Trade-off . . . or Trade-on

Adam Brandenburger*

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> The whole organism is so tied together that when slight variations in one part occur, and are accumulated through natural selection, other parts become modified. This is a very important subject, most imperfectly understood.
> – Charles Darwin, *The Origin of Species*, 1859[1]

> The achievement of Japanese industry toward ever better quality at reduced cost constitutes lessons in management for the whole world.
> – W. Edwards Deming[2]

1 Biological Mechanisms

The concept of a **trade-off** is fundamental in many fields. In biology, the concept is fundamental to elaborating on Darwin's original insight that variation in one trait in an organism may not be independent of variation in another trait. For example, there may be a trade-off between the number and size of eggs that animals produce (think of fish, birds, and turtles), or between the speed and strength of animals (think of cheetahs and lions). These two examples embody two different underlying mechanisms:

- **Resource demands** Underlying resources, such as energy, space, or time, in fixed supply and allocated to one use are unavailable for another use.
- **Functional demands** Design of a structure that is more effective towards one use is less effective towards another use.

Thus, a trade-off between size and number of eggs may come from an energy budget for their production (the first mechanism), while a trade-off between speed and strength of an animal may reflect the fact that longer bones are less sturdy than shorter ones (the second mechanism).[3]

Biology also offers examples of how trade-offs can be 'transcended,' by changing behavior, say. Thus, we can imagine that for many animals there is a trade-off between increased foraging behavior and increased risk of predation. But, by becoming nocturnal, some animals have escaped this trade-off.[4]

*Stern School of Business, Tandon School of Engineering, NYU Shanghai, New York University, New York, NY 10012, U.S.A., adam.brandenburger@stern.nyu.edu, adambrandenburger.com. Robert Albano and Michael Greenstein provided important input.

2 Beyond Biology

A famous definition of economics is: "Economics is the science which studies human behaviour as a relationship between ends and scarce means which have alternative uses."[5] This definition focuses our attention on trade-offs which arise — this time in the economic domain — in accordance with the first mechanism above. But there are also very important cases where, as in biology, trade-offs can be transcended. In such cases, we will talk of a **trade-on** rather than a trade-off.[6]

In July 1950, American engineer W. Edwards Deming was invited to Japan by the Union of Japanese Scientists and Engineers. Whilst there, he gave his "Eight-Day Course on Quality Control" and also his "One-Day Course on Quality Control for Top Management."[7] In his courses, he explained his Plan-Do-Check-Act (later changed to Plan-Do-Study-Act) cycle as follows:[8]

> This wheel rolls along the line of "concepts regarding product quality" and "sense of responsibility for product quality." The fact that the four stages of the wheel are connected one to the other with no beginning and no end is very important. This is the reason why I drew a circle. You must not stop product design or testing. When your products emerge into the real market, after having inquired into how the product is useful to people, and what they think of it, you redesign it. There is no end to product quality administration. Using product quality administration, producing goods continually being improved, I want you to make more and more adapted items that buyers will want, designing, redesigning, and then finding cheap, better ways to make them. While this certainly benefits the purchasers, it benefits you as well.

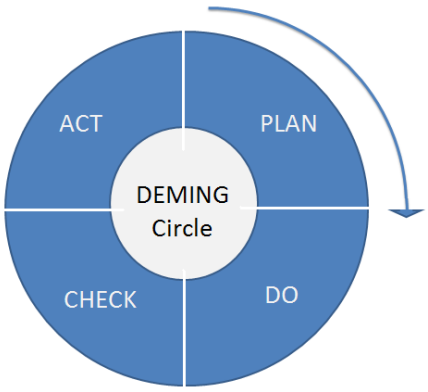

Figure 1

Deming's ideas had a big impact in Japan and are widely viewed as having set Japanese manufacturing on the path to world prominence it achieved by the 1980s. The importance of his ideas took much longer to be appreciated in the U.S.. Indeed, Deming's ideas came as a shock to U.S. manufacturing companies, to whom the idea of a quality-cost trade-on was hard to imagine:[9]

> The assertion that a given company couldn't "have it all" ... was challenged in the 1980s by ... the success of elite Japanese companies that ... acted as though economies of scale and long runs were not important, nor were trade-offs necessary. Indeed, many Japanese

factories appeared to surpass their American counterparts on several competitive dimensions — lower cost, higher quality, greater flexibility, and faster product introductions — all at the same time.

3 Back to Biology ... and Ecology

Expanding agriculture and changes in agricultural techniques have put pressure on ecosystems around the world, as forests and other natural habitats are cleared for crop planting. In the case of coffee, for example, there has been a shift from "shade-grown" to "full-sun" methods and, as a result, increased loss of habitat.[10] A study in Costa Rica investigated the effect on coffee growing of retaining forest 'patches.'[11] The study identified bird species that consume the coffee berry borer beetle, a pest that damages coffee harvests, and found that with more forest cover, the number of these birds increased and beetle infestation decreased.[12] The finding points to the possibility of a trade-on between farming livelihood and biodiversity.

Exercises:

- Give an instance of an analysis (from a domain of your choice) where having more of one desired feature has been viewed as achievable only by having less of a second desired feature, but where you argue that there could be a trade-on rather than a trade-off between the two features.
- Give an instance of an analysis (from a domain of your choice) where having more of each of two desired features has been viewed as achievable, but where you argue that there is, in fact, a trade-off rather than a trade-on between the two features.

Notes

[1]As quoted in Garland. T., "Trade-offs," *Current Biology*, 24, 2014, R60-R61; from which the discussion in Section 1 also comes.

[2]From letter to the Union of Japanese Scientists and Engineers, 10/28/93, congratulating the 1992 Deming Prize winners. Quoted in Noguchi, J., "The Legacy of W. Edwards Deming," *Quality Progress*, 28, 1995, 35-38.

[3]Garland, op.cit..

[4]Garland, T., "Trade-offs & Constraints," 2014, at http://idea.ucr.edu/documents/flash/trade-offs_and_constraints/story.htm.

[5]Robbins, L., *An Essay on the Nature and Significance of Economic Science*, Macmillan, 1932.

[6]The term is found in Brandenburger, A., and B. Nalebuff, *Co-opetition*, Doubleday, 1996, p.127.

[7]See http://www.juse.or.jp/e/deming/75/.

[8]See http://hclectures.blogspot.com/1970/08/demings-1950-lecture-to-japanese.html. Deming attributed the cycle to engineer Walter Shewhart, and it is also known as the Shewhart cycle. Figure 1: http://commons.wikimedia.org/wiki/File:Deming_PDCA_cycle.PNG.

[9]Hayes, R., G. Pisano, D. Upton, and S. Wheelwright, *Operations, Strategy, and Technology: Pursuing the Competitive Edge*, Wiley, 2005, p.50.

[10]See http://www.rainforest-alliance.org/education/documents/conservation-coffee.pdf.

[11]Karp, D., C. Mendenhall, R. Figueroa Sandi, N. Chaumont, P. Ehrlich, E. Hadly, and G. Daily, "Forest Bolsters Bird Abundance, Pest Control and Coffee Yield," *Ecology Letters*, 16, 2013, 1339-1347.

[12]Op.cit., p.1346.