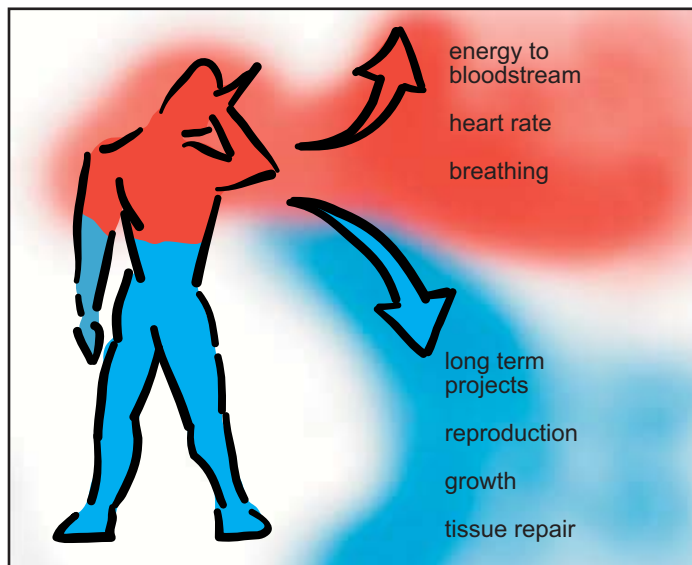


Robert Sapolsky

iteration 1

Response to Stress

Stress hormones mobilize energy and then turn off all the non-essentials.



Systematically exposing rats to stress causes them to generate stomach ulcers. Here's how it works:

To survive a crisis, a living system needs energy. It mobilizes energy into its bloodstream. Then after it dumps the sugar into the bloodstream, it wants to deliver it as fast as possible and the heart rate goes up as well as breathing. Next, it turns off all long term projects—shuts down everything that is not essential. It shuts down digestion, for instance. The first step of this is that your mouth gets dry.

It shuts down growth and reproduction and tissue repair. Next, it shuts down the immune system when under stress, because the immune system can't help the organism in the next two or three crucial minutes when it is under attack (or believes it is under attack). Finally, in the short term under stress, you can think more clearly.

People who turn on the stress response too often get sick.

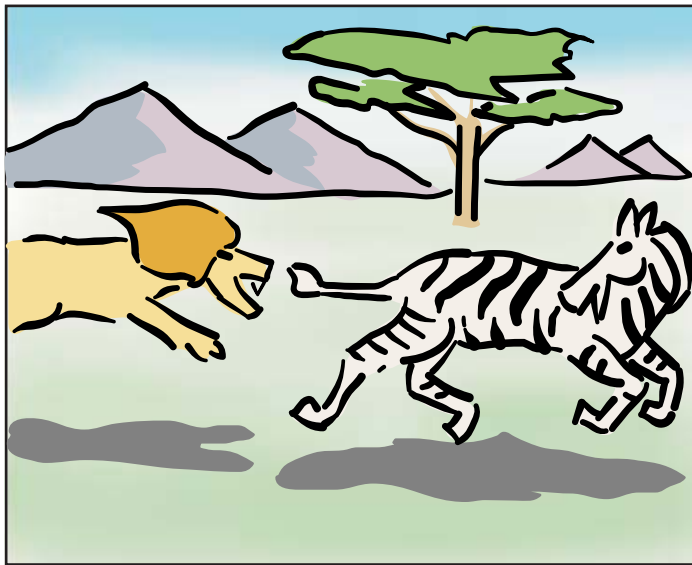
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Robert Sapolsky

iteration 1

Homeostasis and the Stress Response

A stressor is anything in the outside world that moves you out of homeostasis



A stressor is anything in the outside world that moves you out of homeostasis. Stress response is what you do to reestablish homeostasis. For people, a stressor can happen just by *thinking* that you're just about to be knocked out of homeostasis. You can have an anticipatory stress response. If you think that way in a regular basis—you're being anxious, paranoid, neurotic. For 99% of the beasts on the planet, the stress response is being hunted and killed. For us, the same response is turned on with thought, and if we turn it on chronically, we get sick.

Creative Concept 002 Thought Leader Forum 2002

Robert Sapolsky

iteration 1

Type A Personality Kills

Toxic hostility can kill you



How are stress and heart disease related? You get into cardiovascular trouble for the same reason that your toilet plumbing wears out. The more force with which blood moves through the vessels, the faster it wears out.

The link between stress and coronary disease is completely solid and this link is called "Type A" personality. It's a bigger risk factor than if you smoke or are overweight. The key factor is the "hostility", called toxic hostility. You interpret everything in the world as being an attack on you. Everything is personal. If that's your response, you're

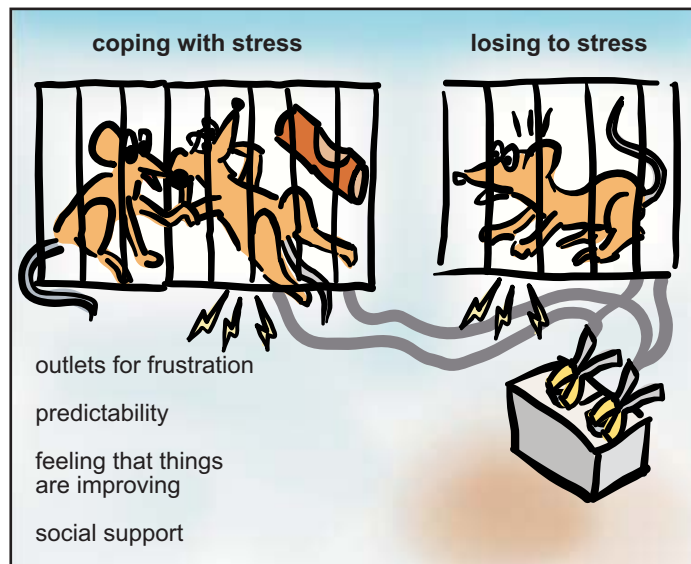
raising your blood pressure every day.

Here's how they figured out Type A personality. A doctor and his partner had a cardiology practice and were spending a fortune reupholstering the chairs in their waiting room. The upholsterer asked "what's wrong with your patients, no one else does this to their chairs," and discovers the Type A personality. But the doctor was too Type A to listen to the upholsterer. Years later he realized the upholsterer was right.

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Coping With Stress

Why do some people cope better with stress than others?



The critical point is that whatever stresses one person could be a hobby for someone else. Why is psychological stress stressful to some of us and not to others? What are the building blocks of psychological stress?

If a rat is shocked in a cage enough times, it gets stress and acquires a stress-related disease. Now imagine a rat in a second cage gets the same shocks except that this rat can go over to the other side of the cage and bite another rat. It has an outlet for its frustration and doesn't get the disease.

If the second rat has a bar of wood that it can gnaw on (a hobby), it doesn't get the disease either. If there's a warning light that comes on before the shock, the rat copes.

If we have predictive information, we deal with the stress better. Without the warning signal, you never know when you're safe.

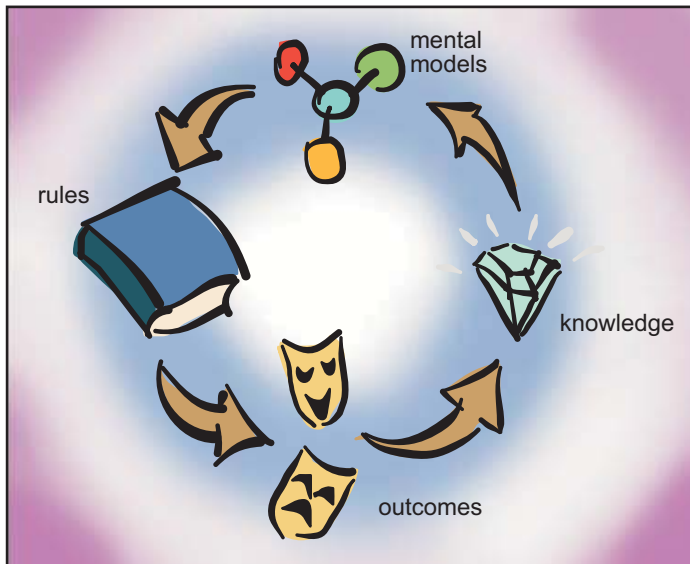
A rat that can press a lever and have a sense of control (real or perceived) over whether it gets a shock or not, doesn't get sick.

Give a rat a friend, and it doesn't get an ulcer. After you control for socioeconomic status, the most socially affiliated have a greater survival rate. Being socially isolated is a huge health risk factor.

So we need outlets for frustration, a sense of predictability and control, a perception of life improving and social support. We invent the stuff in our heads and are stupid enough to fall for it.

Mental Models

Our mental models evolve through an iterative process



We use our mental models to generate decision rules. When we apply these rules, they have outcomes--sometimes good and sometimes not so good. Information from these experiences constitutes feedback from which we may glean new knowledge. This knowledge then influences our mental models.

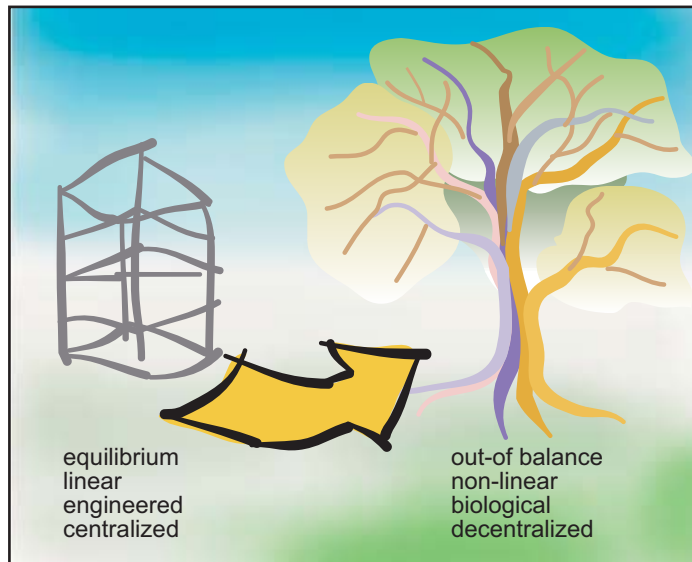
The purpose of the Thought Leader Forum is to call upon the collective experience from a variety of other perspectives and fields of practice so that we may all have the opportunity to gather knowledge to adjust our mental models.

Michael Mauboussin

iteration 1

From an Engineered World to an Organic World

Scientific understanding is reshaping how we see the world, and it will filter down to every aspect of our lives



Global themes: going from an engineered world to an organic world. The past is based on equilibrium, linear, engineered, and centralized in mindset. The present and future is based on out-of-balance situations, non-linear, biological metaphors, and decentralized control.

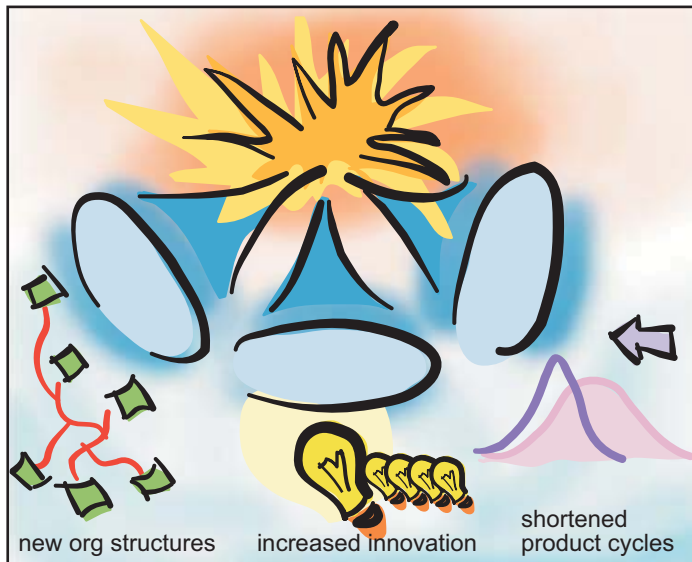
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Michael Mauboussin

iteration 1

Responding to Change

We will respond to change by adjusting organizations, innovation and product life cycles



How we react to change is also important. Change causes stress but also makes systems improve. We will see change in our understanding of markets. The dogma from the last 50 years will not stand another 50 years. Organization structures will change to take advantage of the rate of change. Innovation is accelerating, and what does that mean for us as investors. Finally, industry and product life cycles are shrinking. That creates both opportunity and challenges for us.

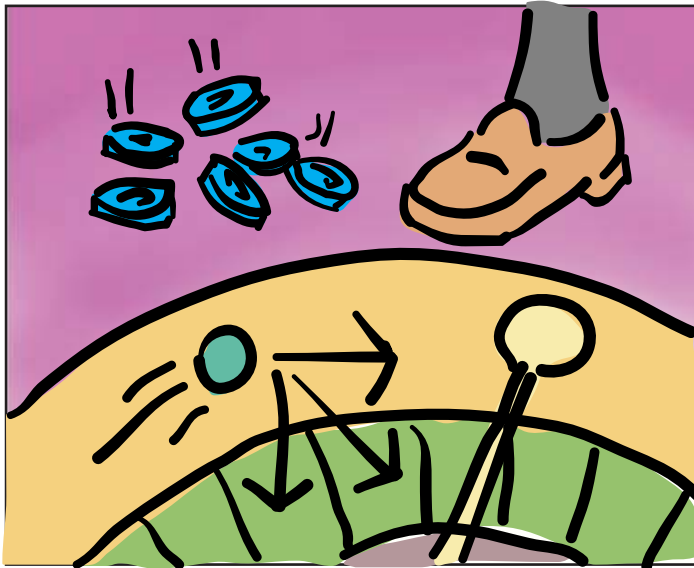
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J. Doyne Farmer

iteration 1

Roulette and Two Ways of Making Predictions

Beating roulette with a computer in a shoe using both first principles and empirical methods.



