

Organizational Learning and Adapting Trajectories Found in a System Dynamics Based Business Game

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Abstract

The counterintuitive associations, known as *Bowman's Paradox*, found between measures of financial risk and return for a large sample of companies across many industries have previously been explained in terms of the attitudes of managers to risk using Prospect Theory. Similar results were obtained by the author from teams playing a System Dynamicsbased business game to simulate a magazine publishing industry. Experimental results of the dynamic movements of the teamcompanies within the financial measures of risk and return space are presented. Explanations based on organizational learning and adapting group decision making behaviour provide an alternative account of the archetypal team transitions observed.

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There is little reported in the literature on team or group long term learning in organized systems characterized by complexity, feedback relations, non-linearities and time delays that would allow a direct comparison with actual firms or industries. Apart from Sterman's (1989) studies of learning (or non-learning) with the Beer Industry Game, no studies, to my knowledge, examine the group dynamics and the group learning and adapting behaviors among competing teams that produce the observed macro behaviours as an industry of firms matures. This study could shed some light on the processes at work as well as point the way to possible interventions to rescue groups that have gone off the rails, or, better still, to prevent them from getting into such situations in the first place. Previous studies of the behaviors of firms have focused on the so-called *risk-return* phenomenon. *Prospect theory* and *organizational learning* have been suggested as possible explanations for the phenomenon.

The risk-return phenomenon

From financial risk theory one is led to expect a positive association between measures of risk and return (Bowman, 1980). That is, companies following a more risky strategy (e.g., launching new products, entering new markets or embracing new technology) will be more likely to experience a higher volatility of returns, but subsequently be rewarded by a higher average return. Thus, one might expect a positive association between such measures for Risk (measured *ex post* using, say, Variance of Return on assets or earnings) and Expected Return (measured *ex post* using, say, Average Return on assets or earnings as a surrogate for the Expected Return for that level of risk) for a given firm in a given industry over a given period of time.

Bowman (1980) performed a study using a large sample of firms in several industries over successive five year periods and found an opposite effect. He separated the firms in each industry at their median values into a two-by-two array according to four combinations of high and low Variance of Return (which he labeled *risk*) and high and low Average Return (which he labeled *return*). He found that a negative association prevailed in the majority of industries studied. A sample of his experimental findings are compared to the results of a simulated industry (to be described later) in Table 1. This has since become known as Bowman's Paradox or the Risk Return Paradox.

Prospect theory

In a subsequent study, Bowman (1982) suggests an explanation based on Prospect Theory (Kahneman and Tversky, 1979; Tversky and Kahneman, 1981). Prospect Theory proposes that, through the mechanism of Action Framing, decision makers markedly change their attitude to risk depending on how they perceive their circumstances. Those that perceive themselves to be below some relative target or reference point, would be more inclined to have a risk-taking attitude, whilst those above target would be inclined to be risk averse. This might explain, then, why firms with below-average returns exhibit above-average variance of returns, and vice-versa; leading to the observed negative associations in industries of firms. Indeed, Bowman (1982) found from a Content Analysis of documents such as the annual reports of selected companies, that references to 'new' initiatives (which he linked to risk taking) were mentioned far more frequently for companies in the below-target-return category.

Table 1
A Comparison of the Negative Association Ratios for Firms in Selected Industries
and the Aggregated Simulated Industries

Industry	Negative Association Ratio *	Number of Firms in the Industry
Values for the period 1968-76 taken from Bowman, 1980, Table 1:		
Food Processing	1.9	50
Electronics	1.4	31
Packaging and Containers	1.2	26
Values computed from the industry simulations:		
1st. Period	2.25	54
2nd. Period	1.56	54

* The negative association ratio is computed from the number of firms in each cell of below or above target return and low or high variance of return in a two by two contingency table using the formula:

$$\frac{(\text{below_high} + \text{above_low})}{(\text{below_low} + \text{above_high})}$$

If the ratio is greater than one then a negative association is indicated between Average Return and Variance of Return, and a positive association is indicated if the ratio is less than one.

