL Bounds Tests

This study used ARDL bounds test technique to examine cointegration (long-run relationship) among variables and also to observe short run dynamics. The test uses lags of endogenous variable, lagged and contemporaneous values of the exogenous variables in Eqs. (1) to (4). From this equation, short run effects are directly assessed and long-run equilibrium relationships are indirectly estimated. Hence, ARDL bound test estimate following unrestricted error correction model [14]:

$$\Delta \ln MP_t = a_{0MP} + \sum_{i=1}^{n} b_{iMP} \Delta \ln MP_{t-i} + \sum_{i=1}^{n} c_{iMP} \Delta \ln UP_{t-i} + \sum_{i=1}^{n} d_{iMP} \Delta \ln TN_{t-i} + \sum_{i=1}^{n} e_{iMP} \Delta \ln GUJ_{t-i} + \sigma_{1MP} \ln MP_{t-1} + \sigma_{2MP} \ln UP_{t-1} + \sigma_{3MP} \ln TN_{t-1} + \sigma_{4MP} \ln GUJ_{t-1} + \varepsilon_{1t} \quad (1)$$

$$\Delta \ln UP_t = a_{0UP} + \sum_{i=1}^{n} b_{iUP} \Delta \ln UP_{t-i} + \sum_{i=1}^{n} c_{iUP} \Delta \ln MP_{t-i} + \sum_{i=1}^{n} d_{iUP} \Delta \ln TN_{t-i} + \sum_{i=1}^{n} e_{iUP} \Delta \ln GUJ_{t-i} + \theta_{1UP} \ln UP_{t-1} + \theta_{2UP} \ln MP_{t-1} + \theta_{3UP} \ln TN_{t-1} + \theta_{4UP} \ln GUJ_{t-1} + \varepsilon_{2t} \quad (2)$$

$$\Delta \ln TN_t = a_{0TN} + \sum_{i=1}^{n} b_{iTN} \Delta \ln TN_{t-i} + \sum_{i=1}^{n} c_{iTN} \Delta \ln MP_{t-i} + \sum_{i=1}^{n} d_{iTN} \Delta \ln UP_{t-i} + \sum_{i=1}^{n} e_{iTN} \Delta \ln GUJ_{t-i} + \phi_{1TN} \ln TN_{t-1} + \phi_{2TN} \ln MP_{t-1} + \phi_{3TN} \ln UP_{t-1} + \phi_{4TN} \ln GUJ_{t-1} + \varepsilon_{3t} \quad (3)$$

$$\Delta \ln GUJ_t = a_{0GUJ} + \sum_{i=1}^{n} b_{iGUJ} \Delta \ln GUJ_{t-i} + \sum_{i=1}^{n} c_{iGUJ} \Delta \ln TN_{t-i} + \sum_{i=1}^{n} d_{iGUJ} \Delta \ln MP_{t-i} + \sum_{i=1}^{n} e_{iGUJ} \Delta \ln UP_{t-i} + \omega_{1GUJ} \ln GUJ_{t-1} + \omega_{2GUJ} \ln TN_{t-1} + \omega_{3GUJ} \ln MP_{t-1} + \omega_{4GUJ} \ln UP_{t-1} + \varepsilon_{4t} \quad (4)$$

Where,

Δ is the first difference operator, MP is prices of Maharashtra market, UP is prices of Uttar Pradesh market, TN is prices of Tamil Nadu market and GUJ is prices of Gujarat market, α_0 is drift component ε_{1t} ….. ε_{4t} is white noise, $\sum$ is a summation of error correction dynamics
σ, θ, ∅ and ω are long run relationships of among variables.

The F test was used to identify the long run relationship among variables in the equation. The null hypothesis for Eq. (1) is equal to zero, i.e. $H_0 = \sigma_{1MP} = \sigma_{2MP} = \sigma_{3MP} = \sigma_{4MP} = 0$, in contradiction of $H_1 \neq \sigma_{1MP} \neq \sigma_{2MP} \neq \sigma_{3MP} \neq \sigma_{4MP} \neq 0$, which is indicated as F_{MP}(MP/UP,TN,GUJ). Likewise for Eq. (2), $H_0 = \phi_{1UP} = \phi_{2UP} = \phi_{3UP} = \phi_{4UP} = 0$ against $H_1 \neq \sigma_{1UP} \neq \phi_{2UP} \neq \phi_{3UP} \neq \phi_{4UP} \neq 0$, which is denoted as F_{UP}(UP/MP, TN,GUJ) and so on.

