How to Drive your Elephant - Dealing with Complex Problems

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One thing that has always intrigued me about elephants is how the people who drive them manage to control the beast without a harness. There have to be ways, since it can be done, but it cannot be simple. So elephant driving may be seen as as a metaphor for controlling complex systems. What you'll find below is a talk that I gave on this subject at a recent meeting in Italy. It is not a transcription, but a version written from memory that tries to maintain the style and the sense of what I said.

Thank you ladies and gentlemen for being here today. I see that most of you are entrepreneurs or company managers and so it is a real pleasure to have a chance to speak to you. We, the academics, can only speak about what is to be done, but you are the people who can get things done. For this reason, I thought that I could tell you something that might be useful to you. So, I'll be speaking about elephants.

Now, of course this is a joke. This talk will not be about elephants; not as the main subject, at least. What I know about driving elephants comes mostly from a story by Rudyard Kipling that I read long ago and that, of course, is not enough for me to qualify as an expert on elephants. What I have in mind, instead, is to tell you something about control theory. But, since we were supposed to have parallel sessions today, if I had mentioned control theory in the title to my talk I was afraid that nobody would have appeared to listen to it. So, I mentioned elephants, instead. From this, at least, you have learned that even academics may know something about marketing.

The elephant is a nice metaphor for what I would like to tell you today. You see, you can't fit a harness to an elephant, at least not of the same kind that is used for horses. Then, how do the

people who ride elephants tell the beast to start, stop, where to go and the like? The way it is done, I understand, is by means of such things as vocal orders, pressure with one's legs and also by a big pointed stick that is used to prick the elephant's head. I don't think the elephant is very happy about being pricked in that way; actually, there is probably a good deal of cruelty involved. But we'll be using elephant driving just as a metaphor for controlling complex systems, so let me just say that it seems to work: you can control an elephant by very small external influences. This is the core of control theory: you want to be able to control large and complex systems doing the smallest possible amount of work.

Control theory is a fascinating subject, often used for controlling such things as planes, ships, and other kinds of machinery. It might also be used for elephants, but there is a difference. With a car or a truck, you turn the steering wheel so much and the wheels turn of so many degrees. You don't need to make a big effort with the wheel to turn a large truck, but the point is that the result is proportional to the effort. On the contrary, the elephant may not like to go the way you would like it to go and may react in ways that are not at all proportional to what the driver does. That must make things much more difficult. Now, there is a whole class of systems, we may call them "complex systems," which are difficult to control because they react in ways that are not simply proportional to the intensity of an external influence. That means economic and social systems, for instance and - perhaps - also elephants. For what we are discussing here, we might consider that these systems are dominated by internal feedback effects.

The behavior of complex systems is often difficult to predict, but that doesn't mean it is impossible and there is a whole branch of control theory that deals with this problem. Sometimes, controlling complex system is defined as involving "cybernetics," a term that was proposed by Norbert Wiener in 1948. There are several definitions of cybernetics today, but Wiener was very interested in feedback dominated systems; that is, complex systems. That seems to be still the main aim of cybernetics, although nowadays the term has a bit faded from public consciousness. The term "cybernetics," anyway, comes from a Greek word which means "rudder" and that shows what Wiener had in mind when he coined it. A rudder is used to steer a ship and that may be a better term to use; rather than "control". Especially when we think of very large complex systems such as the economy or the state, "control" sounds like what the Soviet planners were trying to do and that, as you know, turned out to be not so successful. So, you don't want to control every detail of the system; you don't want to tell the elephant how exactly to move its legs. You just want to steer the elephant in what you think it is a good direction. Then, the elephant knows how to walk.

We don't have a general theory that tells us how to steer a complex system (nor an elephant), but we do have good models that allow us to understand how a complex system behaves. And if you understand how the system behaves, then you can think of what to do to make it go in a certain direction. One of the commonly used methods to describe complex systems is called "system dynamics." It was developed mainly by Jay Wright Forrester in the 1950s and 1960s. You may not have heard of Forrester, but the study known as "The Limits to Growth" was performed using the methods that he had developed. You may have read that "The Limits to Growth" is a set of wrong predictions, a flawed study, the work of a group of eccentric (and perhaps slightly feebleminded) academics who had thought that the sky was falling. That is not true – it is mostly propaganda and our tendency of believing what we like to believe. "The Limits to Growth" (1972) and an earlier work by Forrester himself, titled "World Dynamics" (1971), were pioneering works that showed that it is possible to understand the behavior of large and complex systems such as the whole world's economy and, within limits, predict their evolution.