There are two ways to make predictions. The first is from first principles. We make mental models of the world. But most models are made the other way, or empirically. Organisms tune their models by experience.

When we play baseball we don't solve Newton's equations, but we do use them experientially. Roulette is just a classic physics problem based on the rate of change of velocity. The motion of a ball on a perfect track isn't chaotic; prediction is difficult because of the circularity of the wheel and imperfections in the track create a kind of turbulence. We built a shoe

computers that we used to predict where the ball would land. We combined formulas and empirical experience in the process.

Roulette provides a way of making prediction based on both first principles and on empirical time series analysis. The empirical method wasn't as accurate but was more robust.

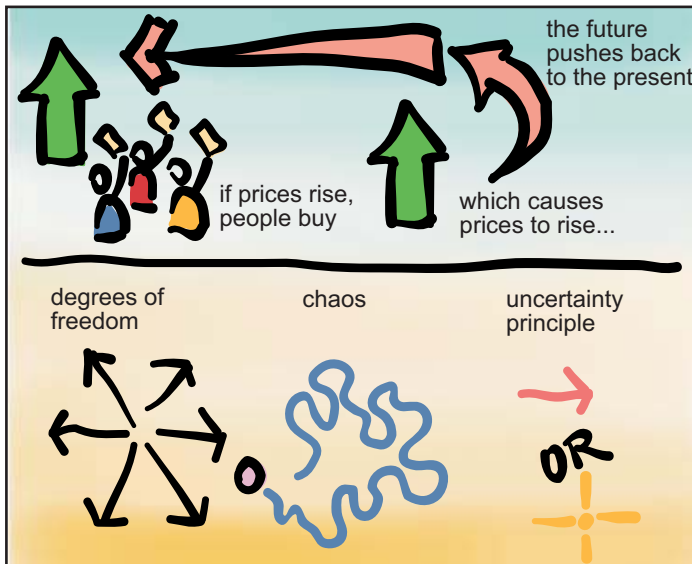
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J. Doyne Farmer

iteration 1

Making Predictions Can Alter the Future

Why it's hard to make predictions



The hard part is the curse of dimensionality—high degrees of freedom create an exponentially more difficult problem to solve. When you add chaos and the Heisenberg uncertainty principle, things get worse.

is more complicated than investors usually think.

Most economists believe that future price movements are fundamentally unpredictable. If prices rise, more people will buy, which drives price up so price rise happens before anyone can take advantage of it. The future is pushed back into the present. So the story behind efficiency

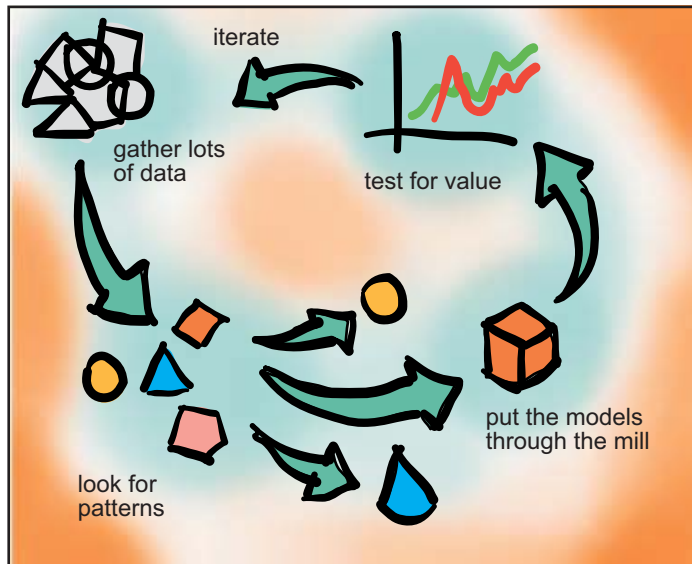
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J. Doyne Farmer

iteration 1

How the Prediction Company Model Works

Data, patterns, modeling, iteration on a massive scale



The Prediction Company process starts with data. We gather a lot of data. We search through the data for patterns. Patterns are like features. Think of features in this way: monkeys interpret images in their visual system through pattern recognition (like identifying edges between light and dark).

When we find a feature, we run it through the mill to see if it has any power, and then iterate that process. We also use the law of large numbers. We try to predict the little ripples, not the big waves. You can combine predictions on the ripples to make more accurate portfolio

forecasts. The models are not that great: we just have lots of them and know how to put them together in useful ways. The trading is completely automated—no human decisions. The decisions are pretty crude. The machine doesn't have a lot of understanding of what is going on in the market.

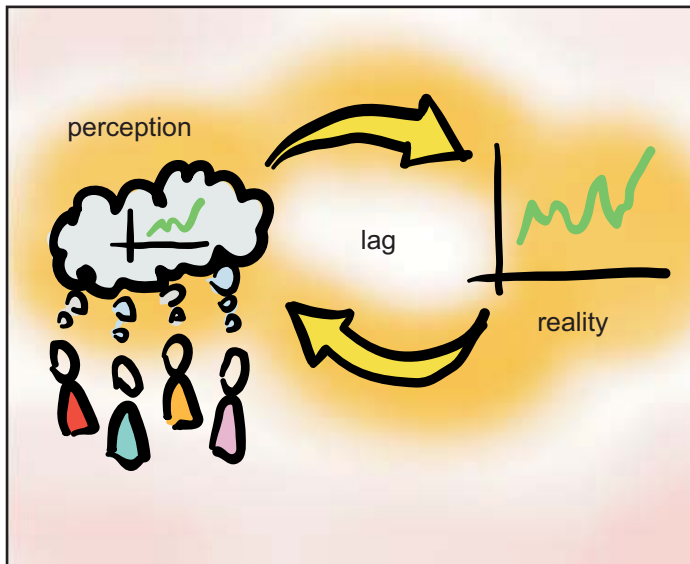
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J. Doyne Farmer

iteration 1

What Drives Speculative Bubbles?

Market institutions and psychology: reality influences perception and visa versa



Market institutions are important causes. For some situations randomness may be a better model of human behavior than rationality. Begin with a random process model that respects market structure, and then add some slightly intelligent behavior. Psychology is an important factor especially on the short term. On longer timescales human psychology is also important. There seem to be universal patterns of human behavior, such as speculative bubbles, that play themselves out again and again. {Bananas can't be stored long enough to create bubbles—but anything that can

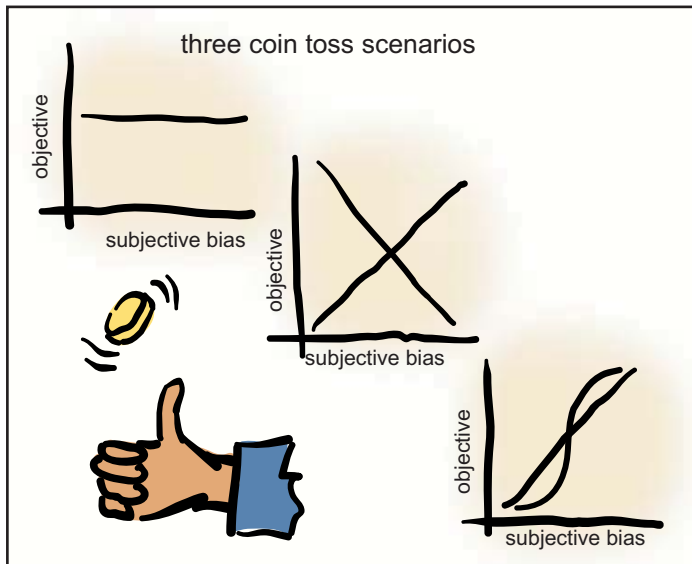
be stored can be subject to bubbles). There are patterns in how the bubbles appear and occur. In some deep way markets may be inefficient. If we were cognitively stronger than we are now, we could, however, find the appropriate patterns. Most of the recent drop in the tech sector seemed to be irrational. If the allocative efficiency is not perfect then the predictive efficiency can't be perfect.

Reality influences perception and visa versa. There's a lag in that feedback that makes it hard to understand and predict the market behavior.

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Simple Example From Gambling

If forecasts influence reality too much, look out--you might get what you ask for!



Imagine a system with "n" agents. Each agent makes bets on horses. Odds are based on the net wager on each outcome. Allow the possibility that the outcome is influenced by the odds. Maybe the jockey looks at the odds and thinks they have to rig the race. The outcome of a company is influenced by the perception of the company. Demand is subjective; supply may also be subjective.

Now simplify the model. Look at a coin flip. There are only two outcomes. Then map the subjective bias to the objective world. If 80% of the people bet on tails, that's the subjective bias. The objective bias would be 50% for a fair coin. A person whose

odds most closely match the behavior of the coin will end up with all of the money over time.

Now imagine that as heads gets more likely, the probability gets less likely. Like an efficient market. In this model the bias stays close to 0.5 because it exhibits stable feedback.

Case two. If there is unstable feedback, then the subjective bias will tip and the objective bias runs up to either all heads or all tails, whichever way the instability lies. Initial conditions tend to determine the outcome.

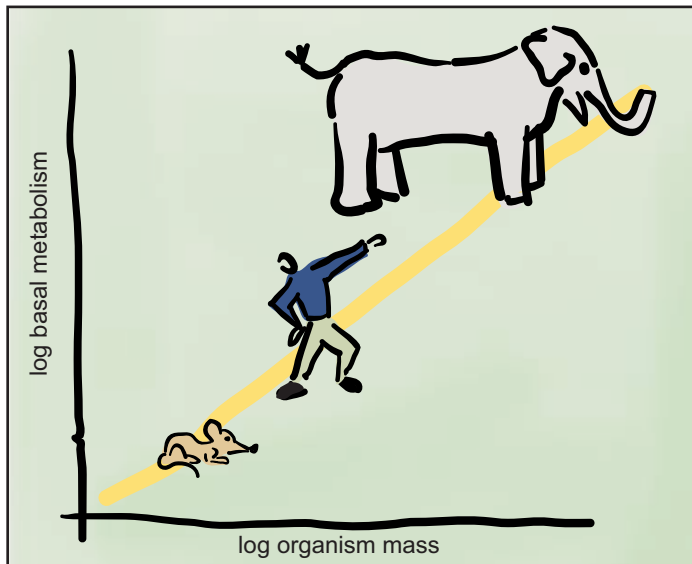
If forecasts influence reality too much, look out-you might get what you ask for.

Geoffrey West

iteration 1

Scaling Laws in Biology

All living things share a power law relationship between their mass and their basal metabolic rate



Life is the most complex system in the universe. It's extraordinarily diverse and stretches over very large scales from microscopic to the blue whale. It covers 27 orders of magnitude and if we include the biosphere, it's 40 orders of magnitude. But some characteristics of life are extremely simple.

A fundamental, shared phenomenon is the metabolic rate—how we stay alive. When you plot the basal metabolic rate (watts) vs. mass of the organism on a log log plot, simplicity emerges. There's a simple straight line indicating a power law meaning that the relationship between metabolic rate and mass is an exponent of $\frac{3}{4}$ (3 orders of metabolic magnitude over 4 orders of mass). Human metabolism is a little less than a light bulb, at 100 watts.

There is a sequence of these scaling laws. Unicellular, cold-blooded and warm-blooded organisms have the same scaling law and exponent of $\frac{3}{4}$. We extended unicells and then added mitochondrions and human cells. These all end up on the same line. Even enzymes end up on the same line.

If the metabolic rate scales as mass to the $\frac{3}{4}$, then power or energy required to support each unit mass decreases with size by a $\frac{1}{4}$ power exponent. Therefore there is an economy of size. Even though all mammals are made of the same stuff, the amount of energy needed to keep a gram of rat alive is significantly more than that required to keep a gram of elephant alive. Therefore, in this sense, getting bigger is better. Maybe, that's why companies merge.

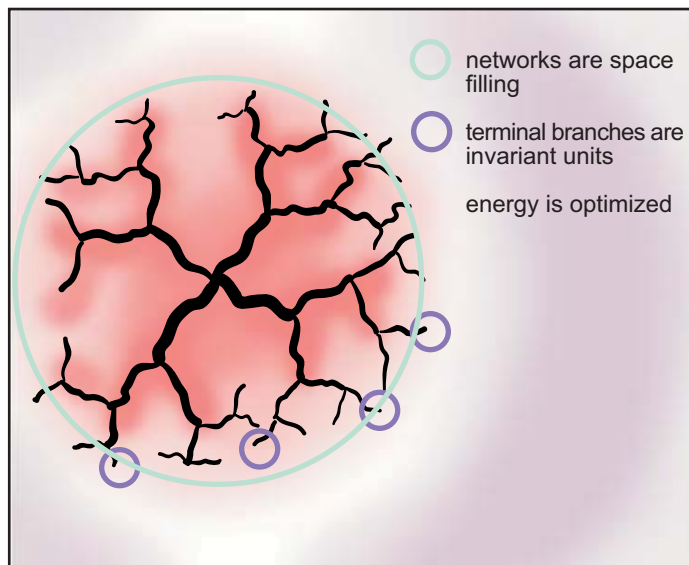
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Geoffrey West

iteration 1

Hierarchical Branching Network Systems

Evolution has created hierarchical branching networks to sustain, feed and inform the components of living systems



Organisms are made up of a huge number of individual components. How do you sustain, feed and inform those individuals in a roughly efficient and democratic way so they can perform their tasks? Evolution has created a bunch of hierarchical branching network systems. Almost all of a person's biology is nothing more than branching network systems. The skin is almost superficial because it only holds us together.

