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Résumé de l'article

Les contributions aux études sur la négociation collective sont fondées soit sur une analyse verbale qui comprend l'idée d'une zone d'indétermination, soit sur une analyse davantage quantitative qui repose sur les techniques de la théorie du jeu. Les deux groupes recourent essentiellement à des modèles statiques comprenant des variables qui changent peu. L'expérience indique, cependant, qu'une même suite d'événements peut mener d'un comportement de départ ferme à des changements brusques et dramatiques d'attitudes. Mathématiquement, de tels phénomènes ne sont pas «sages» (well-behaved) et de pareilles «manques de suite» conduisent à des problèmes insolubles. Un tel mode de comportement ressortait de la plupart des modèles jusqu'à ce que René Thom invente la trouvaille mathématique analytique connue sous le nom de théorie de la catastrophe, théorie que l'on applique dans plusieurs sciences, y compris, à l'heure actuelle, en économique.

La théorie de la catastrophe la plus usitée est la catastrophe de «pointe», et c'est cette dernière qu'on applique dans le présent article. L'idée fondamentale en est qu'un syndicat, du moment où il entreprend la négociation d'une convention collective, peut s'y engager sans beaucoup de conviction, mais il peut soudainement changer de position. S'il doit affronter simultanément des risques considérables et de fortes provocations, il peut devenir très docile ou, tout à coup, très agressif. L'attitude qu'on prend dépend pour beaucoup des opinions qui prévalent à l'intérieur du syndicat immédiatement avant le changement draconien dans le comportement du groupe.

La «frontière» qui sépare un comportement docile d'un comportement agressif de la part du syndicat est en réalité un «territoire». Le changement dramatique d'attitude ne se produit qu'après que le «territoire» est traverse. Une suite de petits changements en influant sur les variables peut avoir pour résultat un grand bouleversement (une catastrophe) dans le comportement du syndicat.

A Catastrophe Theory of Union Behaviour

Byron Eastman

This paper develops a catastrophe model of union behaviour. It presents an explanation of the unexpected character of some work stoppages as well as for the breakdown of negotiations which appeared headed for resolution.

One group of important contributions to the literature on collective bargaining, as exemplified by Stagner and Rosen[1], Cassel and Baron[2], and Gellerman[3], chooses as a source model that of Pigou[4] which incorporates the concept of the range of indeterminateness. Another group of contributions comes from those applying the principles of game theory — Harsanyi[5], Moreley and Stephensen[6], and Siegal and Fouracker[7]. The former group use largely verbal descriptions in their models; the latter are more quantitative in their approach. Both groups discuss models that are essentially static and, more importantly, fail to specify the conditions leading to the often observed sudden and dramatic changes in the behaviour of unions.

These models incorporate a bargaining range or range of indeterminateness represented by an overlap between the union's and management's expectations. Figure 1 illustrates the general idea of such models.

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1 R. STAGNER and H. ROSEN, *Psychology of Union Management Relations*, Belmont, California, Wadsworth, Inc., 1965.

2 F.H. CASSELL and J.J. BARON, *Collective Bargaining in the Public Sector*, Columbus, Ohio, Grid Inc., 1975.

3 S.W. GELLERMAN, *Managers and Subordinates*, Hinsdale, Illinois, The Dryden Press, 1976.

4 A.C. PIGOU, *The Economics of Welfare*, (2nd ed.), London, Macmillan and Company, 1933.

5 J.C. HARSANYI, *Rational Behaviour and Bargaining Equilibrium in Games and Social Situations*, Cambridge, Cambridge University Press, 1977.

6 I. MORELEY and G. STEPHENSEN, *The Social Psychology of Bargaining*, London, George Allen and Unwin, 1977.

7 S. SIEGEL and L. FOURACKER, *Bargaining and Decision Making: Experiments in Bilateral Monopoly*, New York, McGraw-Hill Book Co., 1960.