Modifying the behavior of these large and complex systems turned out to be much more difficult. The authors of "The Limits to Growth" searched for ways to avoid the collapse that was predicted by their models. They found that it was possible to keep the system from collapsing if we could stop the world's economic growth and stabilize the world's population. That was easier said than done. Not only the suggestion was refused, but the authors were accused of being part of a

conspiracy to take over the world, to be planning to exterminate most of humankind, and similar niceties. We are seeing a similar reaction nowadays with the global warming issue which, by the way, has to do with a large and complex system; that of the Earth's climate. So, it is very difficult to control very large complex systems, if nothing else because these systems tend to resist change and sometimes react violently against those who try to control them (maybe elephants do the same when they are pricked on the head).

But that doesn't mean that system dynamics is useless. If you reduce a bit your ambitions; that is, if you don't try to save the world, just a little bit of it, then system dynamics can give you good advice. So, what I'd like to tell you now is about an idea that Jay Forrester had; that of the existence of "critical points" (or leverage points) in complex systems. Points you may act on to steer the system without having to do a large effort. A little like pressuring or pricking the elephant in some specific points of the head. You can have a very strong effect on the system by a very small external influence.

This idea of Forrester can be found in his papers, especially those dealing with "urban dynamics," where he reports that most of the commonly implemented policies in urban planning generate results that are opposite to those intended by the policymakers. But Forrester's ideas were also described and discussed in a paper that Donella Meadows wrote in 1999 with the title *"Leverage Points, places to intervene in a system"*. It is a rather famous paper, also very interesting. I strongly suggest to you to read it when you have a moment. But let me describe its main points for you.

Donella Meadows says that it is easy for most people to identify critical points (or leverage points) in a system; points which strongly affect how the system behaves. If you think about that for thirty seconds, I am sure that you can think of several of these points in your life, in your career, in your company. Elements that either push you onwards or prevent you to do so. Say, your boss stops you from doing what you would want to do, or maybe your husband or your wife are not doing what you would like them to do; that kind of things.

And here is the interesting point. Sure; people are good about identifying critical points; but very bad about doing something about them. What Forrester had noticed is that people tended to act on these points; but pulling the levers in the wrong direction. They would mostly act on the critical points in such a way to worsen the problems, rather than easing them. That sounds strange at first; but let me give you a few examples and I think you'll agree with me (and with Forrester) that people do tend to pull levers in the wrong directions.

You are all involved in managing companies, so I'll try to give you examples that have to do with industry. Let me start with an old story, that of the whaling industry in 19th century (this talk seems to be concerned a lot with big mammals!). In 19th century, people used whaling technologies that may appear to us a bit primitive: sailing ships and hand-held harpoons. Nevertheless, they were efficient enough that whales were captured faster than they could reproduce, at least for some kind of whales that were relatively easy to capture. By mid 19th century, there was a depletion problem: too many whalers and not enough whales. The result was something similar to the reaction that we have today with of crude oil depletion. You heard the cry: "drill, baby, drill." It means drill more, drill deeper, drill in places where no one had drilled before. In the case of whaling, we could say that the reaction was something like: "hunt, baby, hunt". Get more whaling ships, better equipped, going faster, and go chasing as many whales as you can. But that worsened the problem. The more whales were killed, the less there were in the ocean. By the 1880s, whalers had run out of whales, at least of the kind that was hunted in that period. So, the whole whaling industry collapsed. Whalers should have agreed to hunt fewer whales, not more. They should have placed quotas on the number of whales that could be captured. That would have given time to whales to reproduce and give the whaling industry a chance to survive. That was the right way to pull the lever; but; as Jay Forrester and Donella Meadows tell us, that is very difficult.

This kind of behavior has to do with the gut reaction of industry managers when they see sales going down. Their reaction is often the same: lower prices in order to maintain one's market share. That may involve being more efficient, lowering the quality of the product, laying off "unnecessary staff" and, in general, cutting corners wherever possible. That may work in the short run, if the problem is only temporary. Then, when sales pick up again, those people who have maintained - or increased - their market share, will emerge as the winners. But if the problem is structural, as it was in the case of whaling, then it is a suicidal strategy. Everyone tries to keep a constant share of a market that keeps shrinking and the end result can only be collapse.

Let me make a modern example: years ago I stayed at a seaside hotel in Italy. They have me in their mailing list and they keep sending me leaflets with their special offers. I notice that this hotel is becoming cheaper and cheaper as time goes by. If they keep that trend, at some moment it will be cheaper to stay there rather than eating at home. How long can they go on reducing prices without going out of business, I can't say, but surely it cannot be forever. As I said before, lowering prices is a suicidal strategy in the long run.