What are general properties of these networks? All of these derive from Darwinian natural selection—continuous change and feedback. First, they are space filling. Second, the terminal branches of the network are invariant units. These are the most important biological parts of the living system because they are the interface for exchange of matter and energy. For example, you can live in

a tiny house or a large building, or a shack, but the electrical outlets and the water faucets are invariably the same size. The same is true for computers.

The third postulate: just as natural selection didn't reinvent the fundamental units, the continuous feedback leads to a certain optimization which minimizes the energy needed to sustain the organism.

Examples are the circulatory system, the structure of the brain, the structure of mitochondrial pathways inside cells over time, freeways in LA, and so on. Whether this can be ported to organizations or not is not known, but is at least extremely suggestive.

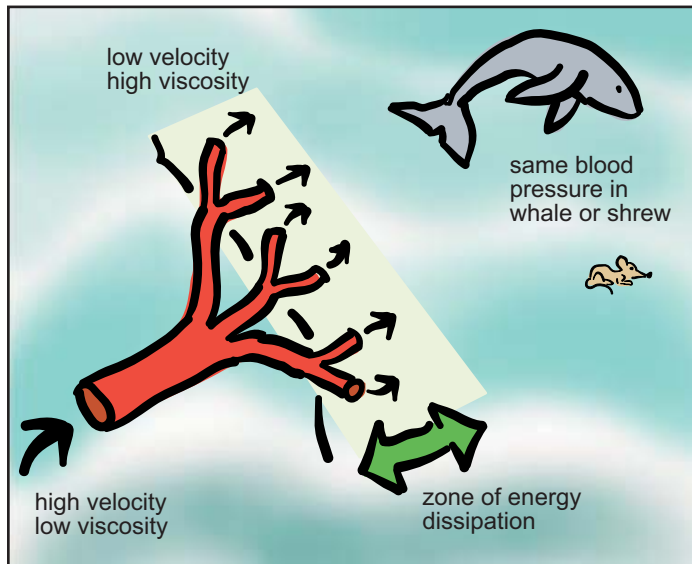
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Geoffrey West

iteration 1

Energy Dissipation

Energy is dissipated in the lower portions of the network; greater system size varies as a power law with efficiency



What is the energy dissipated in an arbitrary network? Predominantly, the minimum configuration is that area is preserved over branching—the cross-sectional area of the parent is the sum of the cross-sectional area of all the daughters. If the network were arbitrary, when a pulse hits a branch point, some of the wave would be reflected back. The minimum configuration is where there are no reflections from the wave due to pumping. That's called area-preserving branching (impedance matching in electrical engineering terms).

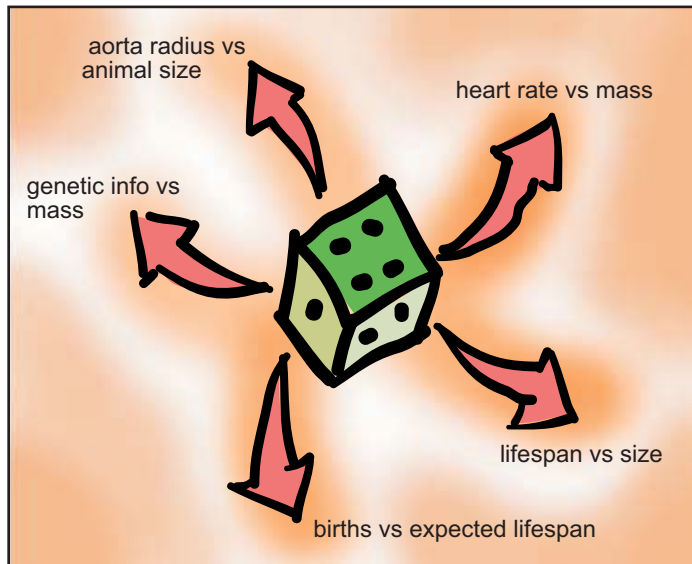
But this can't be true entirely. If it were, the velocity of blood in the aorta would be the same in the capillary. So viscosity comes into play. Energy is dissipated. The wave dies out and the blood is very slowed down. Instead of being area preserving, it's actually

area increasing. We only dissipate energy in the lower part of the network. If you decrease the size of an animal so small that the aorta dissipates energy itself, it turns out that there is no increase in efficiency in creating an animal that small, therefore it did not evolve. So we can predict the size of the smallest mammal using the theory. It ends up being about one gram, the size of the shrew. The theory also predicts that if you calculate the hydrodynamic resistance of the network, it decreases in size and this drives the increase in efficiency. Hence, getting bigger has some advantages. If the resistance is decreasing as mass to the $\frac{3}{4}$ but the metabolic rate is increasing, the pressure or voltage that is driving it has to be an invariant. The blood pressure and velocity of blood flow is the same in all the systems from a shrew to a whale.

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Four is the Magic Number of the Universe

The number 4 occurs in all power law relationships in all types of phenomenon of living systems



The radius of the aorta plotted vs. size for mammals is a slope of $3/8$. If you squared the radius, you'd get an exponent of $3/4$. Heart rate decreases as mass to the $1/4$. Lifespan varies with size as mass to the $1/4$. There is a lot of spread in the data, but the best fit is 0.235. Therefore, there's an invariant in the system—the total number of heart beats in a lifespan. Namely, 1.5 billion. This number is a crucial number of biology. If we understood the origins of this number, we'd understand something fundamental about life. There's nothing fundamental about heart beats. What is fundamental is what goes on in the molecules in the respiratory process producing your energy. The number of turnovers of that reaction rate is invariant.

One other invariant is birth rate. Births per expected lifespan is roughly a constant for different organisms. This is also true for humans taken separately as a species. Number of children varies inversely with average lifespan.

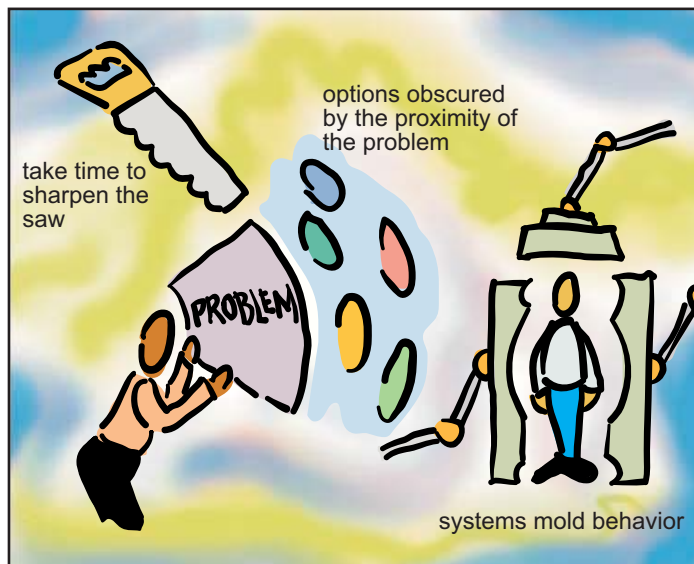
If you assume an engine lasts 100k miles, it has about the same number of turnovers or cycles as a human being. No particular meaning, but it's amusing to know.

The genetic information (length of DNA) also varies as mass to the $1/4$.

There are many, many scaling power laws that cover the whole scale from sub-cellular to ecosystems.

Traditional Responses to Change

We build systems that train us to respond to change in the same, ineffective (sometimes pathological) ways



The task at hand always drives out maintenance. There's a hermit that lives out in the forest and knows how much wood he has to cut to stay alive. He hears a message that there's a freak storm coming. He runs out, picks up a rusty saw, sees the small woodpile and thinks that the saw needs sharpening. But he starts cutting instead. Even though he knows the saw won't cut as fast when it's dull, he won't stop trying to cut with it. If the saw is the organization, there are times when it is sharper and times when it is not so sharp. Our organizations are full of dysfunctions, but the task at hand drives out the need to do maintenance—it always gets pushed off.

We narrow options under stress. The problem consumes the mental horizon and from that vantage point, people apply only solutions that they've used in the past. They can't see other options. But that makes things get worse. It's called accelerating commitment to a declining strategy. This becomes a vicious circle.

People can get very clear about their strategy but very narrow. Our everyday interactions train us into mental sets, and then when certain cues come up, we automatically apply a mental set, whether it works or not.

Denial is the third traditional response to change. In Vietnam the body count was a measurement system—a balanced scorecard—and we counted the dead enemy every day. We supposedly killed three times the population of North Vietnam over the course of our stay there. Usually when people end up cheating, it's because the system is designed to help people cheat, trains them to do so and rewards them for that behavior. When confronted with this systems approach to the problem, we deny the problem out of hand. Denial is about avoiding reality and ignoring facts that lead to an unpleasant outcome. Denial is about refusing to take responsibility for something. Organizations practice denial.

Robert Quinn

iteration 1

Five Principles to Embrace

How do you get out of the rut and really embrace change?



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Get off the path of least resistance. How do you get what you want? We want to stay in our comfort zone. The other question is, "what do you want to do, or create?" If that vision or image is vivid enough, it may cause you to step outside your comfort zone. We get there by making fundamental decisions.

Practice authentic engagement. Tell the truth to people. When we make fundamental decisions the world around us changes. We are empowered to empower others.

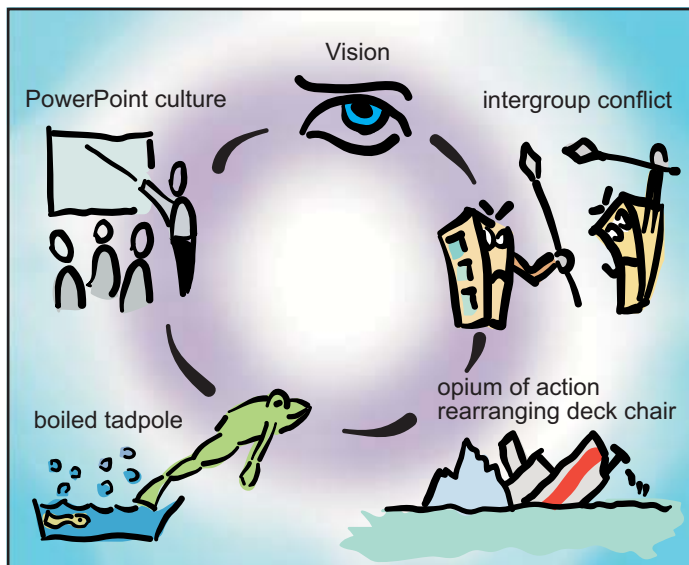
Practice adaptive confidence (competence?). This means I have the confidence to move into chaos knowing that I can move out with new competencies at some other time. Adaptive means I'm open. Confidence (competence) means I'm stable.

Grounded vision. Picture the future, ground it in what people know about the present.

Practice tough love. A lot of leaders know how to be tough. Another leader will stand by the people to discover what needs to be done to discover ways to innovate their way out of whatever situation they have found themselves in. These two capabilities must remain in creative tension with one another. One is not embraced at the expense of the other. Entice people forward in an experiment learning how to create the new system. If you're committed to working together, a new system will emerge. "We built the bridge as we walked on it." It's hard to get used to this idea. "I work in an organizing." This calls for a whole different set of pictures. We don't work in organizations—we work in an organizing.

Companies Experiencing Slow Death

Companies die slowly due to five very common reasons



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Fear of change, self-preservation, inertia, divergence between personal and corporate agenda, avoidance of responsibility all are reasons for why companies can't or won't change. People think they know what's going on. Everyone knows change is necessary but no one is willing to engage. There is always pointing of fingers to other parts of the organization or outside the organization. People believe they have run out of time.

There are a couple of behaviors that show up in nearly every company. People get burned to a crisp. Dialog dies and the "PowerPoint culture" triumphs. This means that the only time that people talk to one another is in meetings with presentations and numbers. Control gets pushed too far, which leads to lying and cheating, which leads to chaos.

You can't take the check at the end of each pay period knowing that change has to be made and not doing anything about it. That's a failure of moral courage.

The human system is another part of the problem—it's where the roots are. At least one major inter-group conflict exists in every organization. This conflict dulls the saw.

Another influence is the opium of action—just doing something to be in motion. It's like rearranging the deck chairs on the Titanic.

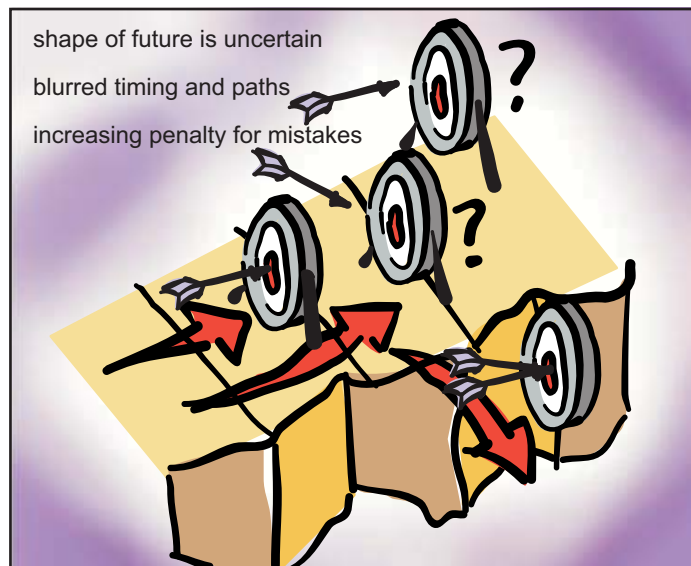
Finally, people are starved for vision. We can't connect meaningfully to one another without a picture of what's going on. People need an image to move towards. Ultimately the way people know what's real is by looking at the behavior patterns of the senior people.