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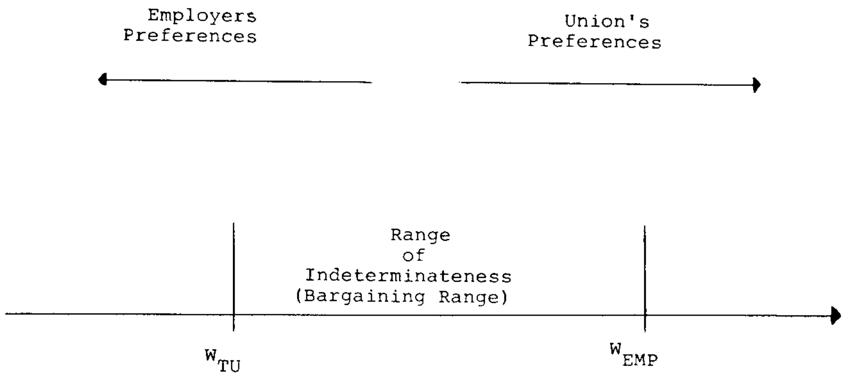
FIGURE 1



The employer's preferences grow with movement to the left on the wage line. The union's preferences increase with movement to the right — higher wages. Somewhere along the continuum represented by the wage line is a minimum offer acceptable to the union, W_{TU}. At another point on the wage continuum is the maximum wage the firm will offer, W_{EMP}. If W_{TU} is greater than W_{EMP}, there is no bargaining range and a strike or lockout is likely. But if W_{TU} is less than W_{EMP}, as in Figure 1, then bargaining will take place. According to these models the final negotiated wage will depend on the relative bargaining strengths of the union and the employer.

Such models suggest that if there is a bargaining range then a solution is easily arrived at through the negotiation process. The problem is that the relatively static nature of the models precludes discussion and analysis of the dramatic changes in the behaviour of unions *during* the bargaining process. The evidence suggests that a common sequence of events leads from preliminary, stable behaviour to sudden, dramatic changes in behaviour. Another difficult feature for these models to handle concerns the actual dynamics of the change — a sequence of small changes individually has no major effect; but the «straw that breaks the camel's back» has a major effect on behaviour, *even though it is of the same size as the other changes.*

The analyses of union behaviour presented by the two aforementioned groups are ideal for phenomena which are continuous and «well-behaved». Phenomena which are divergent and filled with discontinuities have until very recently proved at best, troublesome, and at worst, intractable. The recent innovation in modelling which has ameliorated such problems is the invention of René Thom[8] who devised a method to deal with special types of biological processes. The potential for Thom's ideas in other fields was explored by Zeeman[9] who also provided the major thrust for their dissemination. Because they deal with abrupt, qualitative, discontinuous change, Thom said his ideas dealt with *catastrophes* — catastrophes in a very broad sense: the bursting of a balloon, the jump of electrons from one energy level to another, the crash of a stock market, and so on.

Catastrophe theory has been applied by many disciples[10]. In physics, for example, Berry[11] has used catastrophe theory to both describe and predict the shapes that appear in natural as well as artificial caustics. Thompson and Hunt[12] were able to predict the multiple failure modes resulting in the buckling of beams, girders and panels used in engineering applications. Kozak and Benham[13] modelled the biochemical phenomenon of denaturation and were able to make accurate quantitative predictions of this transition in molecular form.

In economics, its applications have been limited: Varian[14] has used it to examine the behaviour of the business cycle; Balasko[15] has reexamined the concept of economic equilibrium in the light of catastrophe theory; and Zeeman[16] has used it to explain the unstable behaviour of stock exchanges.

This paper develops a catastrophe model of union behaviour. It presents an explanation of the unexpected character of some work stoppages as well as for the breakdown of negotiations which appeared headed for resolution.

8 René THOM, *Structural Stability and Morphogenesis* (translated by D.H. Fowler), New York, Benjamin Addison Wesley Publishing Co., 1975. Translation of René Thom, *Stabilité structurelle et morphogénèse with additional material.*

9 E.C. ZEEMAN, *Catastrophe Theory: Selected Papers 1972-1977*, Reading, Mass., Addison-Wesley Publishing Co., 1979.

10 See, for example, W. GUTTINGER, «Catastrophe Geometry in Physics and Biology», *Physics and Mathematics of the Nervous System*, Lecture Notes in Biomathematics 4, New York, Springer, 1974, pp. 2-30.

