

Why Small Companies Exist

Organizational Entropy Effects on
Business Efficiency

The Question

- We are all familiar with economies of scale. Large operations are more efficient than small ones, big factories make widgets at lower cost than small factories. Wal-Mart can drive small stores out of business everywhere they go.
- But in our business this effect doesn't seem to exist, does it? The exhibit hall at National has hundreds of small companies that do well. Why hasn't some large company "Wal-Marted" all the small corrosion firms out of business?
- Sometimes big wins and sometimes it doesn't. Something strange is going on here. But what?

The Answer

(at least partially)

- Believe it or not, research on the intersection of business theory, computer science and physics has given us a possible answer.
- It turns out that there are at least two different KINDS of work. Physical work and intellectual work.
 - Physical work has economy of scale
 - Intellectual work does not.
- The reason for the difference is communication. Thinking work such as engineering requires people to talk to each other, and the more we talk, the less we accomplish. So, the more people who are involved in making a decision, the more slowly the decision is made. Big companies have more communication, so they are slower at making decisions. This is a big disadvantage.
- When work is physical, bigger is better.
- When work is intellectual, smaller is better.

The Explanation

- In October 1948, a relatively unknown electrical engineer at Bell Labs named Claude Shannon founded the science of Communication Theory with a paper in the IEEE journal entitled “***The Mathematical Theory of Communication***”. This paper not only explained how communication networks operate mathematically, but set theoretical limits on how fast and accurately any communication system could perform. He calculated these limits by showing the connection between Boltzmann's theory of statistical entropy and the information content of communication signals.

Communication Entropy

- What Shannon discovered is that uncertainty and information are the same thing. Consider the sentence.
- The C_t _n th_ Ha_.
 - We don't need the missing letters to read the sentence, because they contain no uncertainty. Context and the structure of the English language force a solution.
- Once again, Shannon discovered that **information** and **uncertainty** are the same thing. Since uncertainty is measured by Entropy, the Entropy content of a message is an exact measure of the information present.

Organizational Entropy

- Dr. Richard Janow at the New Jersey Institute of Technology has now applied Shannon's communication Entropy to the decision making process at companies. Dr. Janow compared organizational decision networks to communication systems and showed how Shannon entropy places strict limitations on decision making productivity in organizations based on their size.
- Dr. Janow's work shows that there is an inverse relationship between an organization's ability to make a decision, and the total information content (Shannon entropy) of communication by decision makers.

Entropy

- Just to review, Entropy is defined as:
 - A thermodynamic quantity representing the unavailability of a system's thermal energy for conversion into mechanical work, or;
 - The lack of order or predictability; gradual decline into disorder, or;
 - the average unpredictability in a random variable, which is equivalent to its information content.
(Shannon Entropy)

Organizational Entropy

- Without going into the math too deeply, the basics are this;
 - Individuals make decisions based on their ability to process information and the threshold amount of information needed for them to make a decision.
 - If R_i is the individual's information processing rate and I_d is the information needed to make a decision, an individual's decision rate R_d is simply $R_d = R_i/I_d$. For an organization of independent decision makers (no communication) the decision rate is simply $(R_i/I_d) \times n$, where n is the number of independent decision makers. In other words, for an organization of independent decision makers, the total decision rate scales linearly with population, assuming all decision makers are equally competent.

Organizational Entropy

- When decision makers communicate, they create uncertainty for each other equal to the entropy (information) content of their communication. As their uncertainty increases, extra work is required to overcome the extra uncertainty caused by communication, slowing the rate of decision making.
- In other words, communication creates uncertainty (entropy) in the mind of the decision maker, which slows the rate of decisions. The more communication, the more entropy is created and the more slowly decisions are made.
- The amount of entropy in an organization depends on the size of the organization and how likely the members are to communicate.

