Does Technical Complexity Moderate the Relationship between Organization Structure & Firm-level Innovation?

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The study explores relationship between organization structure and perceived innovation, with moderating effect of technical complexity. Structure comprises centralization, concentration of authority, participation-in-decision-making and formalization. Innovation is measured by perceived innovation. A scale for perceived innovation has been designed and validated for the study. The sample consisted of 250 employees who responded to questionnaires, 171 in-depth interviews were also conducted. Data was analyzed using both statistical and qualitative techniques. Correlation, two-way-ANOVA, graphed simple effects and content-analysis were used to compute results. Positive relationship was found between participation-in-decision-making and perceived innovation, and formalization and perceived innovation. Negative relationship was found between centralization and perceived innovation. Technical complexity moderated the relationship between formalization and perceived innovation, and concentration of authority and perceived innovation.

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Introduction

The idea that there is a best structure or design for innovations is no more acceptable. Researchers do not seem to converge on a best one. Of late there has been less focus on what promotes innovation in manufacturing organizations, as services seem to dominate the interests of corporates, researchers and academia alike. The current study specifically focuses on what promotes innovation in the manufacturing industry. Many researches talk about how strategy or leadership or organizational support promotes innovations. However, very few researchers have expressed interest in how an organization's structure impacts innovation. Innovation not only includes development of new prod-

ucts and services, but also new operating practices, managerial tactics and even business strategies. It may not always be a process of creating, rather a process of building, improving and adapting (Youtie, Shapira, Slanina, Wang & Zhang, 2005). Therefore, organization structure is the most important factor inside an organization which has direct impact on innovations. Popular research has also not focused on whether structure's impact on innovation varies from one organization to another due to differences in technology, work processes etc. To be more specific, why a particular structural factor influences innovation in different ways across different industries? It is these gaps that the current research attempts to address.

Objectives of the Study:

- To study the relationship between components of organization structure and innovation.
- To study whether this relationship is moderated by technical complexity.
- To compare structure – innovation relationship across two manufacturing sectors.

Literature Review

Centralization & Innovation: Kanter (2004) also found innovative organizations to be decentralized. McNulty and Ferlie (2004) posit that innovations increasingly require decentralization today. Findings of Khandwalla and Mehta (2004) indicate that extensive decentralization helped innovations. Decentralization improves democratic decision-making, fosters responsiveness among employees, and enhances the ability of lower levels to influence management (Samaratunge, 2003) hence, facilitating innovations. Lee, Min, and Lee (2016) analyzed the effect of organization structure on innovation and found that decentralization fosters innovation, and a decentralized decision-making system promotes open innovation. Darvishmotevali (2019) found that decentralization promotes innovation in employees by inspiring creativity, initiative and risk-taking in them as a result of freedom for decision-making. On the basis of above researches the following hypothes is were generated.

Hypothesis1: Centralization has negative relationship with perceived innovation.

Hypothesis 2: Concentration of authority has negative relationship with perceived innovation.

Centralization has been conceptualized as a combined measure of concentration of authority and participation-in-decision-making.

Participation in Decision Making & Innovation: High levels of participation in decision-making leads to innovations even in the case of minority dissent (West & De Dreu, 2002). Khandwalla and Mehta (2004) found that decisions in innovative-organic structures emerged through participation of those involved in and affected by the decision directly. A study by Zubair, Bashir, Abrar & Baig (2015) concluded that participation in decision-making had a positive relation-

ship with employee creativity and also positive climate for creativity and change. On the basis of above, literature the following hypothesis was generated.

Hypothesis 3: Participation-in-decision-making has positive relationship with perceived innovation.

Formalization & Innovation: Use of formalization settles ambiguity and uncertainty. Greater autonomy and flexibility at implementation stage might be harmful for innovations according to Drach-Zahany, Somech, Granot and Spitzer (2004). Wijnberg, Ende and Wit (2002) report that formalization increases the accountability of decision makers towards each other and towards the organization as a whole. Some studies also concluded that formalization had a negative impact on innovation. However, their argument cannot be accepted without question as formalization may assist a different form of innovation (Kalay & Lynn, 2016). In their study they found that formalization has positive effects on administrative innovations, technological product innovations. On the basis of the above researches the following hypothesis was generated.