11 M.V. BERRY, «Waves as Catastrophes», *Physics Bulletin*, March, 1976.

12 J.M.T. THOMPSON and G.W. HUNT, *A General Theory of Elastic Stability*, London, Wiley, 1973.

13 J.J. KOZAK and C.J. BENHAM, «Denaturation: An Example of a Catastrophe», *Journal of Theoretical Biology*, Vol. 63, 1976.

14 Hal. R. VARIAN, «Catastrophe Theory and the Business Cycle, *Economic Inquiry*, Vol. XVII, Jan. 1979, pp. 14-28.

15 Yves BALASKO, «The Behaviour of Economic Equilibria: A Catastrophe Theory Approach», *Behavioral Science*, Vol. 23, 1978, pp. 375-382 and Yves BALASKO, «Economic Equilibrium and Catastrophe Theory: An Introduction», *Econometrica*, Vol. 46, No. 3, 1978, pp. 557-569.

16 E.C. ZEEMAN, «On the Unstable Behaviour of Stock Exchanges», *Journal of Mathematical Economics*, Vol. 1, 1974, pp. 39-49.

A CATASTROPHE MODEL

The catastrophe model describes phenomena which behave discontinuously. If more than one stable state is possible in a system then the transitions from one stable state to another are called catastrophes. The simplest ways for these transitions or «jumps» to occur are called the elementary catastrophes, of which there are seven, varying in mathematical complexity and geometric representation. The simplest catastrophe is a fold catastrophe. Next in complexity is the cusp catastrophe, the most popular.

These two catastrophes are representable graphically and are easy to visualize — a maximum of three dimensions are used. Higher level catastrophes such as the butterfly, swallowtail, hyperbolic, elliptic and parabolic umbilic use from four to six dimensions and are not so easily visualized.

Each of the catastrophe models illustrates the stable states as a set of lines, points or surfaces in a behaviour space. As long as the system under examination is stable its behaviour is continuous. But should it leave the stable state, the resulting instability will only settle again at some distant point.

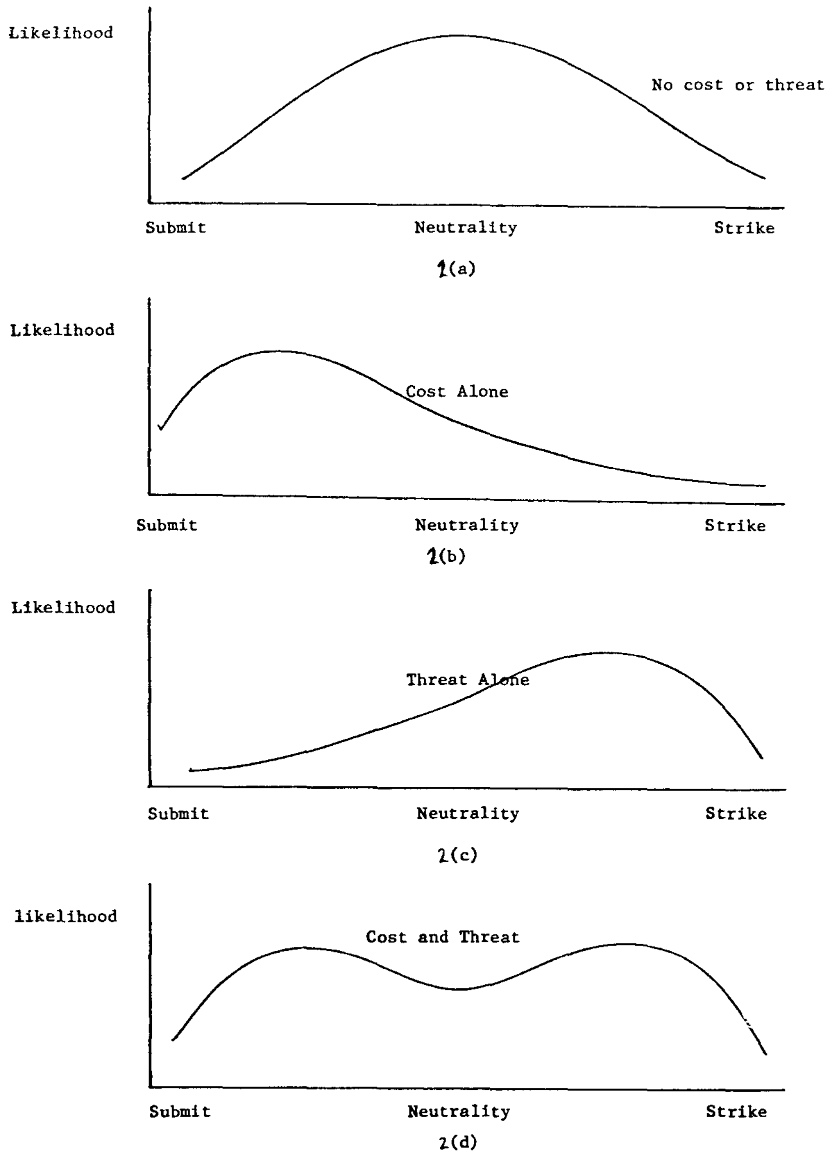
The graphs depicting the catastrophes are rich with information about causes and effects. By far the most popular catastrophe is the cusp catastrophe. It is used here to describe union behaviour.

