

Introduction to System Dynamics Modeling
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Causal Loop Diagram Part - 1
Lecture - 2.3
Guidelines to build CLD – II

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Core Concepts

- Cause and Effect
- Feedback loops
 - Makes system complicated
 - Key causal links are those inside feedback loops
- Positive Feedback loop
 - Even number of “-” signs; Amplifying, reinforcing, growth (rapid decline), unstable
- Negative Feedback loop
 - Odd number of “-” signs; Balancing, Stabilizing, Stable equilibrium; often good.
- Delays in Feedback loops
 - E.g., carrying cup of tea; taking a shower; etc.

time units important

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So, core concepts that we kind of explore through a Causal Loop diagram are of course cause and effect that is why it is called Causal loop diagram. We try to understand the feedback loops. See if at end of it, if your causal loop diagram is just a linear thing A affects B, B affects C, C affects D that is not a loop. That is just a it is a the Linear Regression model. There is no feedback, nothing is happening here.

So, the entire thing which makes it difficult is when feedback starts to kick in, it makes the system complex and key causal links that we are interested in are those inside those feedback

loops. In positive feedback loop, even number of negative signs, it will have an amplifying effect, it will have cause reinforcing, it will cause growth or a rapid decline.

Essentially all these systems are becomes unstable without something to balance or something to goal seek or negative feedback loop are balancing, stabilizing, stable equilibrium, often good. That is when it all the terms positive and negative here. It can be a misnomer positive. It just goes with the number of the direction of moment and things like that.

But what we are actually looking for is what are things that is causing system to balance to stabilize, stable equilibrium etcetera and the feedback system and everything even many of our day to day lives or even simple electromechanical systems all have based on feedback. There AC in this room is based on feedback. Imagine if there is no nothing to balance it, it is going to get super cold.

So, there has nearly there will be a balance, even if the system, even if there is some failure point within the sensors, there will be other natural balancing factors like how much what are the cooling agent we have in the system or what is that capacity of it, how much it can actually cool etcetera.

So, those are the things which is going to limit the temperature within the room. So, there are various factors that can cause the system to not go grow beyond a point. So, all those are good or when we drive a car or drive a bike, we continuously take feedback. It is not like when you left the hostel and even if you know which path to take, you have to consider instantaneous feedbacks from the trucks and the bus which comes, other cyclist, friend's etcetera as you come here.

You cannot just expect to do your thing without taking any feedback at all, right. So, it those are completely it is always inherent in the system. We are trying to make it explicit in very mechanical systems the electrical systems it becomes more controllable and easy. Once you move in a social systems, it becomes little more difficult like driving a car requires lot of

feedback. You have to be really alert you know people give you unwanted feedbacks and everything is there.

So, then it becomes difficult to model there it is very easy to model the traffic when it is smooth flowing. Modeling congestion is very difficult. That means there is continuous feedback happening, people have to you know that is still right and eventually people reach their places. It is not that nothing happens. People go home, people go to work, people commute, things life moves on by taking continuous feedbacks and delays also occurs in the feedback loops from everything.

But only thing is going to be and here time units matters. Just because you are doing causal loop and systems level please pay attention to the time units. Units matter here time units matter. So, usually if the we take some time units for the causal loop diagram say time units can be say in weeks, or months or years.

And if everything is corresponding to that yearly thing, then we do not put any delay mark. If something is causing additional delays beyond our regular time units that we are taking that is when we use the delay mark. So, and everything takes a delay like our tea breaks are long, so I mean source of long delays during assignments, studying for exams etcetera, but that is how it is. So, then I am sure as students or masters PhDs can relate like when faculty goes for tea, it takes long time for them to come back, you have to wait and then they go for meeting them. So, there is lot of delays ok.

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Guidelines for CLD (1)

- All links should have unambiguous polarities
 - Ambiguous polarity indicates presence of other pathways
- Proper Variable names
 - Variable names should be nouns or noun phrases. Action (verbs) are captured by the causal link
 - Choose variable names whose normal sense of direction is positive
- Normal Sense of direction is positive

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Let us look at some guidelines for the CLDs. All links should have unambiguous polarities. Ambiguous polarities can indicate presence of other pathways; meaning you can have only plus or minus, you cannot write it depends you have to choose and say plus or minus. Answer cannot be it depends on lot of things that won't work.