The study adopted two sets of asymptotic critical F test value provided by [15] for decision in order of lag selection. One set assumes that inclusion of all variables are I (1) and another one is assumed to be I(0). In general, if the sample size is large, then the study has to follow [16] and the sample size is small then follow [17] critical F test value. The decision of cointegration-causality exists if computed F-statistics are higher than upper critical bounds; the decision of no cointegration is reached if the estimated F-statistics falls below the lower critical value; the decision of inconclusiveness is taken if computed test value lies between lower and upper critical bounds. In this circumstance, we can check the order of integration of included variables followed by [18] techniques to notice cointegration [14].

2.2 Granger Causality

Considering that a variable potato price in Tamil Nadu (*x*) is said to Granger-cause to another variable, i.e. prices of Maharashtra (*y*), it implies that there would be at least a unidirectional relationships [19] though these variables follow I(1) individually. If a variable *x* does not Granger-cause variable *y* then there would not be unidirectional or bidirectional causal relationships in the short run as well as long run. Thus, Granger-causality test is a suitable method to examine the causal relationship between two or more variables. If the cointegration (long run relationship) exists among the variables, then the short- run effects can be found by employing Vector Error Correction model (VECM). Unlike unrestricted vector autoregression (VAR), the VECM is a restricted VAR. This model treated all variables as endogenously differenced form; a number of equations must be equal to a number of variables. Eq. (5) include lags of dependent variable depend upon lags of independent and dependent variable, error correction term (EC) and error or white noise. An estimated error value may decline due to the inclusion of lagged *x* and *y* values in the model.

The VECM as follow

$$(1-B)\begin{pmatrix}\ln MP\\ \ln UP\\ \ln TN\\ \ln GUJ\end{pmatrix} = \begin{pmatrix}C_1\\ C_2\\ C_3\\ C_4\end{pmatrix} + \sum_{i=1}^{n}(1-\mathrm{B})\begin{bmatrix}d_{11i}d_{12i}d_{13i}d_{14i}\\ d_{21i}d_{22i}.....d_{24i}\\ d_{31i}d_{32i}.....d_{34i}\\ d_{41i}d_{42i}.....d_{44i}\end{bmatrix}\begin{bmatrix}\ln MP_{t-i}\\ \ln UP_{t-i}\\ \ln TN_{t-i}\\ \ln GUJ_{t-i}\end{bmatrix} + \begin{bmatrix}\kappa_1\\ \kappa_2\\ \kappa_3\\ \kappa_4\end{bmatrix}(\mathrm{ec}_{t-1}) + \begin{bmatrix}\gamma_{1t}\\ \gamma_{2t}\\ \gamma_{3t}\\ \gamma_{4t}\end{bmatrix} \quad (5)$$

Eq. (5) where B denotes as backward shift operator. The ec_{t-1} is an error correction term and k_1 to k_4 are the adjustment coefficients, indicating that how much disequilibrium is adjusted in the lagged period. d's are parameters to be estimated and γ_t's are serially uncorrelated random error terms (Ghosh, 2010). Both F-statistics and t-statistics were used for the lagged explanatory variables of the ECM to test the significance of the short-run and long-run causal effects respectively. The choice of optimal lag length of *p* was selected on the basis of Schwarz–Bayessian Information Criteria (SBC) and/or Akaike Information Criteria (AIC).The SBC criterion is applicable for selection of the smallest possible lag length, whereas the AIC criterion is adopted for selection of maximum relevant lag length.

Table 1. Summary statistics

	Tamil Nadu (TN)	Madhya Pradesh (MP)	Uttar Pradesh (UP)	Gujarat (GUJ)
Maximum	2733	2076	2086	2076
Minimum	376	211	147	326
Std. Dev.	450.044	325.016	374.796	386.912
Coefficient of variation (CV)	35.449	47.146	56.781	44.878
Skewness	0.927	1.345	1.484	0.917
Kurtosis	0.643	2.912	2.432	0.336

2.3 Data

Three major states, such as Maharashtra, Uttar Pradesh and Gujarat, which are supplying the majority of the potato marketed in Tamil Nadu were chosen for the market integration analysis. From each state, one major market was selected to collect price data which treated as the representative market in each state. Accordingly, Villupuram market was selected as a representative market for Tamil Nadu. Likewise, Udaipur in Rajasthan, Akola in Maharashtra, and Gadag in Karnataka were selected as the representative markets. Month wise time series data on potato prices were collected for the period between January 2005 and September 2016 from Domestic and Export Market Intelligence Cell (DEMIC), Tamil Nadu Agricultural University and AGMARKNET.