Hypothesis 4: Formalization has positive relationship with perceived innovation.

Formalization has positive effects on administrative innovations, technological product innovations.

Technical Complexity & Innovation: Technical complexity led to rapid innovation according to Kash and Rycroft (2004). High level of job complexity in technically complex organizations provides plenty of opportunities for innovation. Sharma (2000) found that a high technical complexity was the key driver of innovations in the chemical industry. Vedamanickam (2001) found positive correlation between technical complexity and innovation. The Pharmaceutical sector according to Quere (2003) was characterized by constant transitions from maturing technology to radically new technologies. He says major technological breakthroughs of the 20th century have come from incorporation of in-house R&D capabilities (from fermentation to organic chemistry) in pharmaceutical firms. Ramirez and Tylecote (2004) found that pharmaceutical companies compared to others are characterized by high number of innovations. Their success strongly depends on their ability to launch new products on a regular basis. On the basis of above findings, the following moderating hypotheses were generated:

Hypothesis 5: Technical complexity moderates the relationship between formalization and perceived innovation.

Hypothesis 6: Technical complexity moderates the relationship between centralization and perceived innovation.

Hypothesis 7: Technical complexity moderates the relationship between participation in decision making and perceived innovation.

In a study of 339 organizations, Bart (2004) measured firm-level innovation by

asking respondents to indicate: How innovative they perceived their organizations to be (using a 10-point scale). How important innovation was to their organizations (using a 10-point scale).

Perceived innovation that the present study measures is similar to Bart's (2004) measure of firm-level innovation. The variable measures employee perceptions of how innovative they consider their organization, the extent to which activities and processes in their organization encourage and promote innovations.

Literature studying perceived innovation is either not available or might be rare. Hence, it may be considered as a new concept, a contribution of the current study. In the present study perceived innovation has been included as a measure of innovation, the other measure being perceived number of innovations.

Research Methodology

Organization Structure: The independent variables are centralization, concentration of authority, participation in decision-making, formalization.

Perceived Innovation: The dependent variable portrays employee perception of how innovative they consider their organization is. The measure includes employee perceptions of the organization's overall approach to innovation. Perceived innovation has been measured using a scale designed by the researcher and validated for the purpose of this study only.

Perceived Number of Innovations: Refers to the total number of innovations introduced by the organization in a time-duration of 7 years. It includes innovations happening at all levels of production, in any functional unit. This data was collected from employee interviews. Each innovation that employees mentioned was listed by the researcher verbatim. Employees were asked to indicate the contribution of each innovation mentioned to the organization. After evaluation by senior management, the list of innovations quoted by employees was finalized.

Technical Complexity: The moderating variable in the study; refers to the extent to which technology operating in a firm is advanced, automated, elaborate and complex. It forms a scale or continuum along which technology types vary in their chronological order of development, from the simplest and the most conventional to the most advanced, automated and complex. According to Woodward's (1980) categorization, companies undertaking production of units to customer requirements or *One-Off* production are lowest in technical complexity (heavy engineering industry in the study). Companies using continuous-process-flow production of dimensional products are highest in technical complexity (pharmaceutical/chemical industry sector in the study).

Test Instruments: Data was collected using four inventories:

Centralization Scale: The centralization scale is formed by combining two

scales, one for 'concentration of authority', and the other for 'participation in decision-making'. The entire instrument had 8 items, 4 items from each of the two scales, both rated on a 5-point rating scale. The values on the scale varied in intensity from 1-never to 5-always.

Delegation of Authority Scale: Designed by Daftaur, cited in Pestonjee (1988: 233-34), this scale measures concentration of authority. It is a 5-point rating scale from 1-never to 5-always. Lower the concentration of authority score of an individual higher the centralization score and vice versa. Cronbach's alpha coefficient of reliability =.95

Scale for Personal Participation in Decision-Making: Hage and Aiken's scale cited in Miller (1977: 287-89) was used to measure participation-in-decision-making. It is a 5-point rating scale, from 1-never to 5-always.