Organizational Entropy

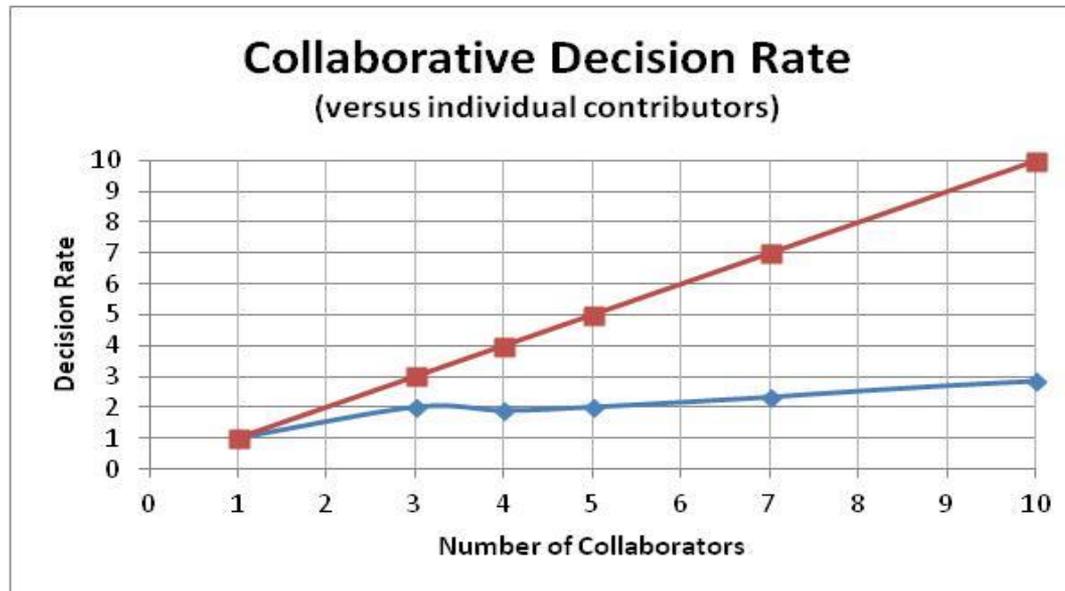
- Per Janow, (via Shannon) the communication entropy in an organization depends on the number of people and the probability that they interact. The general equation is:

$$H = -k \sum_{j=1}^n P_j \text{Log}_2(P_j)$$

- Where H (Shannon entropy) is a constant times the sum of interaction terms. Here, n is the number of communication channels, k is the equivalent to Boltzmann's constant and P_j is the probability of communication on each channel j from 1 to n. Note that entropy increases as $P_j \text{Log}_2 P_j$, or faster than the total amount of communication.
- For an organization with full communication between everyone, decision making slows rapidly as the size of the organization increases.

Entropy Cost

- To see the effect of this effect, I made a graph of Dr. Janow's results showing the difference in decision rate between an organization with perfect (non-synergistic) collaborators ($P_j = 1$) compared to individual contributors. ($P_j = 0$)
- As you can see, 10 collaborators are only 30% as efficient as 10 individual contributors.