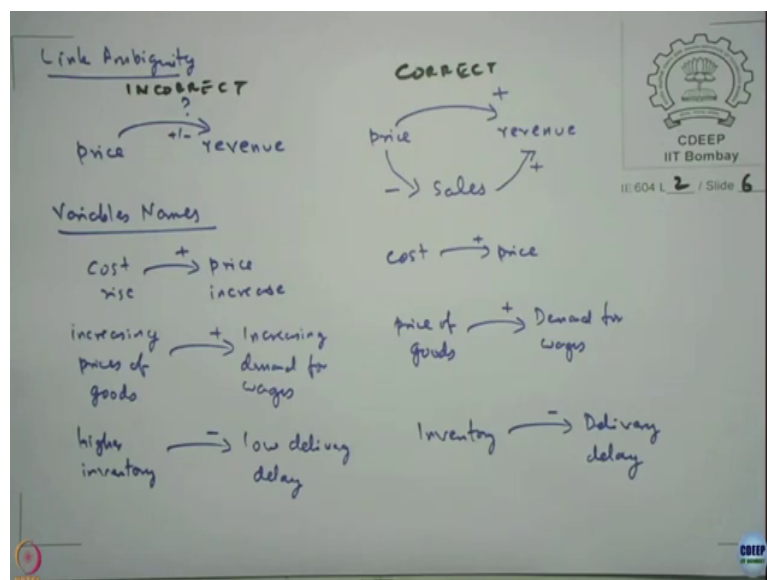
If at all it depends, then you have to uncover what it depends on depends, then elaborate their statement. Do not just stop there. That is what we mean by alternative pathways. There is something else that is affecting, list all those things. Your model will look bigger which is fine. There is no this thing for gravity points. So, you just go ahead and list what are alternative pathways are there.

So, second point is proper variable names. Variable names prefer to be nouns or noun phrases; actions are captured by the causal link themselves. So, you do not need to write the

action or verbs as a variable. Variable should be nouns or noun phrases. Choose variable names whose normal sense of direction is positive.

You do not need to say this causes this whatever criticism increases unhappiness, your criticism decreases happiness. So, it is a normal sense can be in the positive or would have cause increases losses; it is a cause decreases profits that could be the, so variable names normal sense can be in the positive direction. So, it is easier for us to visualize, it is nothing but same thing the normal sense of direction is positives for the variance ok.

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Let us take these 3 things and do some examples for that. Let us call it link ambiguity. So, standard I can moderns economics is price and revenue. Price affecting revenue; depends sometimes when price is large of course you know this it should increase my revenue but that is not always.

So, this revenue is my is actually calculated not on one product, but it is the on many sales of many products and if price is too high, then people may stop buying things right. So, there is a bigger narration, there is just relating price to revenue. So, on left side I will try to write the incorrect one, on right side I will try to do the correct one. So, to do that you can identify alternate pathways.

So, as price increases we expect revenue to increase whereas, price increases sales can fall down; this from basic economic theory, but revenues always just quantity sold into the price of product, right. So, both direction is the same revenue is nothing but sales into price. So, we just use the same relationship that we study in other Economics course. Revenue is product of sales and price whereas, price increases sales can come down which had cause some ambiguity here saying whether when price alone if you keep it, then we do not get the full pitch.

So, that is what we mean by ambiguous thing. So, you do not do this or you do not say like this, you do not do these things. These are all incorrect. You are going to do a plus slash minus sign, just leave. So, let us look at variable names. Here the point was the variable name should be noun and noun phrases and we should avoid the action or the action is already captured in the arrows that is what we have already have. So, again whatever I write on the left side is the incorrect ones.