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The criterion validity measure used was 'autonomy'. Organizations in which decisions were made by only a few people at the top, relied on rules and close supervision as a means of ensuring consistent performance by the workers. The presence of a well-trained staff is related to a reduced need for extensive rules. Organizations that are highly autonomous tend to have a non-participative internal decision structure. Greater the autonomy, larger is the executive's span of control.

Formalization Inventory: Formalization was measured by Hage and Aiken's Formalization inventory cited in Miller (1977: 284-86). This scale consisted of 15 items to be rated on a 4-point rating scale, from 1-definitely true to 4-definitely false. The criterion validity of the scale has been given, the criterion measure used was 'Alienation'. Formalization is positively related to 'alienation'. Greater the degree of formalization in the organization, the greater the likelihood of alienation from work. Dissatisfaction with work is high in organizations where jobs are rigidly structured. Strict enforcement of rules was strongly related to work dissatisfaction. Social relations are also disturbed when rules are strictly enforced. Significant positive relationships were found between routine work and rule manual, job description and specificity of job descriptions.

Scale for Perceived Innovation: Perceived innovation was measured by a scale designed by the researcher. It assessed how innovative employees perceive their organization to be. It also assessed employee attitudes of the organization's approach towards innovations. It consisted of 20 items, to be rated on Likert-type 5–point rating scale from 'strongly disagree' to 'strongly agree'. On an item, a score of 5 indicated highest score while 1 indicated lowest score. Each item was written in both English and Hindi. Some of the items in the perceived innovation inventory were as follows, "My organization is in a constant effort to improve its products through innovations", and "My organization's policies and procedures facilitate process inno-

vations at all stages of production". Test-retest reliability was .86. Internal consistency validity calculated by the inter-item consistency method was .90.

The Interview Schedule: In-depth interviews were used to supplement questionnaires for data-collection. Interview data was analyzed using content-analysis.

Description of Sample

A convenient sample of 250 employees from 4 manufacturing organizations of India were selected for data collection. Two organizations from the pharmaceutical/chemical industry (N=130) and two from heavy engineering industry (N=120) were studied. All 250 employees responded to questionnaires. 171 employees were subject to in-depth interviews, 78 from pharmaceutical and 93 from heavy engineering industry. Results were categorized into three parts: for the overall sample (N=250), for the pharmaceutical sector (N=130) and for the heavy engineering sector (N=120). Results computed for the overall sample (N=250) was used to support the hypotheses. Data was analyzed using correlation, two-way-ANOVA, graphed simple effects and content analysis.

Correlation Results

Overall sample (N=250): Formalization shows positive and significant relationship with perceived innovation (r = .38, p<.01). Centralization shows negative and significant relationship with perceived innovation (r = -.13, p<.05). Relationship between concentration and authority and perceived innovation is not significant, however, is in the desired negative direction. Participation in decision-making shows positive and significant relationship with perceived innovation (r = .19, p<.05).

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Pharmaceutical (N=130): No significant relationship was obtained between formalization and perceived innovation. Centralization shows negative and significant relationship with perceived innovation (r = -.28, p<.01). Concentration of authority shows negative and significant relationship with perceived innovation (r = -.30, p<.01). Participation in decision-making shows positive and significant relationship with perceived innovation (r =.20, p<.05).

Heavy Engineering Sector (N=120): Formalization shows positive and significant relationship with perceived innovation (r = .46, p<.01). Relationship between centralization and perceived innovation is in the desired negative direction, however, is not significant. Concentration of authority shows positive and significant relationship with perceived innovation (r = .20, p<.05). Participation in decision-making shows positive and significant relationship with perceived innovation (r = .17, p<.05).

Table 1 shows the two-way-ANOVA findings for moderating effect of techni-

cal complexity between structure components and perceived innovation. Interaction effects of technical complexity and formalization, and technical complexity and concentration of authority are significant. Hence, technical complexity is moderating the relationship between formalization and perceived innovation, and between concentration of authority and innovation.