Kathleen Eisenhardt

iteration 1

Uncertainty in Strategy

Three types of uncertainty plague the traditional creation of strategy



Strategy: Where do you want to do and how do you want to get there? In more dynamic markets, the two questions come together and you can't separate them. There are challenges concerning ambiguity.

increasingly one or two winners in a market space and everyone else is a loser.

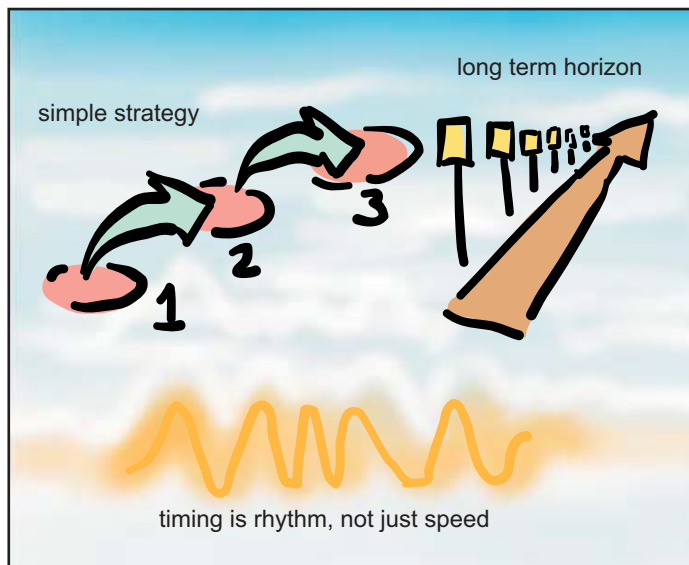
Planning is limited, reaction is insufficient and typical strategies don't work so well.

First is extreme uncertainty about the future. And even if you can get the shape of the future right, you can't get the timing right. Second is blurred timing and pathways. Third is the shifting competitive basis from products to business models. Finally, there's an increasing penalty for mistakes in the stock market. There are

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Three Key Ideas About Strategy

Have a simple strategy, cultivate a sense of time as rhythm, embrace a long term horizon



First, strategy in more ambiguous markets is simpler. This is counterintuitive but true.

The second idea is that time is central to strategy. Timing is part of how you compete and play the game. It used to be that better companies made decisions faster. Smart decision makers today aren't going faster, but thinking about rhythm and timing in addition to speed. In better companies, there is more use of a myriad of time-based measures.

Next, you have to manage over a longer time horizon. There's a tendency to think that everything will all be new in the future so the past doesn't matter. But the truth is you need to hang onto what

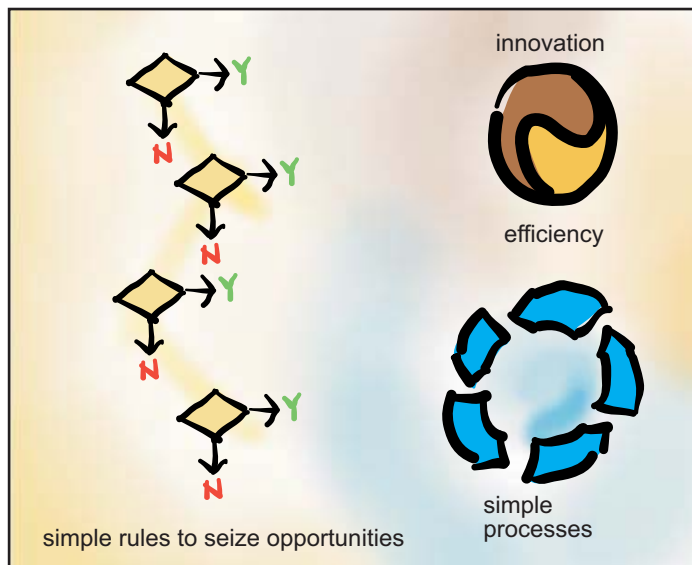
was good from the past and bring it into the future.

Also, strategies shift around in ambiguous markets. How you organize shapes the strategies you can have. Structure drives strategy.

Think of the video game strategy. The strategy for playing a video game is to just play the game. As you play the game you learn the heuristics. Also there's the idea of a "Velcro" organization. At any point in time you know with Velcro that your shoes are tied tight but you can change the tension quickly. That's what you want in an organizational strategy.

Thinking about Business Strategy

Simple rules and simple processes work in high ambiguity environments



Individual business unit strategy is more important than the corporate strategy because they're on the point of energy exchange with the external environment.

Common experience is that innovative ideas suffer from poor execution; companies aspire to lead but always follow; analysis-paralysis; and endless search for consensus.

Myths: successful companies are run by smart people at the top; success is driven by an army of revolutionaries; successful companies operate on the fly, limit information,

eliminate conflict.

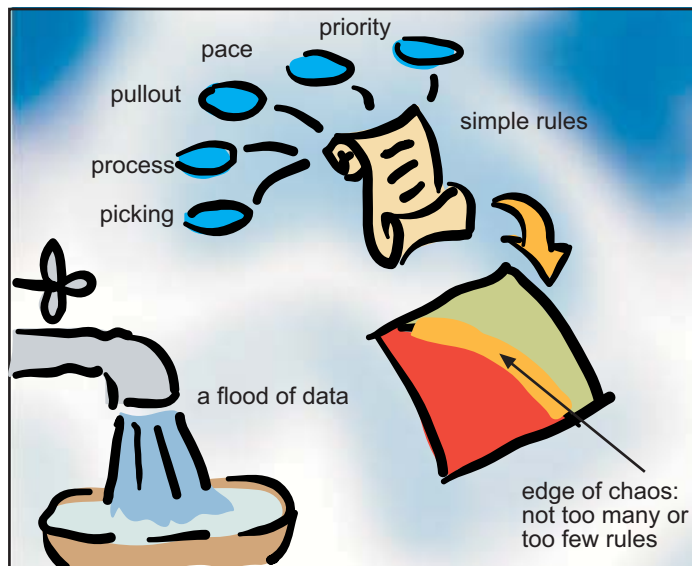
Best practice: focus on a few key strategic processes and a few simple rules to exploit opportunities; how do you get innovation and efficiency; business unit teams are central to success. The key is that strategy is a few simple rules and a process.

Kathleen Eisenhardt

iteration 1

Strategy on the Edge of Chaos

Use simple rules to live on the edge of chaos, and support it with a flood of data



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The classic way to fight a war is the positioning strategy—find the hill to defend. The second way to fight a war is the competence strategy—like leveraging a good air force. In conflicts where you don't know what you're fighting about or who the enemy is, or you're the underdog you employ the guerrilla strategy.

Guerrilla strategy focuses on a process. Focus on capturing opportunities. Focus on a couple of simple rules. You're trying to stay on the edge of chaos. The edge of chaos is a place where there are just enough rules. Too many rules

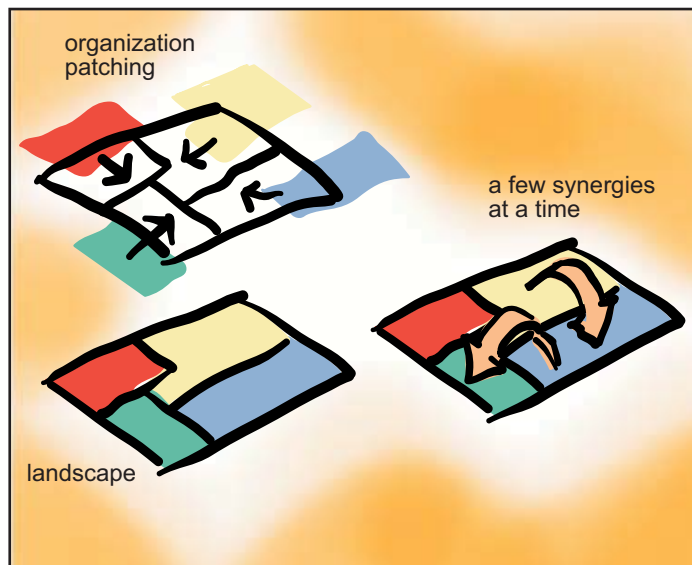
and you're too rigid to move. Not enough rules and you can't move either because everything's chaotic.

There are five rules to consider with regard to categories of simple rules. Picking (selection) rules, process rules, pace rules, pullout rules, priority rules.

You've got to keep paying attention. You want more information while improving, not less. More metrics, more often, more external, more about time. The more you look at data day after day, the more intuition you develop.

Patching and Synergies

Patch the organization components to match the landscape; provide the opportunity for manageable number of synergies



This idea comes from Stuart Kauffman. Think about organization charts. The boxes are trying to map markets that are coming and going and colliding and splitting. Patching is about how do you keep mapping your organization so that the organization is mapped onto the landscape. The best practice is matching the business portfolio to markets in a temporary way. Pay attention to the scale of the business as well as the focus. Third, someone needs to be the patching executive. Then there are economies of scale and agility to consider.

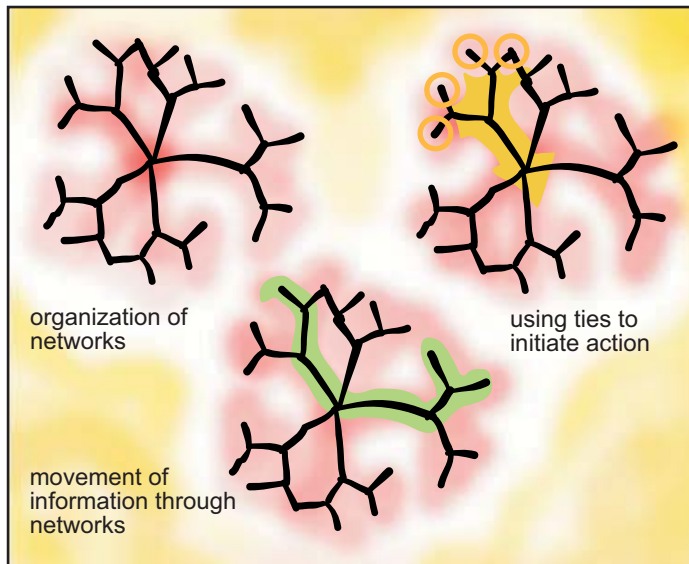
Most companies don't obey power laws when they're changing. They stay stable for a long time and then do a big change. More healthy companies do lots of little changes

and a few large changes—following a power law.

The best practice for capturing synergy in the corporation is a network. The business units are the nodes and the interaction is the synergy. Limit the number of collaborations and make them temporary. Senior managers set the context for collaboration but business units decide whether they will collaborate or not. Senior managers need to set context but don't tell people what to do. The number of links matters: too many and you can't succeed. Don't reward people to collaborate. You want them to be successful in their own businesses and be collaborative when it's in their best interest.

Overview of the Small World Phenomenon

The “six degrees of freedom” idea has a long history and broad relevance for social networks



Many of you are familiar with the phenomenon of six degrees of separation. It's actually called the small world phenomenon. The correct way to state the problem is that it's a claim that any two people in a large population can be connected by a short chain of associations. The social world is therefore a network—a bunch of individuals connected by relationships or social ties. This is not quite the same thing as discovering that someone at a party works with someone you went to school with. That has to do with human psychology: we tend to pick out patterns in the world and tend to highlight them more than others.

We're talking about those times when we don't run into someone with whom we have a mutual friend. But it's those times where you know someone who knows someone who knows

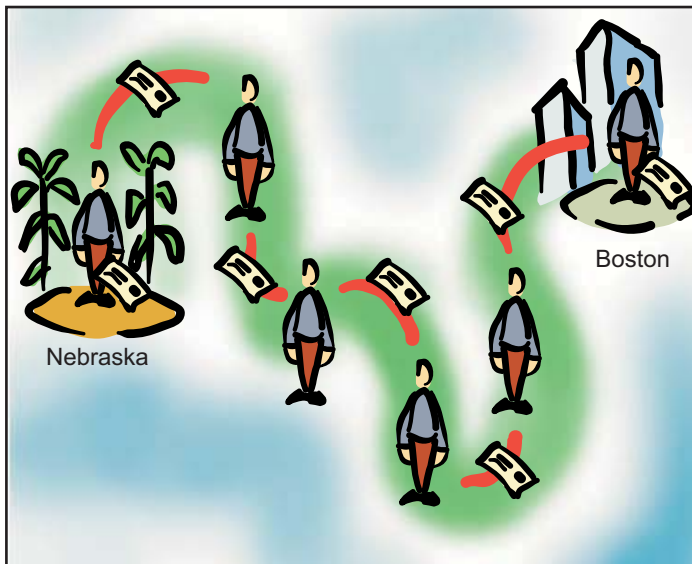
someone. It's surprising and also not surprising. It's actually a sociological problem with a long history. Even though it started in sociology, it has relevance to a great number of other fields.

It's relevant to the structure of social networks. It's a way of thinking about how networks are organized. It's also relevant to the role of social information in financial markets and efficient matching in labor markets. It relates to diffusion of ideas, social information and innovations as well as efficient searching of databases. It's also relevant to using your ties to initiate action, like looking for a job where connections really matter and it's not an open market.

We look at what other people are doing all the time and respond accordingly, creating ripple effects.