Now, let's examine the problem with Forrester's ideas in mind - the critical points of the system. Clearly, the manager of that hotel has correctly identified a critical point: many people can't afford any more long vacations. So, suppose you are in charge of the hotel, what would you do? I think there is something here in the idea of doing exactly the opposite of what that manager is doing; that is *raise* prices. It looks a bad idea at first, but think about that for a moment. If you can improve service, then you can gain a share of the high-end of the market; and that fraction of the market will probably survive the crisis. In times of crisis, rich people tend to become richer and if you want to survive in the hotel business it is the kind of customers you should aim for. But you don't necessarily have to stay in the tourist market. In the end, what Forrester says is to be creative. Don't just fight to stay where you are. Find new roads; new ways of doing things. So, stop thinking about tourists. Think instead of transforming your hotel into a school where people can be re-trained for new jobs in a changing economy. Train people, say, in installing solar panels. That is something that will be needed in the future. It is just the first idea that comes to my mind - but I am sure you understand what I mean. You are all creative people and - if you were hotel managers - you would surely think of other possibilities.

But, unfortunately, creative people seem to be just what we are missing. Everywhere, people are fighting as hard as they can to stay where they are. And, as I said, that is a losing proposition. Think of the automotive industry. They have a lot more clout than the hotel industry and they managed to convince the government to subsidize their sales with taxpayers' money; it is what they call the "cash for clunkers" scheme. But our problem is not that we aren't making enough cars - we are making too many of them! Here in Italy, the cash for clunkers scheme has ended in December of last year and car sales have hit rock bottom. That wasn't a good idea, surely not in the long run. Car makers should think in different ways and move to something else. Windmills or bicycles, I don't know, but surely we can't afford any more to make so many cars. And there are many more examples that you can think of by yourselves.

But I don't want to be too gloomy. I can make for you at least one example where I know that some of your group have been pulling the levers in the right direction: waste management. You see, it *is* possible to make the right choices by being creative and seeking new ways.

As you know, waste management is a critical point of the economy; especially for us in Italy. Small country, lots of people and lots of waste. It is a real problem, even though some people are exaggerating it a little. You know that most Italian politicians, independently of whether they belong to the left or to the right, seem to agree on what is to be done. It is, "burn, baby, burn." Build incinerators to get rid of waste and get energy as a boon from the combustion. It is what is called the "waste to energy" scheme which, in Italy, has been given the fancy name of "thermovalorization". Now, I think that this is another example of pulling the lever in the wrong direction. If you use incinerators to produce electric power, then you'll find that you *need* waste.

Not just that, you also need that specific kind of waste which contains a lot of plastics, which has a high heating power. So, you'll be in trouble if there is not enough waste of the right kind. And that is what is happening right now: with the contraction of the economy there is less waste and it is waste with a smaller content of plastics. So, you have invested in all those expensive incinerators and there is not enough fuel for them. You didn't solve the problem, you created a bigger one.

Fortunately, some people have understood what the real solution of the waste problem is. It means to pull the lever in the right direction: reduce waste; generate as little of it as possible; zero, if you can. "Zero waste" may be an impossible goal, but if you aim in that direction you will always reduce the size of the problem, never increase it. Of course, there are many ways to reduce waste production – some of you are more expert than me in this field, so I am not going to discuss this point. But I think waste management is a good example of how society may react to a problem. At present, the bad solution - incineration - seems to be winning, at least in Italy. But I think that in the long run what is to be done will appear clear to everyone and, at that point, even politicians will start pushing in the right direction – some of them are doing that already.

So, I gave to you just a few examples of Forrester's idea about critical points. It is a very powerful mental tool and not just for the kind of problems I described. It may work even for your everyday life - even if you are not an elephant driver. You probably are engaged in such things as finding money, finding a job, getting a degree. Maybe you have problems with your relation with your children, your spouse, your boss, your coworkers. Sometimes these problems seem to be enormously difficult. Now, consider that one reason might be that you are pushing in the wrong direction. I am not saying that changing that direction will work every time, but you may at least consider it. It is, in the end, about being a bit creative. Try it.

I wish to thank Costellazione Apulia for giving me the possibility of giving this talk in a nice and friendly environment at the meeting "Raccontami una Storia" in Martina Franca, Italy, on March 19th 2010.

References

The paper by Donella Meadows about leverage points is at (http://www.sustainer.org/pubs/Leverage_Points.pdf)

The story by Rudyard Kipling that I have mentioned is titled "Toomai of the elephants" and you can find it, for instance, at http://www.authorama.com/jungle-book-11.html

As I mentioned whales in addition to elephants, you can find a paper of mine on the subject at http://www.theoildrum.com/node/3960

About the negative reaction against "The Limits to Growth" you can give a look to a paper of mine titled "Cassandra's curse: how "the limits to growth was demonized" at www.theoildrum.com/node/3551