A CUSP CATASTROPHE MODEL OF UNION BEHAVIOUR

The interaction between employers and employees can be described by a catastrophe model to illustrate how *gradual* changes in certain variables can lead to sudden *large* variations. The elementary catastrophe known as a «cusp» catastrophe illustrates the behaviour of a union and is useful for providing qualitative understanding. The cusp is the end result of the interaction of two control variables on a behaviour variable. The result is a three-dimensional surface representing the behaviour of the union.

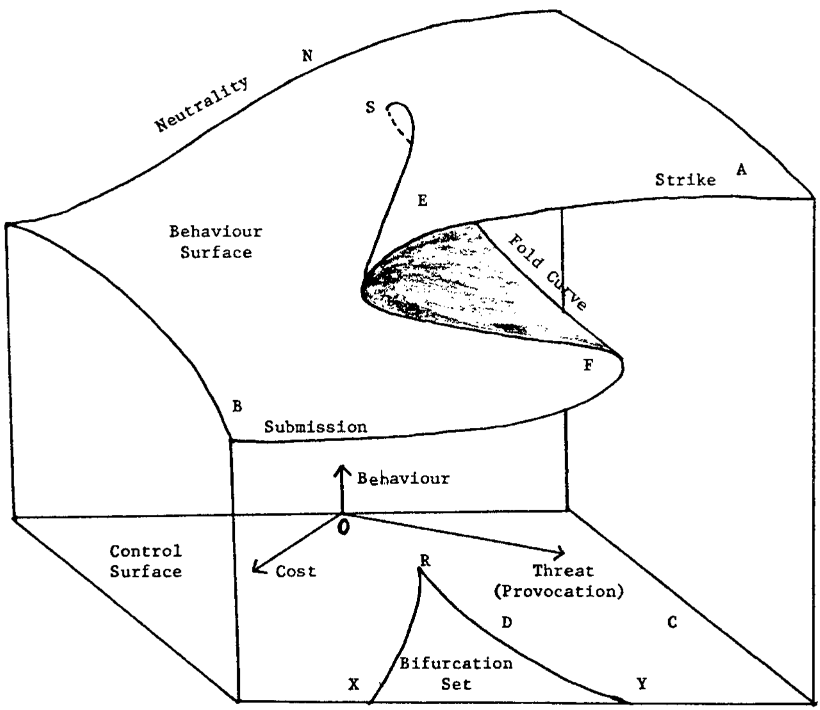
Consider the behaviour of a union in the process of negotiating an employment contract. A cusp catastrophe model would have *cost* and *threat* as the two control variables. It is possible to formulate a likelihood function to illustrate the behaviour of a union under the counteracting forces associated with the cost and threat variables. Four possible sets of circumstances are illustrated in Figure 2.