History of the Small World Problem

We've been aware that networks tend to work this way for a long time, but we haven't understood why



There has been anecdotal observation of the small world phenomenon since at least the 1920's. Originally the idea was just made up. It was published by Karinthy, a Hungarian. In the 1950's, Pool and Kochen became interested in how people mobilize political power. They realized it was a math problem. Their working paper circulated for 20 years before it was published. Then Stanley Milgram heard about the paper in the 1960's. He and Travers invented the "small world method." He chose a single stockbroker in Boston and 296 initial senders in Boston and Nebraska. Each sender forwarded the letter to a friend who is closer to the target than themselves. This repeats for successive senders, yielding message chains. Message chains either reached the target (20%) or terminated.

Ten years later Pool and Kochen tried it again. Within five steps, you can reach 10 billion people if each person has 100 friends and you have six degrees of

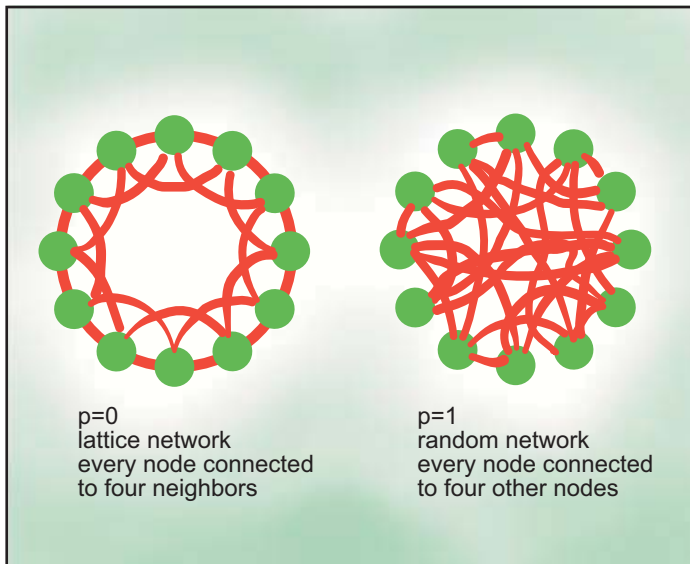
separation. But in the real world, you can't do that calculation: random ties are not realistic. If you pick your 100 best friends, each of them will have a lot of overlap with you, which is called clustering. Like tends to associate with like. You tended to get to know people because you were introduced to them by a mutual friend. As a result you get lots of little triads.

The interesting small world problem then is how is it possible for social networks to be highly ordered locally and still be small globally? The problem is that clustering makes analysis hard.

Nothing happened after Milgram for 30 years. The experiments were hard to perform and large scale network data is hard to collect. Computers allowed us to ask the question, "what are the conditions under which any network can be clustered and still be small?" The main idea is to interpolate between ordered and random networks.

Between Random and non-Random Networks

Clustering and path length can be optimized at a relatively low degree of randomness in the network



So what happens at the extremes where $p=0$ (lattice networks) and $p=1$ (random graphs)? When $p=0$ there are long path lengths if you only know the two people each on your right and left. Messages skip around the ring in 250 steps for 1000 people in the network. Path lengths are very long but clustering is high.

At the random extreme $p=1$, you get exactly the opposite. Here the connections are determined randomly. Path lengths are short and there is no clustering. This implies a small world that's not clustered or a big world that's clustered. But for networks between $p=0$ and $p=1$, there are more interesting phenomena. At $p=.01$, the length has dropped very low and the clustering is still very high.

The length is governed by the number of shortcuts or random links. Surprisingly, five shortcuts reduce average path length by a factor of $\frac{1}{2}$ regardless of the number of nodes in the network. But clustering is governed by the fraction of random shortcuts. When the population is large, then a very small fraction of shortcuts will have a big effect on the path length but will leave the clustering unchanged.

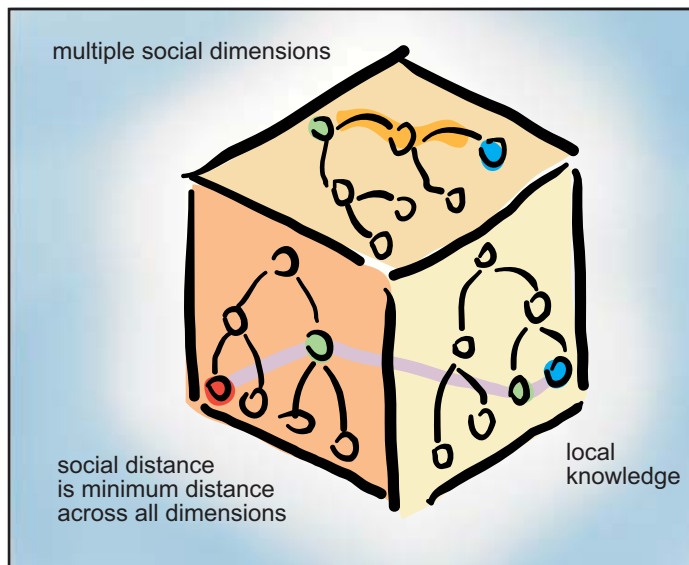
This holds for any kind of network. It was tried successfully with movie actors, in the power grid of the Western US, in neural networks, in the World Wide Web, in ownership network of German firms, in collaboration networks of scientists and in boards of directors of Fortune 1000 companies.

Duncan Watts

iteration 1

Sociology is Important to an Understanding of Networks

Social distance, multiple dimensions, incomplete knowledge, and searchability



A group is any kind of context for interaction. Some groups are more similar to each other than others. There is a hierarchical organization of groups. Teams, departments, divisions, companies, industries. The distance between two individuals is the lowest common ancestor in the hierarchy.

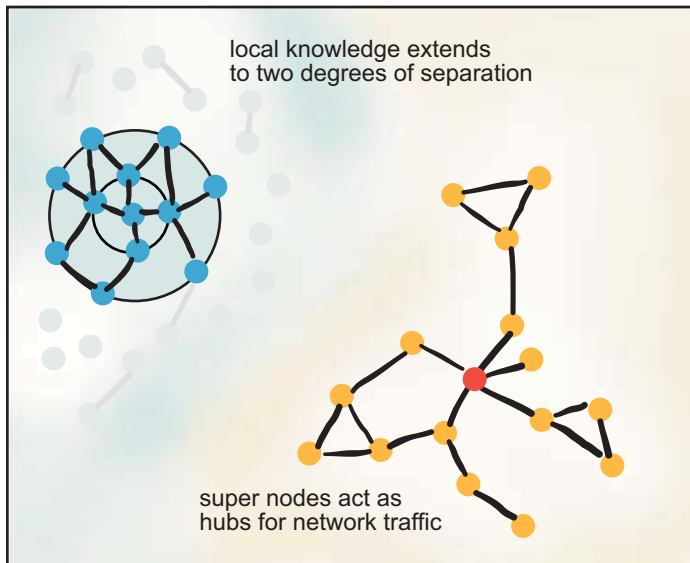
Hierarchy is a cognitive device but it isn't actually the network. Network is generated as a function of social distance—the tendency we have to know people who are like ourselves. Individuals cluster the world in multiple ways. This leads to the notion of social identity or sets of groups, like geography and occupation—multiple dimensions. Social distance is the minimum distance across all dimensions.

We have two kinds of incomplete information in the problem now: social distance and network local knowledge. The main result is that networks turn out to be searchable because it's a generic property of networks. The small world problem is a particularly clean example of social search (locating a remote target using local ties). Social search is a critical aspect of problem solving when the environment is uncertain or ambiguous, and a central database or directory is absent. A peer-to-peer network is an example. Human organizations are already efficient peer-to-peer networks. By extracting the essence of social search, we may be able to design better protocols and smarter networks.

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Kleinberg Networks and Scale Free Networks

Local knowledge in networks and simple search algorithms that rely on hubs



Jon Kleinberg identified the “Algorithmic Small-World Problem.” Beyond a circle of friends, you don’t know much. We have a pretty good knowledge of our friends and a much hazier knowledge of the next ring out. Beyond that it’s a world of strangers. Beyond two degrees you might as well read about it in the newspaper. So, six sounds small, but it’s a really big number in practice. You can’t call up the sixth degree of separation and ask for a job. Nevertheless, the subjects of Milgram were able to solve the problem of reaching the target with only local information and some heuristics.

Scale-free networks implies the existence of a small fraction of highly connected hub nodes. A simple search algorithm—direct message to your most connected neighbor—quickly finds hubs and jumps around

randomly until the target is found. Seek out the hubs and let the hubs do all the work.

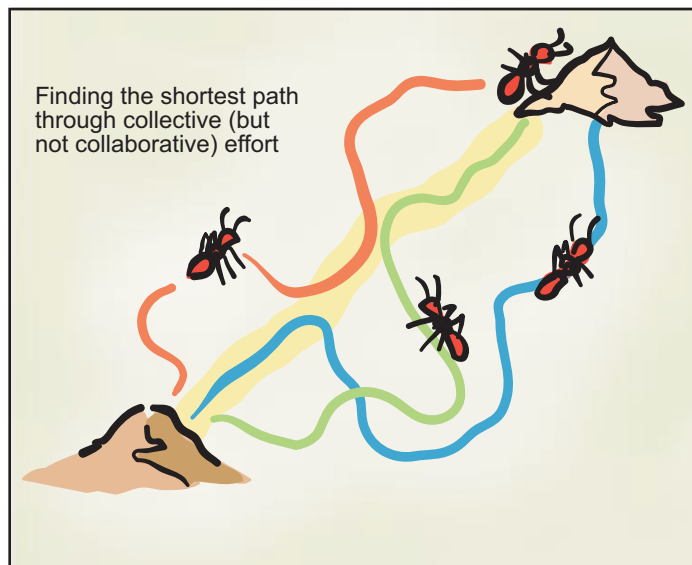
There are some problems with these ideas. They assume that social networks are based on geometrical lattices. There’s no evidence for that. The social world also doesn’t have a condition that the world has to be “just so” in order for it to be easily searchable. There’s no organizing mechanism that creates this condition. We need a model that’s more forgiving. Real social networks are not likely to be scale-free. At the very least, they have cut-offs. The limitation of how many friends you can have is not a function of the size of the system. You only have so much time, energy and effort to devote to other individuals. Also social characteristics like geography are important.

Norman Johnson

iteration 1

Dumb Collectives Solving Hard Problems

Collectives where the individuals lack a global view and don't collaborate can still zero in on efficient solutions



Individual ants in a colony are “dumb,” chaotic and have no global perspective. They have no leaders or central coordination. But they still find the most efficient paths to the food. But this type of cooperative problem solving only works for groups of diverse dumb agents. It's only because they take different paths that they solve for the shortest distance.

Because of the positive reinforcement of collectives, they pick one path over another instead of even selecting two equal paths. There are a few ants picking the best path that

make the rest of the ants choose that path.

A researcher put out food for bees, videoed the bees and then the next day he put the food out at a distance 2X. On the third day the bees were waiting for him out at a distance of 3X. Why are social insects so disturbing? It's because most hive functions are emergent properties.

Why aren't we as impressed with human collectives? Because we're a part of the system and generally underestimate self-organization in our own systems.

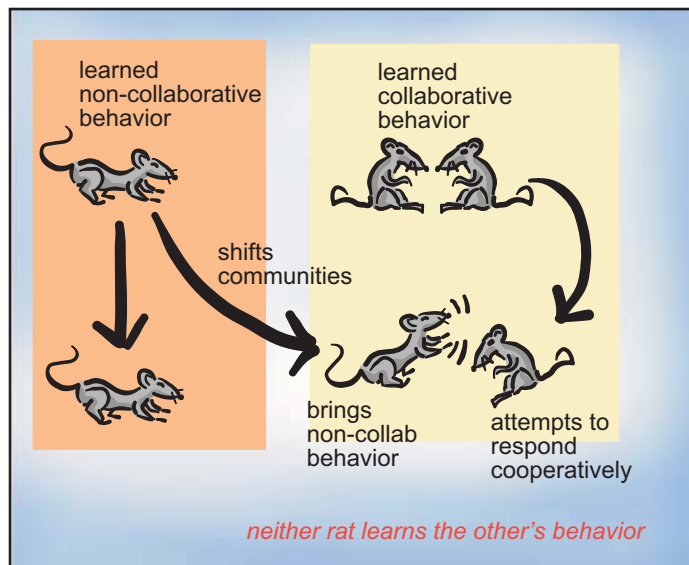
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Norman Johnson

iteration 1

Rat Studies of Maximum Carrying Capacity

We take learned behavior into situations where it may not be the most effective strategy and employ it there anyway



A researcher was interested in understanding the importance of socialness in population growth. He set up two experiments. On one side was the control group. He put 2.5x the number of rats that are the normal density in the control side. They get very anti-social behavior at this density. On the other side, he made them cooperate to get water. Two rats had to push the water bar to get water. If only one rat pushed the bar, a bell went off, and they learned to rush over to push on the bar. This system actually allowed for 8x the normal density before pathological behavior took over.

