Describing systems | Causal flow diagrams

We're going to return to that particular case in a few minutes, but I want to take you from describing a system as a static picture and introduce to you some tools to be able to set that picture in motion.

What I want to do is introduce you to a few key concepts around causal flow diagrams—the idea of feedback loops, for instance—and give you a sense of how to use some of these tools in a fairly simplistic way.

When you start to imagine modeling a system—not necessarily in a quantitative sense—but even just to begin to understand how a system works so that you can think about changing it, it can be very useful to think about the kinds of causal linkages and or feedback loops—and I'll define those in a few minutes—that are holding the system in place or perhaps driving the system off in a particular direction.

It can be very useful to identify those rather than wasting time trying to push back against them. It can be very useful to think about, "*Well, how do I decouple that or reinforce that particular feedback loop to get the system to move towards the kinds of change I want to affect?*" So, it's effectively taking your static system diagram and thinking about those interconnections and components in a much more dynamic way. Moving from components to variables, i.e., things that are measurable, things that change, and thinking about how those variables are interconnected.

You can think about conceptually modeling a system in many different ways. I'm going to use some content by Dr. Jan Sendzimir, a colleague and systems thinker. When I talk about how to model these, he's got some wonderful material that we've adapted here.

When we think about conceptually modeling a system, we can begin using words, pictures, or diagrams to start thinking about the way systems interact and work. I've already gotten you to do a static picture of the Victor Diamond environmental assessment consultation process and we'll return to that example in just a few minutes. You can think about using those kinds of basic pictures and diagrams and then think about causal loop diagrams feedback loop diagrams.

It's useful to begin with the kinds of diagrams—or rich pictures—that I imagine you produced when we did that initial sketch of the Victor Diamond Mine environmental assessment consultation process. To think about how various components or variables within a system interrelate, this kind of rich pictured development has been used extensively by people like Peter Checkland and the idea of soft systems thinking versus hard systems thinking or engineering approaches. The integration of multiple perspectives and surfacing local knowledge can be really, really useful in understanding systems.

It's useful to think about cause and effect. Typically, when we think about cause and effect, we often think about one component or variable causing another. But, in a systems approach, we think about various variables interacting with each other in different ways. Oftentimes, the outcomes are not quite as clear as if they would be when they were just talking about one variable and one effect. When you've got multiple variables and different effects, that's where complexity comes in.

It's useful to distinguish between causation versus correlation. Correlations do not represent the structure of the system. Causal diagrams must include genuine causal

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relationships. You want to avoid making assumptions about systems and these can be often avenues for exploring and doing empirical data collection or looking for other sources of data about a system or even published academic material or other gray literature might help you understand your system of interest.

For instance, this idea that Jan highlights here, that as ice cream sales increase, the murder rate increases. This is not a causal linkage. This is just a correlation that happens to surface in terms of statistical analysis. What might be the causal linkage here is actually that the average temperature is increasing, which is resulting in higher ice cream sales *and* a higher murder rate. The fact that ice cream sales and murder rate go up at the same time does not mean there's necessarily a causal linkage there.

These are obvious pieces. But, by the time you start to think about linking different variables, you really have to think carefully about how they're linked and the kinds of relationships that are there. Then you may even need to, as you surface these kinds of relationships, go to other people within the system who know more about a particular relationship or you may even need to collect more primary data to actually understand what's going on in a particular relationship.

These diagrams should be—and I mention this over and over again—quite iterative, in the sense that you may try out a diagram and start thinking about a particular relationship between variables but you may actually think, *"Okay. Well, actually, we need to go out and test whether than particular relationship is real; whether there is a causal linkage there, whether it's just a correlation; and then whether it is a reinforcing relationship or a balancing relationship in the sense that it is increasing the effect on a particular variable or decreasing the effect on a particular variable."*

These slides I would return to over and over again—as I do—when you're trying to construct your system diagram, your causal linkage diagram. There are useful tidbits and I'm just going to work through them briefly. Please return to these as you construct your causal diagram.

Variables should be nouns or noun phrases. A causal diagram captures the structure of a system, not it's behaviour; so you should think about costs and prices versus costs rising and prices rising. It's much easier when you start to think about the relationships between variables to use nouns or noun phrases.

Variables must have a clear sense of direction and this is one that I often make a mistake on when I'm doing these kinds of diagrams, when I'm talking about these kinds of relationships. Choose names for which meaning of an increase or a decrease is clear. It's necessary to align meaningful linkages in terms of polarities and I'll get to that in a minute or two.

In other words, you want to think about labeling a particular variable as *praise from your boss* leading to increased morale versus a more generic term like *feedback from the boss*. I don't whether that's positive or negative relating to mental attitude. You want to make sure that they have a clear sense of direction when you're drawing your system diagram so that you'd be able to understand the dynamics a little more clearly. Again, these are just tips to help you when you're constructing your causal loop diagram.

Choose variables whose normal sense of direction is positive. Again, this is one that I often stray away from, but it just helps in terms of getting through the logic of your

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diagram. Avoid the use of variable names containing prefixes indicating negation. For example, *criticism decreasing happiness* vs. *criticism increasing unhappiness*. Again, this is just about clarifying and working up the logic of these diagrams. Oftentimes, when you get a whole bunch of variables up and you have a large spaghetti diagram, the more clear you can make it right from the get-go, the more success you're going to have in understanding how these things relate. So these, again, are just tips.