FIGURE 2


Likelihood
No cost or threat
Submit
Neutrality
Strike
2(a)
Likelihood
Cost Alone
Submit
Neutrality
Strike
2(b)
Likelihood
Threat Alone
Submit
Neutrality
Strike
2(c)
likelihood
Cost and Threat
Submit
Neutrality
Strike
2(d)

When there is neither a cost nor a threat, as in Figure 2(a), the union will behave in a neutral fashion. The imposition of a cost on a union will lead to submissive behaviour with the resulting acceptance of the contract as is. This would be the case if the cost were seen as so extraordinary that the best possible action is agreement to the terms of the contract. This is illustrated in Figure 2(b). On the other hand, a sufficiently great threat may have the effect of angering the union leadership, as well as the rank and file, to the extent that the union undertakes strike action, as in Figure 2(c). Lastly, and the case in which catastrophe theory is most revealing, the imposition of a high cost simultaneously with a large threat will produce an uncertain outcome. The union will either concede and accept the contract or it will strike. Which action is chosen and why is best illustrated through the use of the *cusp* catastrophe illustrated in Figure 3. The two control variables, cost and threat, provide the control surface when plotted as two axes in a horizontal plane. The behaviour of the union is shown on the behaviour surface which represents the third dimension in the diagram.

FIGURE 3



Union behaviour is assumed to be representable by a smooth continuum from submission (agreeing to the contract for defensive reasons, e.g., fear) to strike action. The more aggressive the action, the higher the point on the behaviour axis. For most points on the behaviour surface there is only one likely behaviour; there is a one to one correspondence between the control surface and the behaviour surface. But for some combinations of cost and threat the behaviour surface folds over and there are two possible behaviours — submission or strike. These bimodal behaviour possibilities occur when the values of cost and strike are fairly large and nearly *equal*.

To use catastrophe theory to predict the behaviour of a union entering into contract negotiations, consider its reaction to changes in the control variables. Suppose initially the union feels neutral — it has no strong feelings about agreeing to a new contract nor to striking in support of some demands — it is taking a «wait and see» attitude. If the management bargaining team begins to provoke the union without affecting the cost variable, the union's behaviour will change smoothly towards strike action. If provoked enough, the union will strike. (This is illustrated in Figure 2(c) and as point *A* in Figure 3.)

From this strike position assume the union is faced with increasing costs represented diagrammatically as a move toward the center of the control surface from a point like *C* towards *D*. (On the behaviour surface this is illustrated as a move from *A* towards *E*.) Notice that the slope of the behaviour surface is small for this move and hence the union remains militant with its basic stance remaining relatively unchanged. However, increasing costs moves the union to the edge of the pleat in the behaviour surface. Further increases in the cost variable push the behaviour over the edge and the union experiences a sudden, large change in attitude. The «value» of the behaviour falls directly to the bottom sheet. The aggressive posture of the union is no longer possible and the union experiences a sudden, catastrophic change in attitude — it becomes more submissive.

Consider the behaviour that arises from the opposite set of initial circumstances. If the costs faced by the union are large, it will be submissive and agreeable to contract terms. But as threats are increased from this relatively meek position, there will come a point where there will be a catastrophic jump in behaviour from meekness to aggressiveness and a strike will ensue. This would correspond to a movement from a point like *B* to one such as *F* in Figure 3. Initially, the union still behaves in a subdued fashion because the slope of the behaviour sheet from *B* to *F* is very shallow. But further threats may push the union over the edge, but this time in the opposite direction. The behaviour of the union jumps from the lower sheet to the upper sheet and aggressive behaviour is displayed. Therefore, even an accomodating, moderate union may become suddenly aggressive when faced with steadily increasing threats.

In the case of a union which begins initially at a neutral position and then experiences simultaneously increasing costs and threats, the behaviour of the union remains neutral for low levels of the two control variables. But as the control variables move from the origin, *O*, on the control surface, towards the point of singularity, *R*, the behaviour of the union becomes uncertain. The movement *O* to *R*, on the control surface corresponds to the movement from *N* to *S* on the behaviour surface. Increasing simultaneously the values of the control variables beyond this point causes the union's behaviour to either become aggressive and follow the upper sheet or to become passive and follow the lower sheet.