In a most comprehensive study, Fiegenbaum and Thomas (1988) sought to validate the Prospect Theory argument using a very large sample of companies (over 2,000) in more than forty industries, over an extended period of time (20 years). They surmised that the managers of firms in an industry would develop some relative norms of 'target' performance, and they used the median value of average financial return as a proxy variable for the 'target' performance of an industry. Furthermore, the Prospect Theory would suggest that the attitudes of managers to risk in the below-target firms would lead to a negative association (i.e., the further they perceive themselves to be below the 'target' return for the industry, the more risky will be their decisions leading to an observed increase in variability of return), and for those in above-target firms to lead to a positive association (i.e., the lower the average return, the lower the observed variance of return, whereas, firms with higher returns can afford to take risks leading to higher variance).

Fiegenbaum and Thomas proceeded by computing, over successive five and ten year periods, the average and variance of the Return On Earnings (AVROE and VAROE) for each company. For each industry classification, they divided the companies at the median into those above and below target AVROE. They computed the Spearman Rank Order Correlations and the Negative Association Ratios for each sub-category and the results of their analysis across a large sample of industries is shown in Table 2 in comparison with the results from the yet-to-be described industry simulations.

It can be seen that the Spearman Rank Order Correlations are negative (significant at the $p < .01$ level) and the Negative Association Ratios are greater than unity for the below-target return categories of firms. This is in agreement with Bowman's findings. On the other hand, for the above target categories the Spearman Rank Order Correlations are positive (significant at the $p < .01$ level) and the Negative Association Ratios are less than unity signifying positive associations. They interpreted this as indicating a U-shaped risk-return utility function with managers anchoring and adjusting their risk-taking preferences at the perceived target for the industry (the median return). If one accepts that Variance of Return is a good measures of Risk and Average of Return is a good measures of Expected Return (this will be questioned later), then the results strongly supported their hypothesis. As they state it:

Using extensive COMPUSTAT-based data on U.S. firms, we consistently found negative risk-return associations for firms having returns below target levels and a positive association for firms with returns above target. These results support the

basic propositions of prospect theory and are extremely robust within and across industries and for all time periods studied (Fiegenbaum and Thomas, 1988, p.85).

Table 2
A Comparison of Rank Order Correlations and Negative Association Ratios for Firms with Below and Above Target Returns Across Industries for Selected Time Periods

Period	Below Target Firms			Above Target Firms		
	Spearman Rank Order Corr.	Negative Assoc. Ratios	No. of Firms	Spearman Rank Order Corr.	Negative Assoc. Ratios	No. of Firms
Values taken from Fiegenbaum and Thomas (1988) Table 4, p.95:						
1960-9	-.48**	2.00	807	+.50**	0.52	807
1970-9	-.63**	2.87	1,197	+.40**	0.60	1,197
Values computed from the industry simulations:						
1st	-.71**	2.00	26	-.35*	1.20	26
2nd	-.29 ⁺	2.40	26	+.41*	0.74	26

 ** p<.01
 * p<.1
 + p<.15

Organizational learning or adapting

Bowman (1980) also suggested that the negative associations he found could be explained by organizational learning. That is, the managements of firms learn to simultaneously improve the financial rates of return and reduce the variances of return with the passage of time. Whether it is true learning in terms of a better understanding by managers of the relationships within and between the firms and their environments, or merely trial and error learning without much true understanding, the end result is that enough firms drift in the direction of improved return and reduced variance to cause the observed negative associations. In an attempt to investigate this phenomenon, the author has gathered data over a number of years from a simulated industry of firms in a business game used in undergraduate and graduate classes in management decision making.

The simulated industry

A description now follows of the training game, adapted from a validated corporate system dynamics simulation model of a magazine publishing company (Hall, 1976 and 1984), that was used for this study. The game can accommodate up to ten teams, each representing a magazine firm in the industry. The teams consist of four or five participants, with each player adopting the role of an executive, such as president, publisher, executive editor, v. p. circulation and v. p. production. The teams are required to make decisions regarding some eight variables appropriate to managing a magazine publishing company. The decisions involve the once-a-year adjustments to such items as subscription, newsstand and advertising rates, promotion expenditures, volume of print runs and the permitted ratio of editorial to advertising pages. After each decision, the players receive feedback in the form of reports.