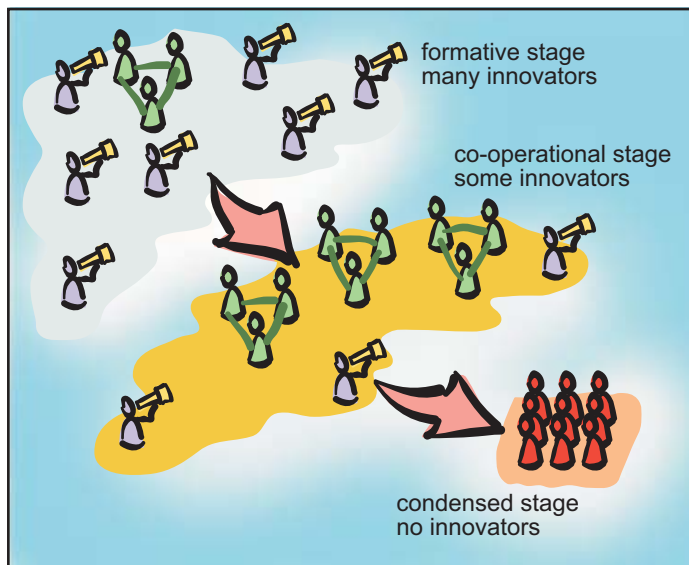
One of the control rats got over into the cooperative side and pushed the bar. The other rats came over to help but he fought them off because in his world approaching rats are competitors. But the cooperative rats were so conditioned that they would not fight back. Even the injured ones would go back to try to help some more.

The past history of how a system gets to a point in its evolution determines its behavior even in extreme situations where an alternate behavior would actually improve survival chances.

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Change in Collective Systems

Systems develop through three stages that shift in part based on environmental change



Here's a model of ants foraging for food or of three stores selling something and you don't have a map to find them. When an ant finds food, it returns to the nest, leaving a pheromone cloud for other ants to follow. The ants are dumb. They know current direction and whether they have food--that's all. They have three rules: carry food, drop food at the nest, and search if there are no pheromone trails to follow.

We can break the development process they go through into three stages: formative, co-operational, and condensed. In stages one and two, individual behavior is locally chaotic. In stages two and three, behavior is globally predictable. Performance in the first stage is individual; in the second stage it's found in the synergy of individuals. In stages one and two, diversity is high and in the third stage the diversity is low.

Now how does change work in the

system? Because the existing solution is so strong, a new source near the existing solution will draw more interest than a new source closer to the nest.

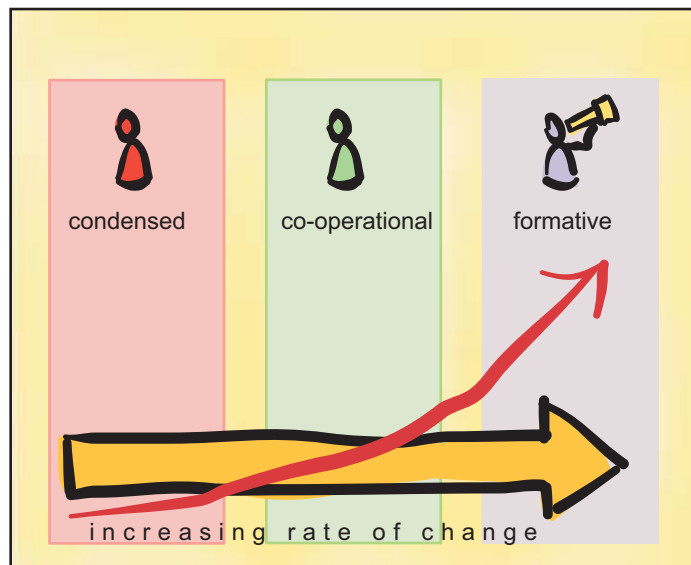
What if the change involves moving the source in a circle at different speeds around the nest? When the food source moves slowly, productivity is only slightly less than for an unchanging source. Herd effect allows for quick utilization of the new resource location. Innovators become important again by sustaining optimal performance of the collective. What happens if the velocity speeds up? At some point, the food source detaches from the optimized solution and the collective gets lost and has to reacquire the target from scratch. There was a boom cycle but because of the speed of change there was a bust cycle. When the velocity further increases (rate of change) it becomes impossible to acquire the target for any length of time at all.

Norman Johnson

iteration 1

Collective Efficacy

In situations of higher rates of change, collective behavior becomes detrimental to system success



Now we should quantify how productive the collective is—the collective efficacy. When it's positive, the collective is actually getting extra food. When it's negative, it's inhibiting the system. As the rate of change increases, the collective actually becomes a detriment to the system. If you increase the number of innovators, the system jumps up and becomes almost as productive. But there are some puzzling things. In the boom and bust cycle, there is higher productivity than in the stable case and also has lower minimums than the stable case. What appears to happen is that the bust is preceded by an

increased coherence—the collective gets too efficient. The rallying effect in the face of change may actually be detrimental.

If there is unimpeded development, systems move to the condensed stage. If innovators are essential because change speeds up, the system hangs out in the condensed and co-operational state. If change happens faster than the collective can handle, the system hangs out in the formative stage with lots of innovators.

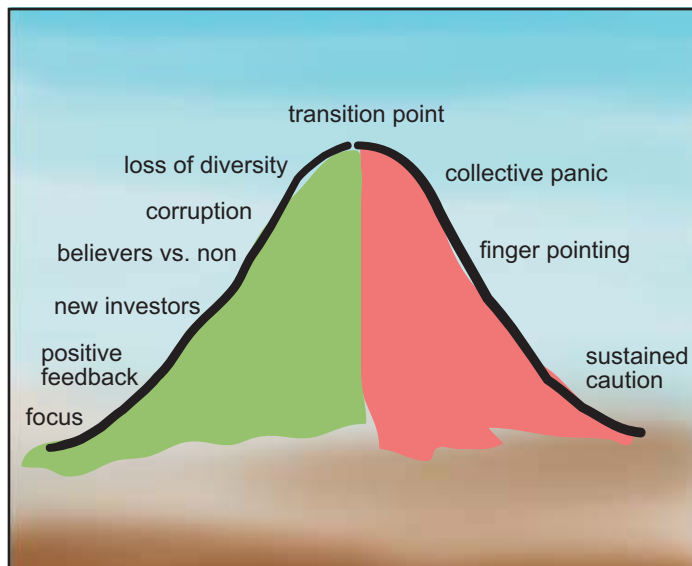
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Norman Johnson

iteration 1

Behavior in Bubbles and Busts

Bubbles and busts are accompanied by readily recognizable behavior patterns among agents and systems



Dynamical excursions plus behavior lock-in equals long term dynamics. Here are some common traits of bubbles and busts. Something focuses the attention like an invention. There's a positive feedback loop that increases the price, often encouraged by changes in rules of investment. Then there's an introduction of new, often inexperienced investors. There's a sorting out between believers and non-believers. There's an overestimation of potential profits. There's corruption in the system. Diversity is lost. A transition happens. Collective panic and finger pointing is followed by sustained cautiousness.

How is the system built? There are individuals that are part of a social network (diversity, connections,

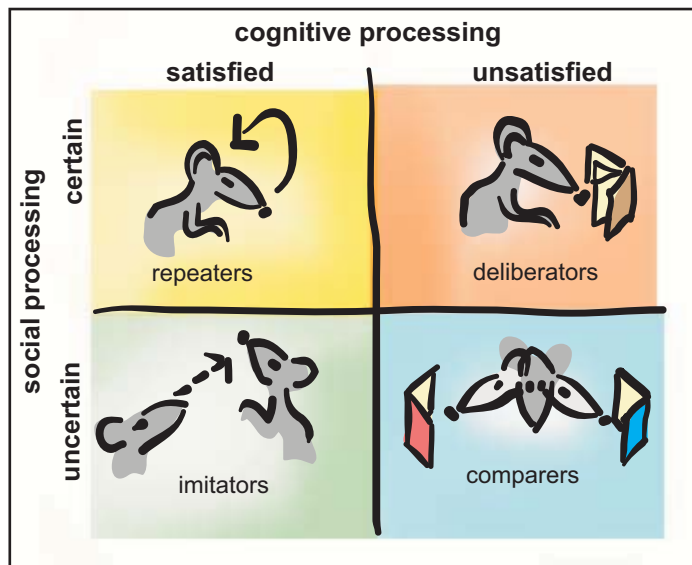
strengths, asymmetry, change) Individuals are connected to other individuals, groups and regulations. The individual has memory, motivation and sensory ability. The general environment sets the context of the whole system. What are the dynamics of the system under stability and in response to change?

We need to create an agent model of the psychology of the individual. Perhaps we can combine current models into a single quantitative model to help understand how people make decisions. The model will have a human environment, strategies, abilities, types of needs, level of satisfaction, etc.

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Four Behavior Styles

In collective settings, agents take on one of four different roles and then migrate between roles as the situation evolves



Consider a model with two axes: cognitive processing—satisfied or dissatisfied; and social processing—certain or uncertain. There are four behavior styles in the matrix. A repeater is certain and satisfied. A deliberator is dissatisfied and certain. An imitator is satisfied but uncertain. Finally, a comparer is dissatisfied and uncertain. Stress increases moving from certain to uncertain.

Researchers conducted a small world model with 1000 consumers buying 10 products using this model.

If the population is all repeaters, there are few products of equal distribution. If the population is all imitators, there are few products of unequal distribution, but highly stable. In a population of deliberators, there is high volatility on all products. Many economic models assume this. If the population is comparers, there is volatility over long times for a few

products. The time swings are longer because of the social interaction. Repeaters are dumb agents; deliberators are homo economicus; imitators are socially driven; comparers are social and rational at once. What's missing in the model is how to change behavior with feedback.

So there are the four behavioral types and the three stages of collective behavior. If there is little change, the system goes to habitual behavior in a condensed collective. If you whack the system, on the collective level it goes back to the formative stage and individual behavior shifts to social and rational behavior. In good times, people are very optimistic and their habitual behavior mirrored that feeling. After change, they can be pushed to the socially driven behavior and be all pessimistic.

Norman Johnson

iteration 1

Sustainable Strategies in Fast Changing Times

The bottom line is to become more aware of the patterns around you and acknowledge your awareness of them



First, feed your mental simulation and think about how things might work. Next, keep the strategy simple in times of fast change. A good example is an early chess program. If you picked a level looking three levels ahead, it was a tough match. If you picked a level looking eight levels ahead, it was thinking that the player was a lot more complex than it really was and you could actually beat the program.

It's important to recognize stages and states. Strategies should match the stage. Enable diversity. Focus on processes, not specific predictions.

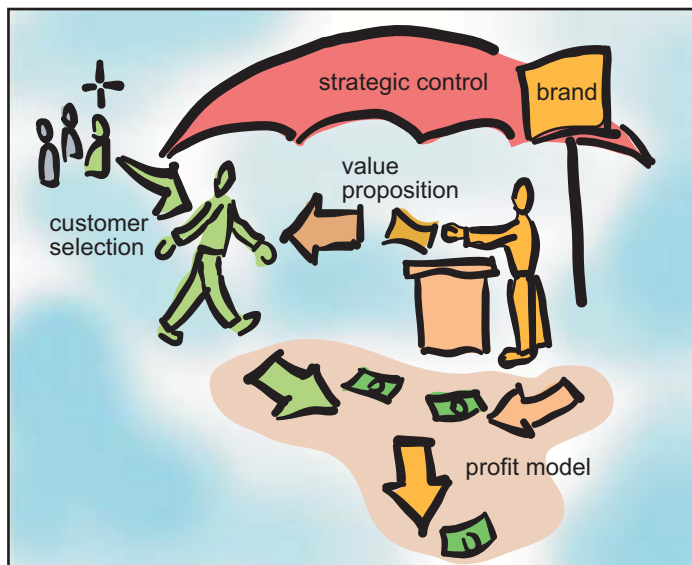
Strategic planning is about developing process not product.

Optimize your response to herd behavior. Recognize herding by the loss of diversity. Resist condensing your social network. Rely on diverse communities. Become more flexible in responding to change even though your tendency is to become more rigid. In times of change, we're mixing groups, and what is acceptable ethics in our community may not be acceptable more broadly.

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Business Models

Everybody in the company must understand how it creates profit, makes money, and how the model will change



Customer selection, brand, value proposition, profit model, and strategic control are the five factors of a business model. If the model is already four or five years old, it will have to change soon or risk value loss. The last two dimensions were the most challenging: how does the business find the profit zone?

Profitability is more important today than it was 20 years ago. It used to be that profitability varied as market share, but no longer. No profit zones have proliferated to airlines, consumer electronics, PCs, homeowner insurance, cars, beverages in a grocery, films, agriculture, environmental remediation, lots of manufacturing.

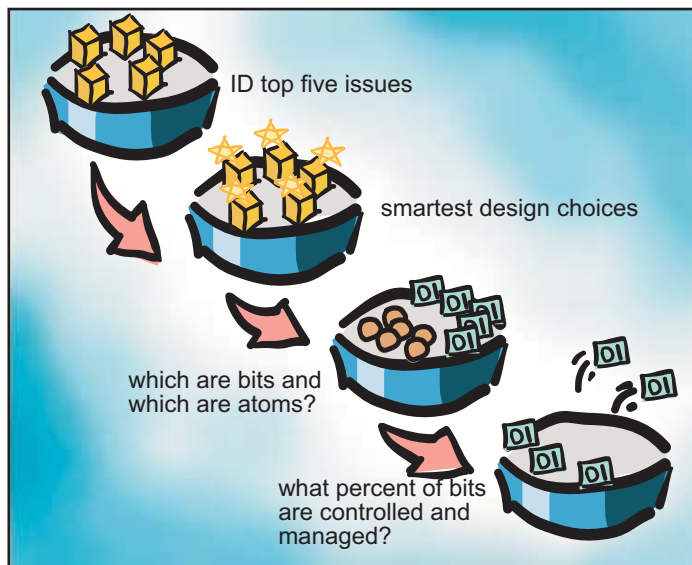
The Art of Profitability focuses on

business design 2.0. It's designed to get people in organizations to understand profitability. How does profit happen in the business? There are at least 23 different models. Second, how can we get everyone in the organization to understand how we make money? Third, what will our profit model be tomorrow and how will we make the change?