Table 1 Two – Way ANOVA: Main & Interaction Effects with Perceived Innovation

Variables	Sum of Squares	Df	Mean Squares	F – Ratio
Formalization	1063.31	1	1063.31	F = 11.01**
Technical Complexity	869.30	1	869.30	F = 9.01**
Interaction Effect	814	1	814	F = 8.43**
Within Group	23748.75	246	96.54	
Centralization	174.74	1	174.74	F = 1.70
Technical Complexity	1210.94	1	1210.94	F = 11.76**
Interaction Effect	195.56	1	195.56	F = 1.90
Within Group	25342.65	246	103.02	
Concentration of Authority	86.16	1	86.16	F = .88
Technical Complexity	6.67	1	6.67	F = .07
Interaction Effect	1617.26	1	1617.26	F = 16.59**
Within Group	23982.57	246	97.49	
Participation in Decision Making	528.30	1	528.30	F = 5.16*
Technical Complexity	1539.48	1	1539.48	F = 15.04**
Interaction Effect	39.39	1	39.39	F = .39
Within Group	25183.08	246	102.37	

Note: N = 250 *p<.05 **p<.01

Fig. 1 Interaction Effect of Technical Complexity between Formalization and Perceived Innovation

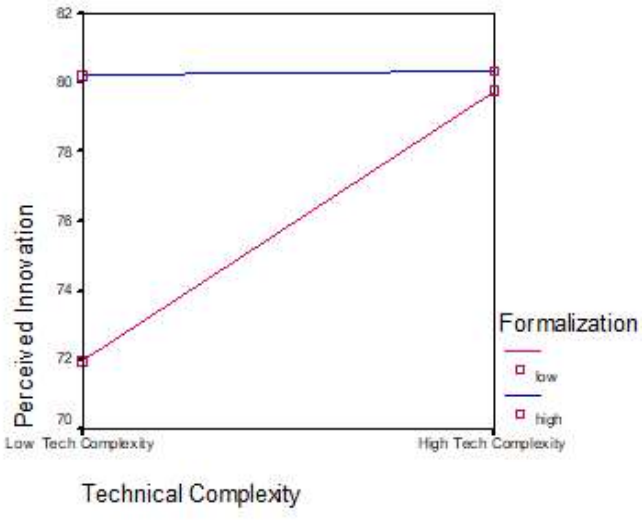

Fig. 1 shows the interaction effect of formalization and technical complexity. It shows almost no difference in the perceived innovation scores of employees scoring high on formalization, in organizations with low technical complexity and organizations with high technical complexity. Fig. 1 also shows that perceived innovation scores of employees scoring low on formalization increase with an increase in technical complexity. The two slopes appear to meet indicating an interaction effect. The slopes depict simple effects of formalization and technical complexity. In the interaction profile, the two slopes of low and high formalization depict simple effects at each of the two levels of technical complexity.

Fig. 2 Interaction Effect of Technical Complexity and Concentration of Authority in relation to Perceived Innovation

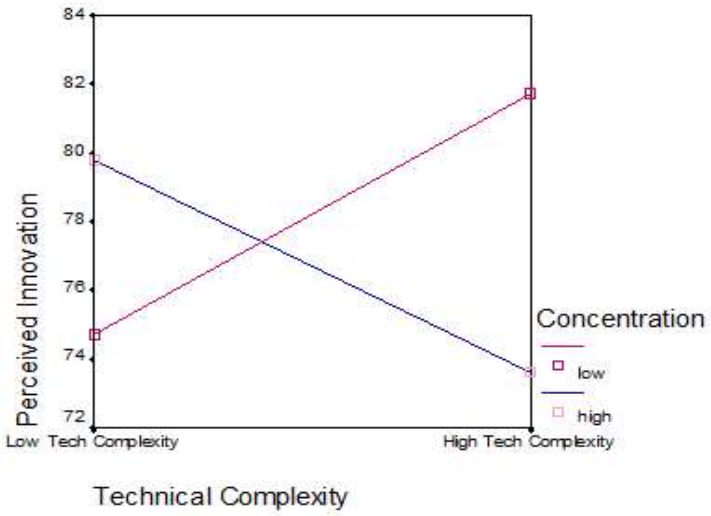

Fig. 2 shows the interaction effect of concentration of authority and technical complexity. The figure indicates that perceived innovation scores of employees scoring high on concentration of authority decrease with an increase in technical complexity. The figure also indicates that perceived innovation scores of employees scoring low in concentration of authority increase with an increase in technical complexity. The two slopes intersect, showing a moderating effect of technical complexity. The slopes of interaction also depict simple effects of concentration of authority and technical complexity. In the interaction profile, the two slopes of low and high levels of concentration of authority show simple effects at each of the two levels of technical complexity.