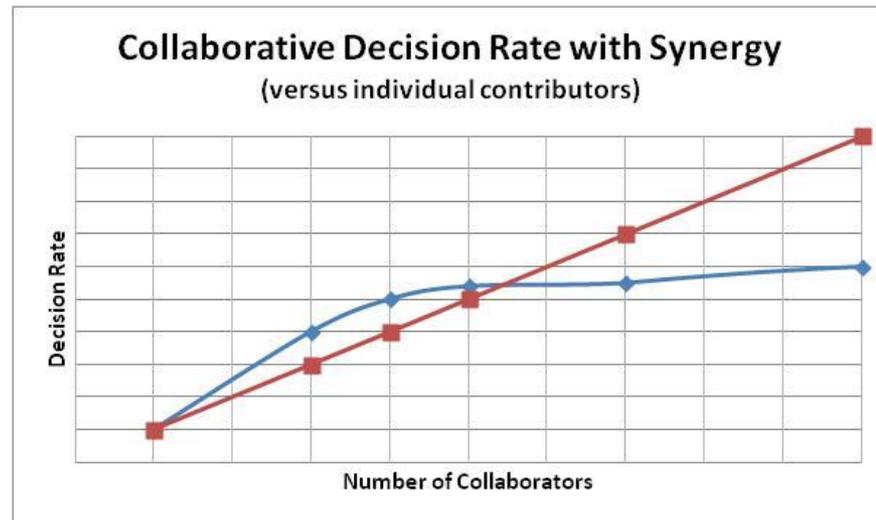


Collaboration

- However, collaboration is not all bad, some advantages do exist. Some are mentioned in Dr. Janow's paper and some in other literature.
 - One benefit is synergy. If you bring together two or more people with experience, they reduce the need for communication, overcoming the effect of entropy. This is also called “information hiding”.
 - Collaboration allows for faster identification of possible errors before they happen. Collaborations are good for finding and eliminating threats that can lead to failure in high risk situations. (various sources)
 - Collaboration can lead to faster acceptance of a decision.
 - Collaboration improves the rate of learning in an organization.

Synergy

- Synergy occurs when colleagues with experience hide their work from each other except when needed. (information hiding) Synergy is collaborative work with low communication.
- The effect of synergy is to allow for small groups of collaborating experienced people to act more efficiently than an equal number of individuals, but only up to a point. Eventually entropy will overpower synergy as headcount increases and limit total productivity. There is always an optimum size!



Decision Quality

- There is good evidence that collaboration lowers risk. In new or highly uncertain, risky endeavors, collaboration can identify possible causes of failure and allow for their elimination, increasing the probability of success.
- The space program is one good example. The risk of failure in space flight is huge, so the space program is by necessity a highly collaborative, slow, inefficient, high entropy activity with multiple checks and balances.

Quality versus Quantity

- This quality benefit of entropy means that a trade off exists between quality and quantity of decision making. More entropy leads to better decisions, but at the cost of a lower decision rate, and vice versa.
- Once again, experience can compensate for this effect. Experienced people can make better and faster decisions than inexperienced people, and allow for better overall performance.
- This is another part of the optimization effect. Every task will need a certain mix of quantity and quality for it's solution, so only one organizational design will be optimal for that task.

Conclusions #1

- Now we get to the point where we can provide a detailed answer to the question at the beginning. “Why do small companies exist?”
- They exist because they are optimally sized and experienced for some important and needed work. No firm that is either larger or smaller can compete effectively.
 - The Goldilocks solution, they aren’t too big or too small, but just right.
- Small contractors exist because larger companies can gain synergy by hiring them to do jobs that are too small for the large firms to do efficiently. However, this advantage disappears if the larger firm must continually manage the work of the smaller firm. Contractors provide synergy only if they can work without communicating.

Conclusions #2

- If your company does physical work (manufacturing, transportation) larger scale should mean more efficiency, and your strongest competitors will be larger companies.
- If your company does intellectual work (engineering, problem solving, etc.) smaller scale should mean more efficiency, and your strongest competitors should be smaller companies with experience.
- Every organization will be optimum for certain tasks, and working on projects that are bigger or smaller than optimum will reduce efficiency. To quote Dr. Janow, ***“The smallest firms with just enough intellectual breadth to accomplish particular tasks should become the low cost providers.”***

Conclusions #3

- If your company does intellectual work (engineering) and your decision making is too slow, you probably need to reduce the number of people involved in decision making.
 - Reduce collaboration and increase the amount of individual work.
 - Adding people only works if they have experience.
- If you wish to grow your company, you should realize that the optimum size of your work should grow with your company. If you wish to do more volume of the same thing, open a second business of the same size in a new location, don't grow the old one.
- One good way to lower entropy and improve efficiency is to hire a contractor, but only if the contractor can work without guidance. Contractors provide synergy only if they can be ignored.

The End

- Questions?