Things changed in the late 90's. The digital wave was not seen as a tool to build a better model, but as a fashion item to wear. But some companies like Dell took the digital transformation to heart. Dell shifted from a conventional to a digital design.

Digital Transformation

Many companies treated digitization like wearing a new fashion instead of using it to drive growth



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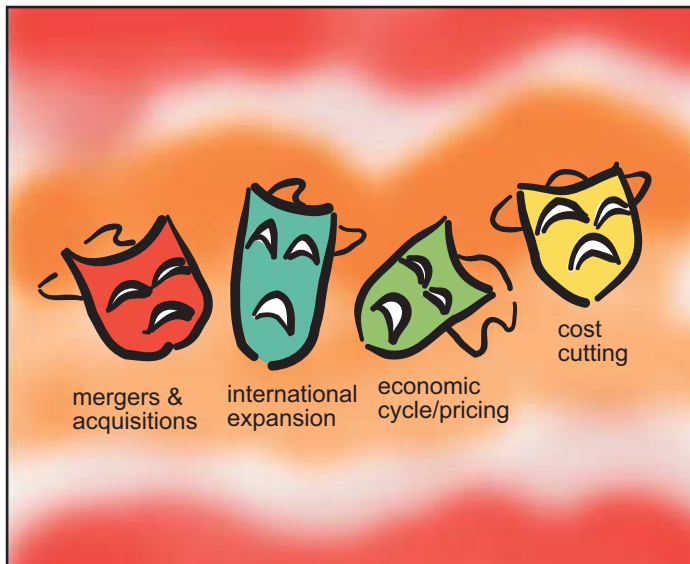
Executives need to ask themselves several questions. What are the top five business issues that face my company? What are the smartest design choices to those issues? Which activities are atom-based and which are bit-based? What percentage of the bits are managed completely by our company? Don't take a bad business and put it online. Dell did an order of magnitude improvement in inventory turns. The Internet offered a 10x improvement in productivity to many companies in many different measures.

What are the characteristics of the worst business in the world? It's a commodity, capital intensive. bar. Barriers to exit. There are others. What is described here is every textbook's definition of a commodity,

like cement. But even in the cement business, the business model can transform profitability. Unforecastable demand is what kills the cement industry. A Mexican company started thinking about this. They went to FedEx to learn how they forecast. Then they put the technology to work. They used digital to build a better business model. Then they concentrated the investment city by city increasing market share and reducing logistics cost. Cemex has ended up being the most profitable even though they are not nearly the largest player. The biggest cost of the fashion aspect of the Internet is that it distracted companies into spending money and focus on bad IP.

The Growth Crisis

Traditional sources of growth can no longer be tapped by most companies



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In 2000, many companies lost a lot of value and some of these were companies with great products like Kodak and Gillette, Polaroid, Xerox and Lucent. They had great brand names at one time and great business designs. We called this the growth crisis. It's like value migration where value moves from company A to B but without the "to" part of the migration. IBM didn't lose value to another company. The value simply went away. Why?

There were masks over the growth crisis: mergers and acquisition, international expansion, economic cycle/pricing and cost cutting. Winners across a lot of industries could create growth through these four masks. M&A was a key growth driver in the 1990's. It increased from \$100M to \$900M a year.

What do your company's growth prospects look like? To what extent can you rely on product related moves to fuel significant growth? If your annual

growth rate bounces around between 9%, you're OK. But if your potential for growth is decaying, then that's a serious problem.

The traditional growth model has hit the wall. It had three dimensions: invent new products, globalize, and consolidate your sector. That model carried the winners for the past two decades. It's harder to find an industry that's not globalized. But product innovation was the soul of growth in the past 20 years. Great products are still available in some industries. But for most of the rest of us, that's no longer the case.

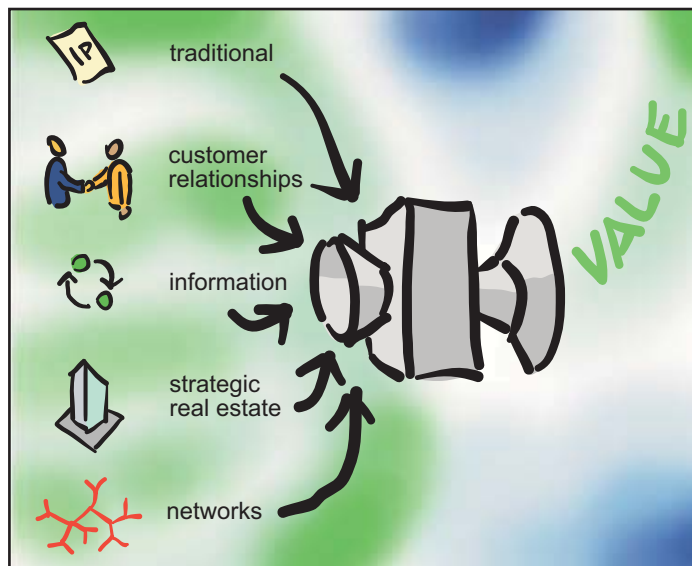
Industry by industry, there are no big product innovations that really matter. In the next five years, product innovation will become more important, but its role will become engine of profit replacement instead of engine of profit growth. You have to invent new products just to replace the profit you're losing.

Adrian Slywotzky

iteration 1

Business Design Innovation 4.0

Focus on the value your assets (many of which are hidden) can create--their prospective value--not on their intrinsic value



We have to ask the fundamental question, "what is the nature of next generation demand in my industry." Demand is about product functionality, but today's economic systems are so sub-optimized that new value can be created for customers that goes beyond functionality. The new growth chess board looks like this. What new benefits can I create as a supplier? Reduce risk, cut cycles, cut capital, help them sell more? How many of those things can you sell to the purchasing agent? You can almost never sell economic benefits to the purchasing agent. But who can those benefits be sold to? Where is the need? Where is the buyer with a budget? The engineer, plant manager, business manager?

Which of those needs or benefits can be created profitably? Most companies have built up an array of hidden, uncounted, unmanaged assets. They come as traditional assets, customer relationships, information, strategic real

estate, networks. Most of the discussion has been focused on traditional assets and obsessively focused on what the assets are worth. Instead, we must ask what value the assets can create. Traditional assets include IP, methods or core competencies, or brand. Customer relationships include reach, interaction, understanding, trust. Information assets include market, software, and systems.

Many companies talk about offering solutions. But few have created solutions and made money. Most fail because of a failure to leverage hidden assets or overlooked hidden liabilities in their company. An asset should allow value creation, superior economics or offer new sources of strategic control. Few companies have done this.

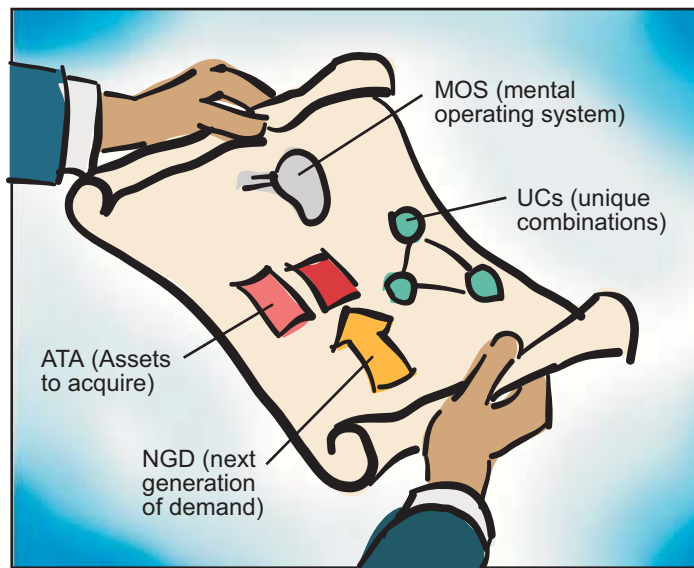
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Adrian Slywotzky

iteration 1

Early Stage Business Design Innovation

Create a blueprint for the next generation based on a positive growth mental operating system



Successful companies use a set of simple rules to focus the company on what's important. Define the mental operating system and determine whether this is growth positive, neutral or negative. There is a small group of companies that understand that it's still about business design innovation. If you want the growth you have to create it yourself. What is the nature of next-generation demand? What assets do I need to acquire, How can I create a unique combination? There are other key questions that you have to ask.

hard work. The future is conditional. It depends on how many companies see the opportunity of business design innovation. There's deterioration in earnings quality. How much bad growth is out there? We don't really know.

What's at stake? This is very

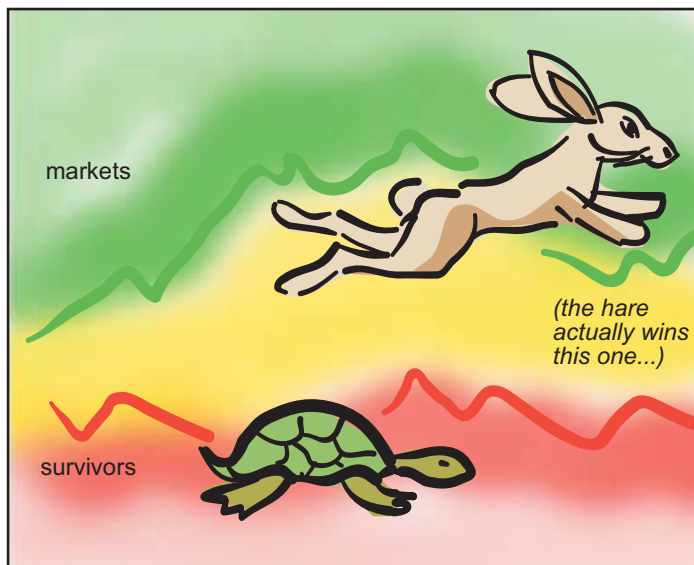
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Richard Foster

iteration 1

Survivors Underperform the Markets

The companies that tend to survive routinely underperform the market: their returns look like debt returns



Capital markets are loaded with non-linear forces. B.C. Forbes founded the magazine in 1917. He invented the gimmick of the 100 largest companies in the company to improve sales. Seventy years later, 39 of those companies still physically existed. That was an interesting list. In 1987, eighteen of them were still in the top 100. In 1918 if you had invested in only these 18 companies, they did about 20% worse than the capital market. We thought that wasn't a particularly good answer.

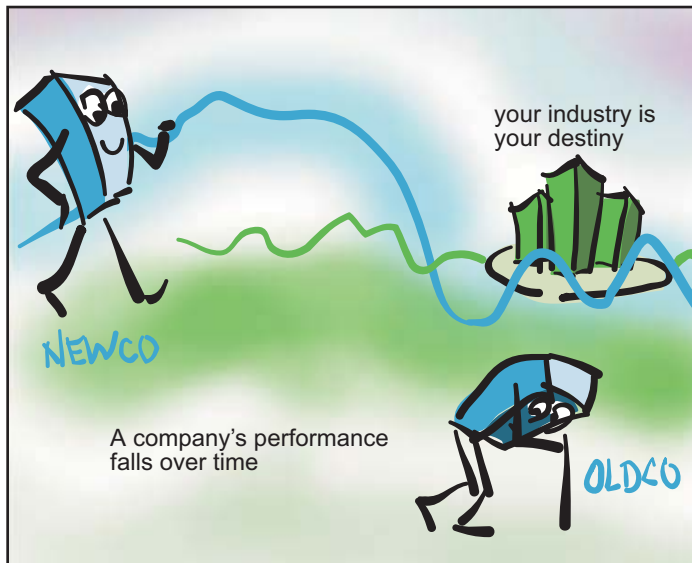
to the S&P they have done 20% worse per year. In great growth periods, they do significantly worse. Survivors actually underperform the markets. They look like debt returns. We looked at the returns of these companies vs. bonds, and they were very close.

We looked at the S&P. In 1926 we picked the 15 companies that survived until 1999. Relative

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Conclusions For Industry and Company Performance

Older companies tend to produce lower total return; industries can sustain failure as a whole; your industry is your destiny



The long term equity-debt spread controls the availability of risk capital in the economy. If there is no market for risk capital there is less innovation and the incumbents have the advantage.

Mature industries track the economy. About half the industries do this.

Most companies perform as their industries do at best. This means that your industry is your destiny and most CEO's don't like to hear this.

Dynamic industries both out and under perform the economy for a while at least. Success is hard to sustain. An example is Pharma in the 1980's. In the mid to late 1970's the industry had a huge collapse. This was caused by the inattention of the Federal government to a number of factors: Medicare pricing, patent life, high interest rates,

Semiconductors is another case. There

was a huge collapse in the mid 1980's when the Japanese built major DRAM factories that caused a price collapse. Companies then made the shift of microprocessors in the 1990's.