So, we do not write cost rise increases to price increases something. This is not correct. The correct one would be if cost increases in general price increases. Again, these are all we are just focusing on one small link. So, do not be too critical on those two variables. You just take it by that or increasing prices of goods results in increasing demand for wages or salaries got.

So, this is how a typical narration which when we to talk to clients and others or study a system, this is what the narration which come out to (Refer Time: 11:15) whatever GST comes, GST goes whatever it does not matter. New taxation come price is increasing.

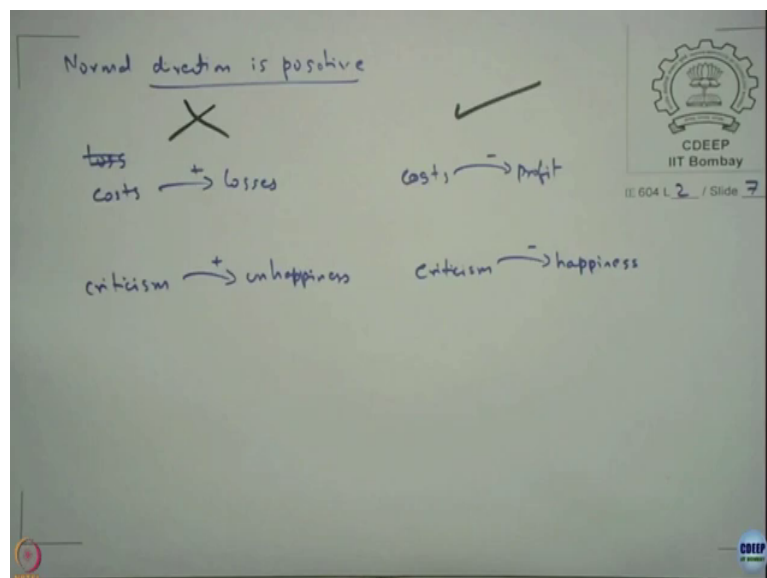
So, there is a pressure to increase your wages and salaries, but to capture it we can just simply write it as price of goods increases demand for wages. So, the action is already captured by the link. So, when we read this link itself, we read it with the way as cost as cost increases, we are looking at the plus sign. As cost increases, the price of good also increase or the price of good increases, it increases the demand for wages.

So, this plus sign indicates that where here it is increasing price of goods as that increases, it increases the increasing demand for wages itself, very complicated confused narration, increasing decreasing and all those things we leave it to just a link and the plus sign wherever something increases decreases, increasing decreasing, all those we leave it to the symbols. Yeah. For a loop we need to look at the bigger system fully. This is just simple examples. Higher inventory we can and give a negative link example also results in low delivery delay. So, what you are saying is if I have well stocked, I have lot inventory I can deliver the product even very short time right that is what people want.

So, that is what I want to say and let us say I have a higher inventory which results in lower delivery delay, but to capture it correctly we say inventory decreases delivery delay. So, here when we read it, its inventory increases, expected delivery delay to come down because I have ready stock available to meet whatever demand that can come in future, right.

So, this is a correct way to write it. So, right side is all the correct ways. This is not the correct ways. So, higher or low etcetera, allow the action to describe by the links.

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For that let me just say that and stop it. Normal direction is positive. Let me give the same example again. Sorry. When say cost increases losses or criticism increases unhappiness, it is just these are just guidelines. It is rather we can try to say costs decreases profit or revenue whatever it is written imagine.

So, these are criticism decreases your happiness, right. These are some again as I told on this side is incorrect one and these sides are the correct ways. These are just common practices, so that when the outcomes when you start looking at it, when you match, we can easily compare right. We typically we want higher the better kind of things. So, we want to from the ground from the start itself use variable names with normal senses in the positive directions, so that when we actually analyze it later, it brings the narration otherwise it looks like there is some double negative thing happening and it is all confusing what we want to do, ok.

So, I will just stop here. So, tomorrow we will again meet 11:30. So, tomorrow we may go little beyond class hours may be till 12:45-12:50 because I am going to do some examples depends on how long you take to complete examples. So, plan to be here at least till 1 o'clock ok.

Thanks.