The simulated annual reports for each team consist (among other things) of the comparative performance of each team on eight criteria. These criteria span from the conventional financial measures, such as growth in earnings, profits and return on earnings, to the growth in readers and

efficiency measures such as cost per reader. The players are rewarded on a schedule that includes growth in profits (the owner's objectives), the percentage above the industry average on the criteria chosen by the team as their 'edge of excellence' (the team's cultural objective), and the size of the operations under the aegis of each player's executive role (the departmental responsibility criterion). For a more detailed description of the game see Hall, 1989.

The relatively simple set of interactive time-difference equations that represents the operations of a magazine publishing firm was translated from a system dynamics model. It nevertheless presents an extremely complex situation to the participants. A path analysis of the interrelations in the model produced over 580 chains of influences from the eight policy variables to the eight performance criteria, and 14 feedback loops (see Hall, Aitchison and Kocay, 1991, for an example of this kind of analysis). Furthermore, the chains of influences exhibit 'indeterminacy' (i.e., the paths do not all have the same sign of path-correlation). To further complicate matters, the feedback loops have the characteristics of 'hidden demons' that can suddenly produce run-away policies and counter-intuitive behaviors¹. So even if the participants have the cognitive skills to fathom the 30 or so basic inter-active influences in the model, they will still have problems intuiting its dynamic behavior. It can be claimed, therefore, that the game exhibits at least some of the macro attributes of real organized systems in its degree of complexity.

The game was played by eight classes of graduate and undergraduate business students taking courses in management decision making. Part of the students grade was tied to their performance in the game. Each class comprised of between five and nine teams. Decisions were made twice a week for six to eight weeks representing twelve to sixteen simulated years of the operations of the magazine companies. As well as receiving individual company reports, the participants also had access to comparative team statistics. In this respect, each class could be expected to act like an industry by developing its own relative norms of performance. To the extent that the teams mirror the behavior of firms in an industry, the observations collected from the game might provide insight into the risk-return paradox.

The Analysis and results

The Return on Earnings (ROEs) for each team in the simulated industry was computed for each simulated year. The period of the game was divided into two equal numbers of years; henceforth referred to as the first and second periods of the game. The Standard Deviations of ROE and the Average ROE were computed for each team over each of the two periods of the game. The data were treated in a similar fashion to Bowman's (1980) and, Fiegenbaum and Thomas's (1988) studies and the Spearman Rank Order Correlations and Negative Association Ratios were computed from the number of teams in the various sub-categories. The results are shown in Table 1 in a comparison with Bowman's results, and in Table 2 in comparison with Fiegenbaum and Thomas's results.

As can be seen from Table 1, significant Negative Association Ratios are obtained for each half period of the game as found by Bowman. From the more detailed analysis of the teams above and below target return for each period of the game (Table 2), similar results were obtained to Fiegenbaum and Thomas for the second period (but at a much reduced level of significance), and in the first period for the below target return category of teams only. The first period above target return category of teams produced a contrary negative rank order correlation. The lower significance levels obtained may be explained by the small sample of teams. In their study, Fiegenbaum and Thomas rejected industries with less than five firms above and below the median return, whereas there were no simulated industries (classes) with more than four teams above and below the median in this study. The contrary first period negative association could be explained by the somewhat artificial nature of the simulation that starts all the teams off together with identical initial configurations. An actual industry could be expected to be comprised of a collection of both younger and older firms of different sizes. By contrast, in the first half periods of the simulations, the team decision makers are

¹ For example, if policy dictates that promotion expenditures are a fixed percentage of revenues (a common practice) then any increase in revenues will lead to an increase in promotion activities that (*ceteris paribus*) will lead in turn to the generation of more revenues, and so on. The feedback loop will work in the opposite direction when revenues drop, leading to a good deal of instability deriving from the structure of the decision making system.

all struggling to bring order and stability to their affairs. This could be expected to distort to results of the first half periods of the simulations.

