2.1 Understanding causality and feedback

Variables are interconnected by causal relationships. The most obvious relationships of cause and effect can be found in the natural sciences. For example, when I apply heat to an object, its temperature will rise; when I apply force to an object, it will move. We can represent this causal relationship in diagrammatic form.

Here, “heat causes temperature”. You can also use the words “influence” or “affect” if it helps the phrase read better. Obviously, this causal relationship will only be the case if “everything else is held constant”. For example, if you apply heat from a match to an object that is being chilled by arctic winds, temperature may not increase. When determining causal relationships, we need to ask ourselves what would happen if the causal influence was the only influence on the object at the time.

Another example is the relationship between food intake and weight. If I increase my food intake my weight will also increase. This is an example of a positive causal relationship. We can label our diagram with a plus sign to show this.

What happens to weight if I lower my food intake? It decreases. When food intake falls, my weight also falls. The relationship is still positive because a change in the cause influences a change in the effect in the *same direction*. The “+” sign doesn’t mean “an increase in”, but rather it means “a change in the same direction”.

Now, perhaps you are thinking that this relationship is not always true. You’re right! After all, we all know someone that seems to be able to eat whatever they want and they never put on weight, right? Well, it’s difficult for a causal statement to hold true for everyone on an individual level and so most statements refer to aggregates of people, and not for individuals. We talk about things “on average”.

What about the relationship between physical activity and weight? If we increase our level of physical activity our weight should fall, *all other things being equal*. Here we have a “negative” causal relationship. When the cause increases, the effect decreases. We can show this with a minus sign.

Combining the two causes of weight together we can see these competing positive and negative influences.

Of course, cause and effect are not always instantaneous. An increase in physical activity may take time before it significantly affects my weight. I may not see any visible change in the mirror for a week or so. There is a **delay** between the cause and its effect. If an increase in one variable does not instantaneously lead to an increase in another then there is a delay. We represent a delay by drawing a double bar across the corresponding arrow.

In social or economic systems we often find that situations are more correctly described by causal loops rather than simple causal lines. These are called “feedback” systems. Past actions feed-back into the loop to influence future actions. For example, when I realize that I have put on weight because I ate too much at Christmas time, I might decide to go on a diet. My past behavior feeds-back to influence my future behavior, and so we have a feedback loop. In reality, a feedback loop is simply a succession of causal relationships: food intake causes weight to increase, my weight influences my concern about my weight and my concerns affect my food intake.

My concerns could also encourage me to do a little exercise. The more exercise I do, the lower my weight. We can add these two new causal relationships into our system. Here, the change in my

weight feeds-back to influence my future decisions to eat more or less or do more or less exercise. There are now two feedback loops in this system.

In complex systems there are often two types of feedback at work: reinforcing feedback and balancing feedback. They both play very different roles and they each give rise to unique behaviors. In the following units we will take a closer look at the how these different feedback mechanisms work and the fascinating and sometimes complex behaviors they generate in the world around us.