Here is another piece that is really important or really helpful: this idea of polarity and whether a particular relationship has a positive polarity—that is, if a cause *increases* the effect, for example, an increase in price vs. a negative polarity where the cause increases and the effect *decreases*. So, for example, increased criticism leading to decreased happiness.

This idea of polarity is very useful. What is the nature of that relationship? Does it have a positive polarity in the sense of an increased in this variable leads to an increase in this variable or a negative polarity in the sense of an increase in this variable leads to a decrease in this variable? Again, thinking that through that very carefully when you're working on the logic of your model can make things a lot more clear.

You want to make sure that these are unambiguous polarities. Don't have things like price either increases or decreases revenues. This adds confusion to your diagram. You want to make sure the logic is clear. If there is an ambiguity, then you maybe have two arms or two branches of this particular relationship. Again, polarity is a really useful tool or heuristics to think about when you're thinking about a causal diagram.

When you're going to develop a causal flow diagram or what they sometimes call an influence diagram, there are a few key points that I'd like to emphasize. Interconnections influence variables. They can have positive or negative polarities and again, this gets really complicated or even complex when you start to have a whole bunch of variables together. Getting that very clear and using some of those tips that I raised before will help you to work through the logic of your causal flow diagram.

Don't worry if it starts off very messy. These are not neat or clean. You won't always immediately start to surface loops. Don't try and force that. These things should emerge as you work through the diagram and as you try and make it more sophisticated.

I always emphasize to people that it can take several iterations to make a causal flow diagram or an influence diagram useful. You may need to ask a lot of questions of it. You may need to seek out, again, as I mentioned, other experts who know more about a particular set of relationships between variables, or even search for empirical data that might help you to describe that relationship; or you may even need to go out and collect that data because it may not be something that has been collected before.

You will likely have to go through several iterations of these kinds of things before something useful emerges. Be patient with yourself and be patient with your diagram and don't be afraid to crumple it up and start anew; but don't get rid of those crumpled up papers because they can be really useful in going back and say, *"Well, actually that relationship was really useful."*

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A few key tips: don't be afraid to define and redefine your perspective and purpose as you go through these iterations. Sometimes a particular perspective and purpose will lead you to see certain kinds of relationships and avoid others. You may need to think about, *"What is my perspective? What is my purpose and is it the most useful for trying to think about?"* in this case, we're thinking about social change and social innovation.

Related to that is this idea of changing the boundary. You really may need to expand your boundary or contract your boundary depending on your system of interest and what kind of system you're trying change. Always keep in mind that that boundary is just an imaginary line. Don't be afraid to change it. Don't be afraid to erase it and say, *"Actually, there's way too much going on here. I need to focus down on this particular piece of the system and understand that."* Don't be afraid to say, *"Well, actually, the kinds of dynamics that are going on within here really don't impact the system that I'm interested in. I need to expand my boundary."* That boundary, again, relates directly to your purpose and your perspective. So those are linked.

Don't be afraid to play with those and go through iterations where you change your perspective and your purpose and change your boundary.

Don't be afraid to redefine variables. Inevitably, as you work through these kinds of diagrams, your understanding of the system will become more nuanced and a lot more detailed. You will likely, as I mentioned earlier, start off with a particular component that is government. You'll end up erasing that and blowing it up into many [components]. If you're talking about a particular variable, for instance, the government involvement, ask: *"What does that mean?"* You'll need to blow that up and make it a lot more nuanced.

Don't be afraid to scratch out variables and try out different things, always pushing yourself to ask more detailed questions about the system and the kinds of relationships there are between the various components. Likely, if you take a more generic component and break it up, there's going to be particular relationships between the variable that you've now created, as well as others. So you're going to end up having to change your diagram and you may even have to go back to changing your boundary or even your purpose and perspective as you work through this.

It's very iterative and nonlinear in the sense that you're not necessarily going to change your boundary and then redefine variables. It may be that you're redefining variables may require you to do some of these other things.

As I mentioned earlier, with some of those other tips, don't be afraid to create more and/or different kinds of interconnections. When you create a connection between two variables, ask yourself, *"What is this relationship? Is it just simply a causal relationship?"* Again, it depends on your perspective and your purpose in describing the system. It may be that it's more than a causal relationship. It may be a relationship of funding. It may be a relationship of authority or responsibility.

Ask yourself what that connection is and whether there are multiple connections that could be drawn. Again, all of this is to make your understanding of the system more sophisticated and more detailed. Constantly ask yourself, *"Is there a different connection that could be made here? Are there more connections? What is the nature of this connection?"*

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Going to the nature of the connection, you may need to think about changes in polarity and this is the kind of thing that looking up data or asking other experts [to learn] about the relationship between variables will help to inform what is the polarity. You may think that a particular change in a variable is a positive change, resulting in another variable's increase, when actually it's the opposite. Changing the polarity can actually change the relationships fundamentally.

These are just some tips, some ideas to help you when you're constructing any kind of causal flow or influence diagram.

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