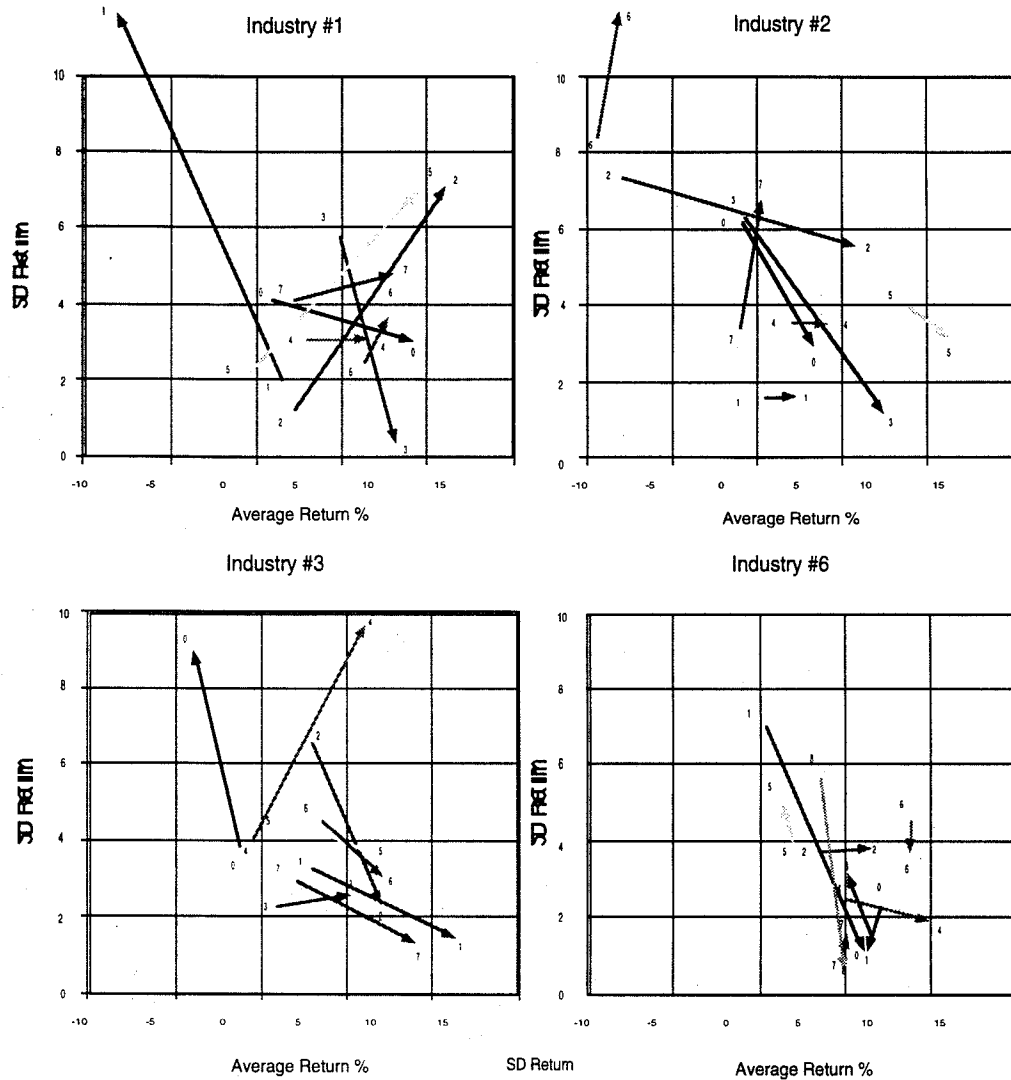
Discussion of the results

Whereas the studies by Bowman, and Fiegenbaum and Thomas involve 'snap-shot' views of a number of firms taken every five years or so using aggregate data, the game allows an observer to explore more the 'moving picture' and dynamics of individual teams. Also, the observer has access to the team participants and can question their motives and rationale in making key decisions. The observer can attempt to follow their decisions to see the macro effects in moving the simulated firms around in the Average Return and Variance of Return space. To illustrate this, the movements from the first to the last periods of teams in different simulated industries (classes) are shown in Figure 1. A variety of trajectories is evident and an attempt to categorize them follows. The archetypal trajectories proposed are illustrated in Figure 2.

First, most teams start out making decisions based only on a rudimentary map of the policy terrain. Their initial moves often lead to less than desirable outcomes as the participants grapple with a complex system beyond their ability to comprehend fully in this early stage of the game. The consequence is often a lower average return and higher variance in the first period of the game. Taking greater risks because of risk preference driven by being below the target return for the industry does not seem to be an important input to decision making at this stage. This does not mean that it is not present, but that it is a secondary concern to just surviving for most teams.