3. RESULTS AND DISCUSSION

3.1 Description of the Variables

Generally, large variation was observed in the prices of potato in all the four states during the last 11 years. Among the four states, Tamil Nadu (TN) has a smaller variation in the potato price (35.49 percent of CV) than other three states. The potato price in TN ranged from Rs.376 to Rs.2733. Higher price variation was observed in Uttar Pradesh (UP), followed by Madhya Pradesh (MP) and Gujarat (GUJ). The measure of skewness and kurtosis confirmed that prices of TN and GUJ are normally distributed, whereas potato prices in MP and UP are not normally distributed (Table 1).

3.2 Unit Root Test

ARDL bounds test does not require the order of integration for assessment of Granger-causality between variables of potato prices in different markets, however, Johansen–Juselius procedure need the order of integration. [20] stated that estimated F statistics would not be applicable when the order of integration is I(2) in the price variables. Hence, we first subject each time series to the ADF unit root tests. Unit root test and their order of integration was estimated by Augmented Dickey–Fuller (ADF) statistic and is presented in Table 2. In the tests, we include both constant and trend terms and employ the SIC for the optimal lag order in the ADF test equation. According to ADF unit root test, potato price in TN is non-stationary in level form and stationary in first difference (integrated of order 1). However, for the potato price in other states, the ADF test indicates its stationarity in level form. Since the tests indicate none of the variables is I(2), we can proceed with the bounds testing procedure.

Table 2. Results of unit root test

Variable	ADF (with constant)	ADF (constant and trend)
Level form		
Tamil Nadu	-1.945	-1.979
Madhya Pradesh	-3.466**	-5.492***
Uttar Pradesh	-4.358***	-5.353***
Gujarat	-3.353**	-4.773***
First difference form		
Tamil Nadu	-3.756***	-3.578***
Madhya Pradesh	-7.972***	-7.942***
Uttar Pradesh	-8.521***	-8.489**
Gujarat	-11.508***	-11.468***

Note: Double star indicates significant at P=0.05; triple star indicates significant at P=0.01

Table 3. Bound test for cointegration

Variable	Without time trend		With time trend		Conclusion
F_{TN} (TN/MP, UP, GUJ)	4.418		4.084		Cointegrated (long-run equilibrium exists)
F_{MP}(MP/TN, UP, GUJ)	14.70		14.56		Cointegrated
F_{UP}(UP /TN, MP, GUJ)	7.778		8.278		Cointegrated
F_{GUJ}(GUJ/TN, MP, UP)	13.381		18.378		Cointegrated
F-critical value at 5 %	**Level I(0)** 2.72	**Level I(1)** 3.77	**Level I(0)** 3.47	**Level I(1)** 4.45	

3.3 ARDL-Bounds Test

Accordingly, we estimate equations (1-4) and apply the general-to-specific procedure to arrive at the final model specification. ARDL bounds test follows two steps: i) as suggested by [15], the optimal lag order for cointegration was selected based on the Schwarz–Bayessian (SBC) information criteria and Akaike Information Criterion (AIC), ii) the presence of long-run relationships (cointegration) among the price variables were examined by using Eqs. (1)–(4). The maximum lag order considered is three. Table.3 reports the bounds F-statistics and Table 4 presents the model estimation results. The bounds F statistics suggested an optimal order of lag as one and it confirmed that there was no serial correlation between the selected lag lengths. Next, the presence of long-run relationship was found in price Eqs.(1-4). But our interest is that to find long-run equilibrium in the potato price of TN market (Eq.1). Ordinary Least Square (OLS) form in Eq.(1) is TN_{pp}(TN/MP, UP, GUJ) and their computed F test value is significant at five percent and higher than the upper bound critical value. Likewise, computed F test value for all the other equations (Eqs.2-4), where MP_{pp}, UP_{pp} and GUJ_{pp} are independent variables, were found to be significant at five percent level and higher than the upper bound critical value. It clearly implies that there was a long run relationship (cointegration) among the potato prices of all the states.

We computed the cointegrating and long-run equations for the TN potato price model. These are presented in Table 4. The long run coefficient of potato price in GUJ is positive and significant at 10 percent level. It suggests that one per cent increase in the potato price in the Gujarat market affects positively the potato price in the Tamil Nadu market by roughly 1.57 percent, holding the other market prices constant. Whereas changes in potato price in the markets of Madhya Pradesh and Uttar Pradesh show an insignificant impact on the potato price in Tamil Nadu.

Table 4. Long run relationship

Variables	Coefficients
Ln potato price in MP	0.250 (0.435)
Ln potato price in UP	-1.677 (1.015)
Ln potato price in GUJ	1.566* (0.866)
Constant	5.710*** (1.700)

Note: Figures in the parentheses are standard errors (SE); one star indicates significance at P=0.10; and triple start indicates significance at P=0.01

3.4 Vector Error Correction Model (VECM) and Granger Causality

Having a cointegration relationship in TN_{pp}, Error Correction Model (ECM) employed to assess short-run relationships among the variables in its equilibrium level. From Eq. (1) ΔTN_{pp}, the coefficient of the error correction term is negative (-0.0007) but not statistically significant (Table 5).