Centralization and participation-in-decision-making appear as more powerful factors influencing innovations, as they have similar effects on innovation, irrespective of technical complexity. Effect

Effect of formalization and concentration of authority on innovations is moderated by technical complexity.

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Qualitative Results

Overall Sample (Total Number of Innovations, N=171): Number of innovations at input level was 76, at throughput level was 568, and at output level were 217. Total number of innovations was 861.

Pharmaceutical Sector (N=78): Number of innovations at input level was 29, at throughput level 331 and at output level was 130. Total number of innovations was 490.

Heavy Engineering Sector (N=93): Number of innovations at input level was 47, at throughput level was 237 and at output level was 87. The total number was 371.

Relationship between Structural Variables & Innovation

Centralization: For the overall sample, 76.02% employees said that a low level of centralization led to high number of innovations. For the pharmaceutical sector, 74.30% supported the finding. For the heavy engineering sector, 77.42% gave similar responses.

Concentration of Authority: For overall sample, 64% said that a low level of concentration of authority led to high number of innovations. For the pharmaceutical sector, a very high 83.33% supported the negative relationship. However, for the engineering sector only 47% supported the finding.

Participation in Decision-making: For the overall sample, 84.80% (a high majority) employees said that high participation in decision-making led to high number of innovations. The finding was supported by 88.46% of pharmaceutical sector employees and 82% engineering sector employees.

Formalization: For the overall sample, 69%, a majority say that a high level of formalization leads to high number of innovations. For the pharmaceutical sector, 54% had similar responses. For the heavy engineering sector, a very high majority (81.72%) supported the positive relationship.

*Technical Complexity: 7*4.85% from the overall sample, 78.21% from the pharmaceutical sector and 72.04% from the heavy engineering sector supported a positive relationship between technical complexity and number of innovations.

Discussion

Findings conclude that centralization has a negative relationship with perceived innovation. Hypothesis 1 and 2 has been supported. Senior management reports in their interviews that decentralization allows an organization to rapidly and eas-

ily adapt to changing environmental conditions resulting from market competition. This helps innovation since decision-making is faster. Empowered employees can take control of their tasks and accomplish tasks in novel ways, promoting creativity and innovation.

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Most employees across other management levels also express similar views. They said that with decentralization came greater flexibility of decision making, so for every decision, employees did not have to wait for long. Employees were free to prioritize and time their work to suit themselves. For every work they did not have to consult or depend upon senior levels. As a result, implementation of innovations was also speeded up. For employees interviewed, decentralization was positive for both initiation and implementation of innovations.

Participation in decision-making shows positive relationship with perceived innovation. Hypothesis 3 has been supported. Employees said when ideas come from various levels and are then discussed in groups representing different functions and hierarchical levels; it is definitely an enriching exercise for innovations. Not only does an idea become rich technically in content, but its overall market impact is also discussed in participative environments. Ideas that are found weak are rejected and decision-making is speeded up. Participation is helpful for both idea-generation and implementation according to employee interviews. The senior management said that by facilitating innovations participation in decision-making helps the organization to compete with other firms in the challenging business environment.

Formalization shows positive relationship with perceived innovation. Hence, hypothesis 4 has been supported. Employees interviewed argued in favor of positive relationship between formalization and innovation. They said that rules and procedures create discipline and responsibility among employees. Rules were important in functioning of cross-functional product teams, for reaching targets/deadlines and in coordination of experts from different functions. Formalization also helped to maintain quality standards. Hence, formalization can assist innovations.

Technical complexity shows significant relationship with perceived innovation. According to employees interviewed, high technical complexity helps innovation, as it equips an organization and its employees with more advanced, automated and sophisticated techniques. Hence, there are greater opportunities for R&D, and development of the process and product line. With high technical complexity processes are eased and speeded up, and there is better control over work processes. The result is that employees get more time to reflect and discuss technical and administrative aspects of production. It breeds multiskilling which increases innovative potential of employees.