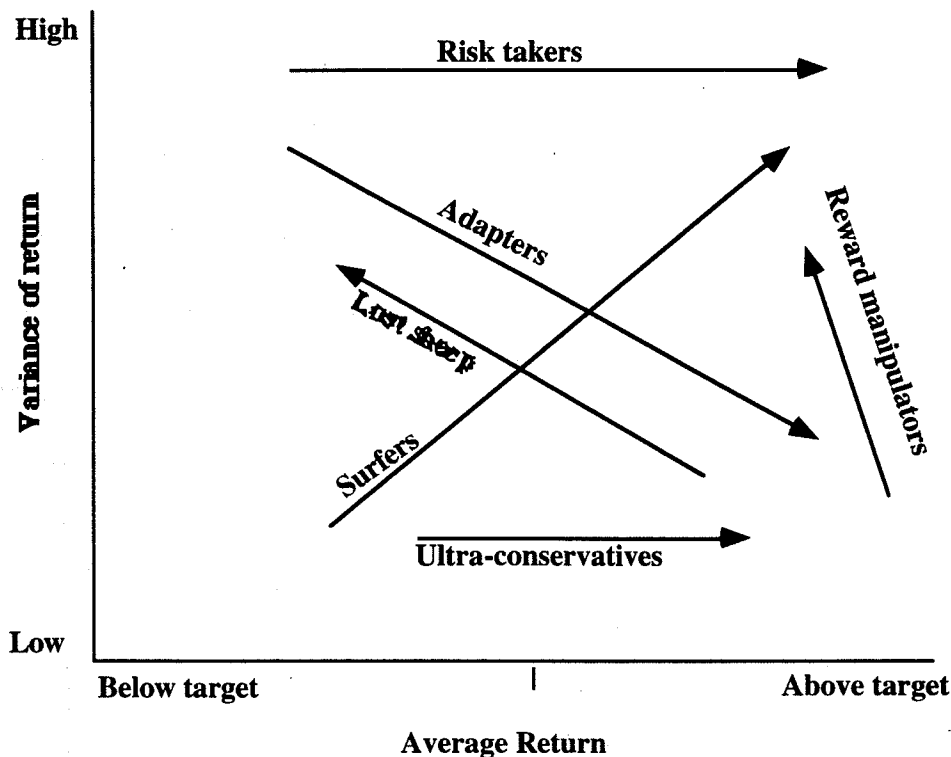
For some of the teams in this starting situation there is usually a general drift from low average return in the first period to higher average return in the last period. This can be ascribed to organizational learning. Such organizational learning is evidenced by the development of richer policy maps as results are obtained from rudimentary experiments with differing policies. Also, the teams learn from each other through the reporting of comparative industry statistics. Strategic recipes are developed, copied or abandoned, forecasts of key items are improved, and norms of more effective inter-personal decision making behaviors are usually established. The net result is a more general ability for some teams to simultaneously increase returns and reduce the variance which possibly contributes to the observed negative association for below median return teams. These teams we shall label the 'adapters'.

Fig. 1 Examples of team trajectories in the Variance-Average Return space.



Some of these 'adapters' find themselves with little room for improvement in the latter part of the game since they are operating at about maximum efficiency for the particular strategy adopted. Since at least some portion of their rewards are geared to growth of return, they intuitively seek ways of manipulating the reward scheme. This they try to accomplish by reducing profits every so often by increasing discretionary spending. When the spending is subsequently reduced, profits and their rewards rise! The morale and commitment of the participants is high. They feel in total control of the firm and they express the sentiment that the game was the high point of their program. The net effect is that the variance of return is increased as return is purposively managed up and down, thus perhaps contributing to the observed positive association for above median return teams. We shall label these teams 'the reward manipulators'.

Fig. 2 Archetypal team trajectories in the variance-return space



Yet other teams, by accident or design, manage to fire up one or more of the 'positive' feedback loops (the hidden 'demons') buried in the game. Their fortunes take off with exponential growth and their meteoric rise is accompanied by a certain amount of loss of control. Their major problem is not a matter of risk taking but more one of coping with a situation that is always tending out of control. In consequence, such teams arrive in the last period of the game with high variance and high average of return that could contribute further to the positive association found for above median return teams. We shall label these teams 'the surfers'.