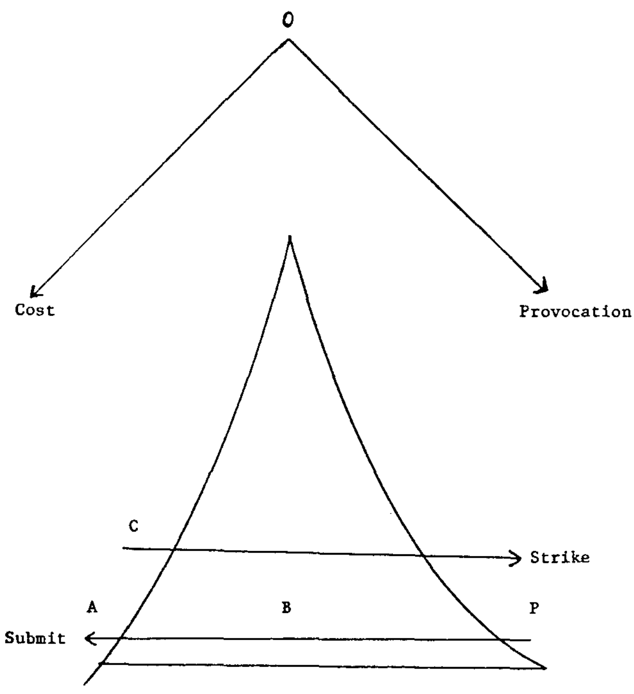
Whether the union chooses strike action or a conciliatory stance depends on the prevailing mood of the union membership as the point *S* is approached. Either action would be considered a relatively large change in behaviour compared with previous behaviour — there would be a catastrophic change. This arises because of the fold in the upper sheet (giving it the same «fold curve»). If this fold is plotted on the control surface, the result is the cusp shaped area which 1) gives the name to the cusp catastrophe, and 2) defines the bifurcation set specifying the limits within which catastrophes (large changes) can take place. Outside the bifurcation set behaviour changes smoothly. An interesting feature of the bifurcation set is that behaviour does not change drastically as the set is entered but only as it is exited after passing through it.

In using this model for prediction we need to know the present feelings of the union membership and a recent history of the way those feelings have changed. We would predict that a management team that is initially arrogant and belligerant and then follows such behaviour by placing increasing costs on the union will cause that union to behave in a different way than if the order of events is reversed — the union is initially faced with high costs and then the management team becomes arrogant and belligerant. In the first case the union starts from a position of anger whereas in the second case it begins from a position of insecuriy.

Consider a union which has been facing belligerant behaviour from a management so that it is ready to strike. Realizing that intimidation will not resolve the conflict, management decides to outline and, perhaps, impose costs on the union. The amount of costs required to generate a settlement will be relatively great. On the other hand, a union which is experiencing or expecting fairly high costs will have to be severely threatened before it will strike. If the aim of both negotiating teams is to avert a strike and achieve an agreement, the initial action should be non-threatening but cost-imposing. If the aim of management is to incur a strike, it should begin with threatening behaviour and understate the costs to the union of strike action. But should a new set of circumstances change the aim of the negotiators, it will require more threatening behaviour to generate a strike after heavy costs are outlined than before, and it will take much heavier costs to achieve a peaceful agreement after threatening behaviour has been extensively used.

An interesting prediction from the cusp catastrophe is derived from the bifurcation set. This relates to the direction one travels across it. As depicted in Figure 4, a union which is initially fearful or insecure could be pushed much further and made to accept much less before a «strike limit» is reached. In such a case, the union begins in region *C* and moves from left to right across the bifurcation set to region *P* — the «strike limit» being the boundary between the bifurcation set and region *P*. On the other hand, the same union beginning in region *P* (angered through provocation) will require a much «sweeter» offer or much greater costs before it would agree to a contract. The size of the bifurcation set depends on the sizes and relative strenghts of the two sides to the dispute — the greater the inequality, the larger the bifurcation set.

FIGURE 4



CONCLUSION

This paper has presented a preliminary examination of union behaviour in the context of a new and potentially powerful tool, catastrophe theory. Some light has been shed on an explanation of the frequently observed sudden and dramatic changes in union responses to negotiation tactics. An interesting result is that relatively weak unions may be pushed to accept an unfavourable contract, but the «push» must be cautiously employed as even a «weak» union may suddenly decide that strike action is preferred to further concessions.

The great advantage of the theory is that it permits a view of the dynamics of collective bargaining. The process can be analyzed from any starting point and the resulting trajectory examined. Hopefully, future research will collect relevant data in order to explore the richness of catastrophe theory in its application to the empirical analysis of the collective bargaining process.

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La théorie de la catastrophe appliquée au comportement syndical

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