Moderating Effect of Technical Complexity between Formalization & Perceived Innovation

A highly significant interaction effect of technical complexity and formalization shows a significant moderating effect of technical complexity, in the relationship between formalization and perceived innovation. Thus, hypothesis 8 has been supported by the findings. Difference in correlations across the two sectors provide the evidence. Formalization has a significant and positive effect on innovations when technical complexity is low. When technical complexity is high, formalization does not exercise significant effect on innovations. With increasing technical complexity, the positive effect of formalization on innovations decreases.

According to employee interviews of the heavy engineering sector (low technical complexity), it was important for their organizations to be formalized because their production system was labor intensive (semi-automated). Therefore, rules were important for coordination of functional experts working in cross-functional teams. Product deadlines had to be met with labor assisted technology, especially because the products were customized.

Moderating Effect of Technical Complexity between Concentration of Authority & Perceived Innovation

A highly significant interaction effect of technical complexity and concentration of authority shows significant moderating effect of technical complexity, in the relationship between concentration of authority and perceived Innovation. Evidence has been provided by the difference in correlations. For the pharmaceutical sector (high technical complexity), highly significant negative relationship has been found between concentration of authority and perceived innovation. A positive and significant relationship between the two variables has been obtained for the heavy engineering sector (low technical complexity). Thus, when technical complexity is low, concentration of authority is facilitating innovation; while when technical complexity is high, concentration of authority is inhibiting innovation.

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Support is provided by employee interviews. Employee interviews show that the average skill level and experience of supervisory staff in the engineering sector were low. Many supervisors were fresh diploma holders. Hence, these supervisors were not considered equipped to take decisions without consulting their seniors. As a result, concentration of authority became important. Employees from the pharmaceutical sector, on the other hand, expressed that concentration of authority had to be kept low in their organization, because decision-making had to be fast. They did not have the time

to wait for the decisions to come down from higher levels because of their uninterrupted production process. By the time the decision traveled, already much harm would be done to the material and equipment. The material used in reactions was mostly highly decomposable. Also, many of the supervisory staff was skilled and experienced. High technical complexity made it necessary for the organization to employ labor of high skill level. Many of them had long work-experience in the organization. The average age of these supervisors was high in comparison to the average age of heavy-engineering firm supervisors. Hence, supervisors in pharma sector were considered reliable for decision-making.

Contributions

1. This single study explores effect of four structure variables (centralization, concentration of authority, participation-in-decision-making and formalization) on innovation.
2. Innovation measures in the study are perceptual. Perceived innovation is measured by a scale designed by the researcher and validated for the purpose of this study only. This scale is one of its kind, since it is difficult to find a documented counterpart in available literature.
3. The total number of innovations (perceived) has been recorded through in-depth interviews of 171 employees during a span of 7 years. Each innovation reported by employees was listed verbatim by the researcher. The list of innovations was finalized by senior management of organizations studied. The entire process was exhaustive and lengthy.
4. Contrary to popular research this study hypothesizes a positive relationship between formalization and innovation. It highlights the potential in formalization to facilitate the implementation rather than idea-generation process of innovations.
5. The study explores the moderating effect of technical complexity in the relationship between organization structure components and innovation. There is hardly any evidence in the available literature of such a finding.

Implications & Suggestions

The study builds strong support for decentralization and participation in decision-making for innovations, it also builds support for formalization and innovation, but only in one type of industry which is labor-intensive. The study hence supports intrapreneurship, which is picking up in global organizations. Firms should encourage formation of 'informal networks' within the organization so that intrapreneurs can be encouraged to promote and develop their unique ideas with the help of their preferred networks. Organization has to provide a conducive environment within its boundaries to nurture employees as change agents. Such employees are self-motivated and skilled, they require an ideal system to work their way forward for innovations. It is time every organization should understand the gravity of

having open, decentralized and participative systems.

Firms could also introduce alternate or parallel designs to suit an innovation goal, like temporary or partial matrix, to take care of new-product-development or new-process-development. The Ambidextrous approach which is mainly driven by high degrees of empowerment, is also a solution to the innovation problem. Today if an organization strives to thrive for a longtime, there is no substitute to innovations.

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