Granger-causality test results are also presented in Table 5. It shows that potato price in UP and GUJ is found to be statistically significant at five percent in the TN price equation. In the equation of MP, potato prices in TN and UP are significant at five and one percent level, respectively. No market potato prices influenced significantly the potato price in UP market. The Gujarat potato price was influenced by TN and UP market prices significantly. TN market potato price is

Table 5. Granger causality/block exogeneity Wald tests (chi-sq test)

Dependent variable	∆TN	∆MP	∆UP	∆GUJ	ECT(-1) (t-Statistics)
∆TN	-	0.888 (0.641)	7.131 (0.028)	7.769 (0.021)	-0.0007 (-0.591)
∆MP	6.986 (0.03)	-	25.578 (0.000)	0.543 (0.762)	0.009 (6.526)
∆UP	3.513 (0.173)	1.249 (0.535)	-	0.204 (0.903)	-0.001 (-0.769)
∆GUJ	21.137 (0.000)	2.072 (0.355)	24.309 (0.000)	-	0.0004 (0.284)
Autocorrelation (F statistics)	2.751 (0.067)				
Heteroskedasticity (F statistics)	0.791 (0.648)				
Normality (J-B) test	0.561 (0.755)				

Note: Figures in parenthesis indicate probability level

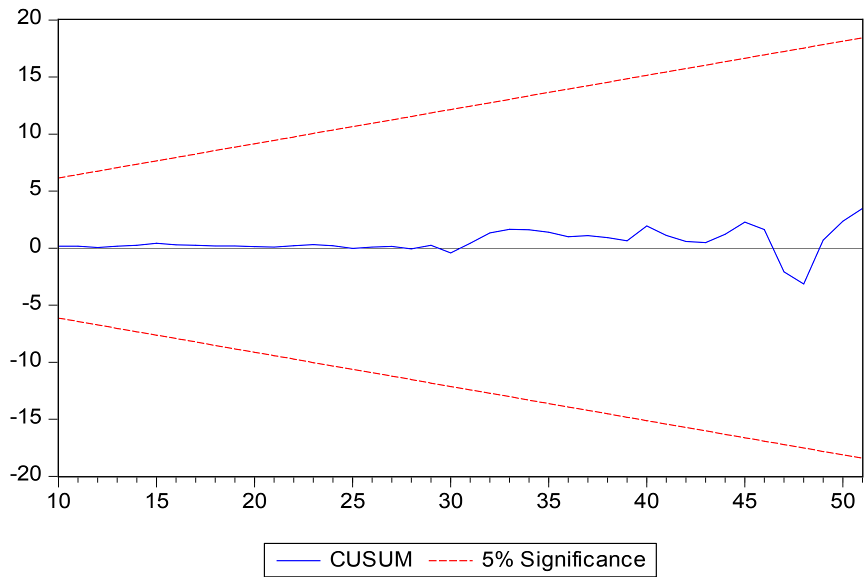

Fig. 1. Plot of CUSUM for the estimated ECM model

insignificant in the UP market equation, indicating that there exists only a unidirectional causality in the short run. Bi-directional causality existed between Tamil Nadu and Gujarat market prices of potato.

Further, the study adopted following diagnostics test such as serial autocorrelation, heteroscedasticity, specification bias on functional form and normality of residuals to estimate deviation from standard assumptions. The results of the all the tests are not statistically significant, indicating that model is appropriate. Finally, we used cumulative sum (CUSUM) to assess stability in the coefficient of estimated ECM. It was observed in Fig.1 that the coefficients were stable with 95 per cent critical bounds.

4. CONCLUSION

To conclude, there was a bidirectional relationship between Tamil Nadu and Gujarat potato markets. Change in these market prices of potato significantly affects each other in the short run. In the long-run, all the markets had equilibrium adjustment, indicating that there would be a cointegrating relationship among the potato markets in TN, MP, UP and GUJ. Specifically, in TN market, the percentage of the speed of adjustment towards equilibrium is very less. The outcomes confirm that Gujarat market significantly would affect the potato market in Tamil Nadu. It revealed that any increase in the potato price in Gujarat markets would cause higher prices for potato in Tamil Nadu. Therefore, adequate precaution measures have to be undertaken to overcome the shortage in arrivals and increased potato price. Further, the state should take an effort to increase potato production and storage facilities in time bound manner.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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