However, a few teams start with a high return through what appears to be sheer luck -- they happen onto a good policy by chance. There is little incentive to learn about the intricacies of the system, and the group may develop group psychodynamic pathologies such as collective fantasies and delusions of invulnerability (after Hirschhorn, 1988) leading to massive misattributions of causality in the organizing system (after Hall, 1984). Performance may start to deteriorate. If a hidden feedback loop becomes activated and goes into reverse, and furthermore this is accompanied by a drop in morale, then the participants' decisions can vacillate in a desperate attempt to find a viable policy with little understanding of the mechanism producing the poor results. This brings about a further deterioration in morale and the commitment of the participants to the team dissolves. No one is prepared to put in the hard cognitive work to understand the situation and the energy of the team is dissipated in dealing with their sense of failure as each blames the other. The simulated firm spirals down out of control. The outcome is a movement in the reverse direction from high return and low variance to the exact opposite. They describe the game as one of the worst experiences of their lives! These teams we shall label "the lost sheep"! They could also contribute to the observed negative association for below median return teams.

Another category of teams could be labeled 'the ultra-conservatives'. Such teams take a very conservative and cautious stance. They take few risks, manipulate few variables in an experimental sense and learn little or only slowly. Their movement in the variance-return space tends to be minimal from typically low variance-low return in the first period to low variance-medium return in the last period. Their trajectory would seem to add little to the observed associations.

Finally, a very few teams have been observed to move from a high variance and low average return position in the first period, to a high variance and high return position in the last period. On enquiring, the impression was gained that these teams were pursuing a genuine risk-taking policy. We shall label them 'the risk-takers'. However, the trajectory of these teams would be unlikely to

contribute to either a positive or negative association, which would contradict Fiegenbaum and Thomas's hypothesis that the phenomenon is due to the existence of a decision makers U-shaped risk-return preference curve! A further study is underway using *cluster analysis* to see if there is any validity to these archetypal trajectory categories hypothesized in both the real and simulated industries.

Conclusions

If these trajectories (or something like them) is evident in the aggregate data used in Risk-Return studies, then they could cast doubt, not on the findings of the associations between Variance and Average Return, but on the previous interpretations placed on these! Specific criticisms of these interpretations follow:

1. Variance and Average Return are not good measures of managers' preferences for *risk* for *expected return*; they merely reflect the later outcomes of management decisions moderated by many uncontrolled influences such as booms, depressions and competitors' moves.

2. Unless there are little or no movements of individual firms in the Variance-Average Return space over successive five year periods, the associations found by Fiegenbaum and Thomas should not be interpreted as validating their hypothesis concerning managers' preferences for Risk and Return. If there is a sufficient number of firms moving along trajectories in the Variance-Average Return space in somehow naturally occurring patterns, then this would produce similar results to those obtained but for an alternative reason.

3. The combination of the 'natural logic' of management policy makers in adapting their firms to complex environments in concert with the 'hidden demons' that lurk in self-organizing systems (Hall 1984) could shape the trajectories of firms over time in the Variance-Return space and provide alternative explanations of the observed patterns of associations. That is not to say that Risk-Return preferences play no part in decision making, but that other influences are also present.

To settle this issue will require a much more detailed longitudinal study to observe the decision making behaviours of the policy elites of firms and at the same time trace the impact on the the individual trajectories of the firms over time and *vice versa*. The strong patterns found in the studies of both Bowman, and Fiegenbaum and Thomas suggests a limited number of such viable trajectories.

The results of such a research study could have important implications for both theory and practice. In the first place, it could lead to a better understanding of how motives, decisions, system architecture (including the endemic hidden 'demons' in the system) and group psychodynamics interact to produce macro industry behaviors. Industry simulations, such as the one used in this study, might provide a laboratory to study management team psychodynamic phenomenon causing the collective fantasies and misattributions of causality that precede corporate collapse. If senior managers could be made aware of the archetypal trajectory their firms are on, perhaps they could invoke intervention strategies to move to some other trajectories that might be somehow more appropriate or desirable. Alternatively, intervention strategies could perhaps be devised to help firms caught in a pathological trajectory (for example the 'lost sheep'), or incentives redesigned to reduce the potentially harmful effects of the 'reward manipulators' syndrome.

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