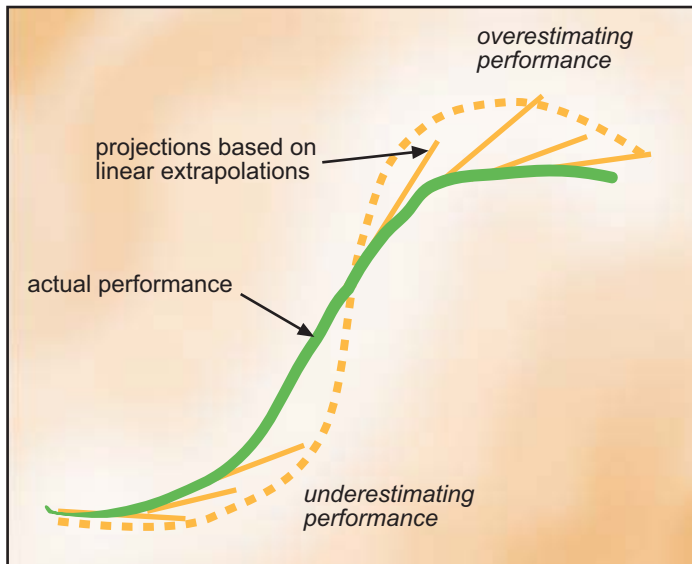
Industries can sustain failure, and the core example is airlines. For 40 years, the industry has underperformed the economy. Since the early 90's even Southwest has been performing with the rest of the pack. Risk factors in an industry are idiosyncratic.

High returns attract competition which lowers returns. Change in number of new companies in the industry varies with Total Shareholder Return (TRS).

Age matters. After companies are more than 15 years old, their TRS falls. There are above average returns in the early years, but below average returns in late stages.

Linear Projections Fail on Non-linear Phenomenon

Linear forecasting over a non-linear business evolution curve yields mis-matched returns by phase and bubbles



Industries evolve in non-linear ways, for example on a typical logistics or S-curve, the way networks grow. Industries actually evolve like this. (However, there's much more dispersion at the top of the curve.)

How do we make simple forecasts of complex evolution? Understand every company in the industry for the last couple of years, and create an estimate. Because of the linear extrapolation each year, you end up making positive adjustments and then negative adjustments as the curve bends first up and then flattens out.

NPV anticipates cash flow evolution. TRS does not track income and there is no risk. Moreover, early P/E ratios are unrealistically large. What if we use a projection model instead of a perfect information model? It evolves more slowly in the beginning and then

there's a bubble at the end of the curve. The investor receives higher returns in the beginning, lower returns in the middle as it adjusts, and then lower returns at the end. The return is falling as the business is improving. Higher returns are in the early part of the cycle, yet in the middle of the high growth period, there are modest returns. The P/E tracks and traces the total return to shareholders.

What if there is faster evolution over 20 years and the greatest growth is over 10 years? You get a bubble. There's very high return to shareholders, then a rapid collapse, and then a small bounce back. P/E ratio also collapses.

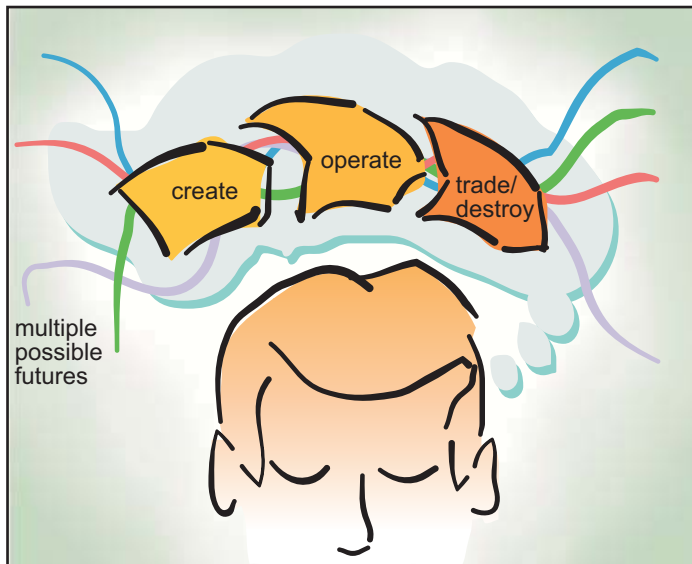
More complex patterns yield more surprises.

Richard Foster

iteration 1

Modeling Companies in a Non-linear World

Companies that used to focus on operating need to add creating and destroying to that focus



Creative Concept 045 Thought Leader Forum 2002

What if we are all linear extrapolators operating in a non-linear world? Then systems are being designed that are immune to disconfirmation. The outliers are being excluded where all the evidence of the non-linear trends are hidden.

There are multiple future paths that could happen. In order to plan appropriately we need to hold them in our minds at the same time, embracing the creative tension. We think and see through the use of our mental models. "I see it when I believe it."

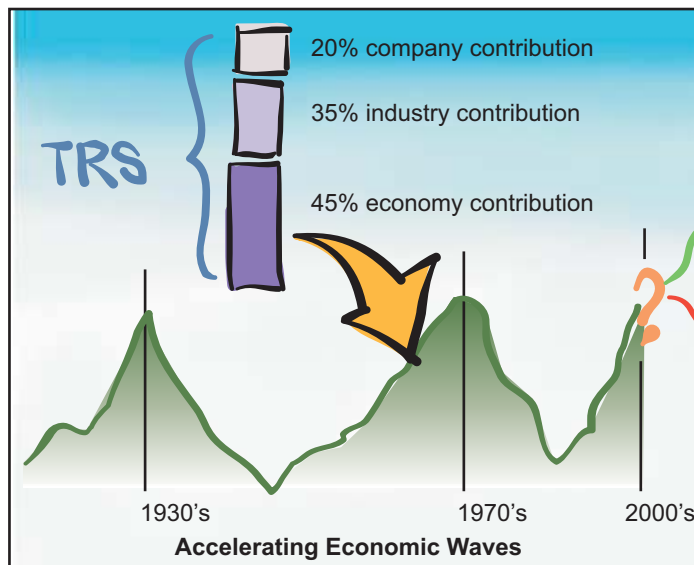
Companies operate, but markets create and trade/

destroy. Companies need to see themselves in the create, operate, trade/destroy model. The process of creative destruction is the essential fact about capitalism. It's about what's happening at the periphery.

The rate of change increases. There have been 869 substitutions in the S&P since its founding. The rate of substitution has been increasing steadily over time in three great waves. The assumption for the future of the S&P is discontinuity. In fact, 75% of the S&P in fifteen years will be company names we don't know today.

Asset Management Implications of Creative Destruction

The faster the pace of change, the more we will mis-estimate until we reconceptualize the investment process



What are the sources of longer term shareholder returns? About 45% comes from instabilities in the economy. Another 35% comes from industry dynamics and the remaining 20% comes from the company.

The natural unit of analysis for securities is the industry first and then the company, not the other way around. History does not forecast future turning points. Industry risk analysis does.

High alpha comes as much or more from understanding the industry as it does from understanding the company. High company alpha comes from the periphery.

Time scales of analysis matter as well. A faster pace of change in the

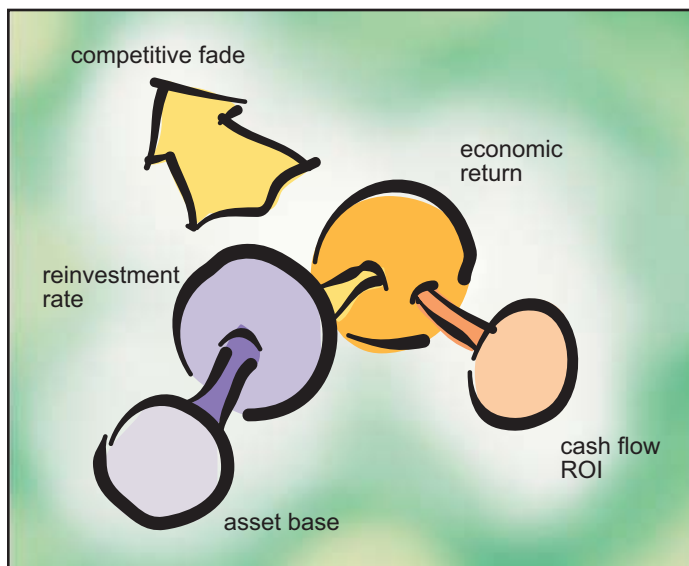
future equals higher volatility. Bubbles won't be eliminated. The more uncertain the future is the more we will misestimate.

Times have changed. Over the last century, the economy would get going and then get whacked. It really got roaring in the 20's and really got whacked in the 30's. After the 30's, we started the greatest boom, reaching the highest point we've ever seen in the 1950's. Then we started a long slide down to the 70's. Then there was a huge build up to the early 90's.

Can today's investment process be relied upon to produce strong returns in the future, or do we need to reconceptualize the investment process?

Competitive Fade

Companies tend to lose competitiveness over time as a natural consequence of competition: measuring this could be valuable



Competitive fade is a pattern over time of a firm's economic returns and reinvestment rates. These two variables are involved—instead of one as in the traditional approach. Over the very long term, a firm's economic returns should regress to the competitive average.

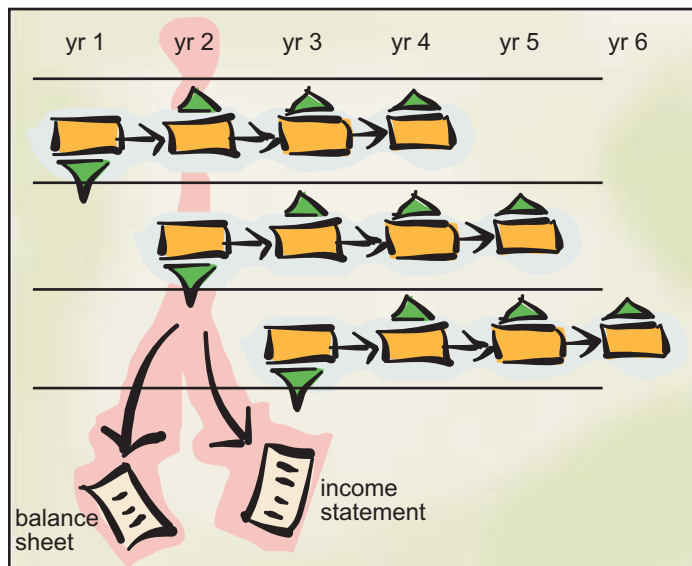
Basic discounted cash flow is the net cash receipts stream divided by one plus the discount rate. We generate net cash receipts from CFROI, and the reinvestment rate from the asset base. CFROI's are inflation-adjusted, as is the discount rate. We view this as a package or

a total system.

The typical approach to the discount rate is made from backward looking data. But this is a total system. All of the parts are related. The discount rate is a market-derived forward looking discount rate. Very similar to the yield to maturity on a bond.

A Company is a Collection of Projects

Looking at company initiatives as a set of projects allows a true focus on business economics

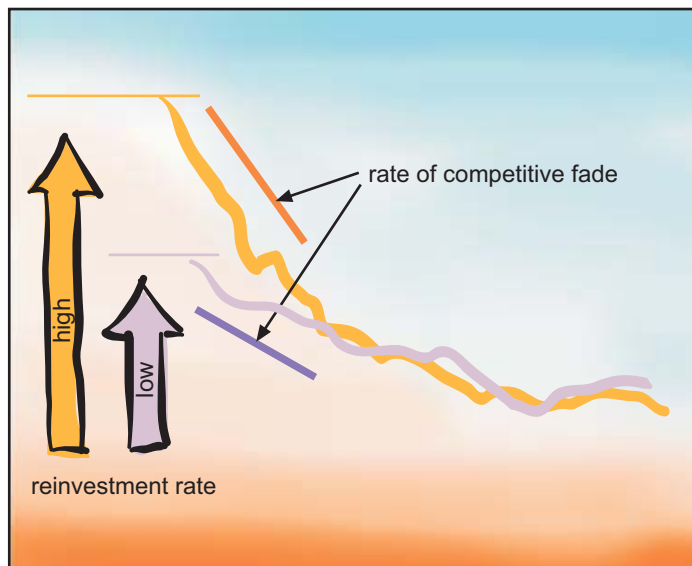


A company can be seen as a collection of projects. For example, if a firm has 4-year projects, each has an initial investment, four years of cash flows and an internal rate of return. We can build up a firm as a set of these projects staggered over time. Now a balance sheet represents gross assets and working capital—depreciating assets and non-depreciating assets. The income statement represents cash flows from this portfolio of projects. This focuses on business economics. So how can we better adjust the reported accounting data to better represent business economics?

If we have a balance sheet and income statement for a particular year, we want a cross-sectional, internal rate of return and average IRR of a firm's portfolio of projects. We start by capitalizing all the assets employed. We specify asset life and gross cash flow over the life. Then we specify the non-depreciating assets so we can calculate the IRR. Everything is in current dollars. This gives us a time series of CFROI's to help us display a firm's track record. We can compare a company's returns from 2000 to 1970 and make peer comparisons domestically and internationally.

Competitive Life Cycle and Corporate Fade

Cash Flow Return on Investment is coupled With reinvestment rates; rate of fade is proportional to reinvestment rate



In the beginning, if the firm innovates, there are high returns and CFROI's are above average. This creates a magnet for competition. Next, CFROI's fade down and reinvestment rates slow. The two go together. If you want to create a lot of wealth, couple that with a high reinvestment rate. But very high reinvestment rates fade at a much more rapid rate than lower reinvestment rates. So there's a trade-off involved.

Imagine two companies that have identical CFROI's, but one has a high reinvestment rate and the other a low rate. The one with the low rate fades at a slower rate than the one with the high rate. When firms fall below the average cost of capital, they need to restructure or improve or they will go bankrupt.

To get back up to the cost of capital, they have to contract assets in a large way and change the business as usual mentality.

As an example, consider IBM. We compare CFROIs to IBM's estimated discount rate. The actual asset growth rate went up, then IBM got into trouble, and the assets were contracted. Now the asset reinvestment is back up. We also examined the relative wealth index. When IBM was underperforming the market, the relative wealth index was compatible with the market performance. When IBM ran into problems, the relative wealth index dropped.