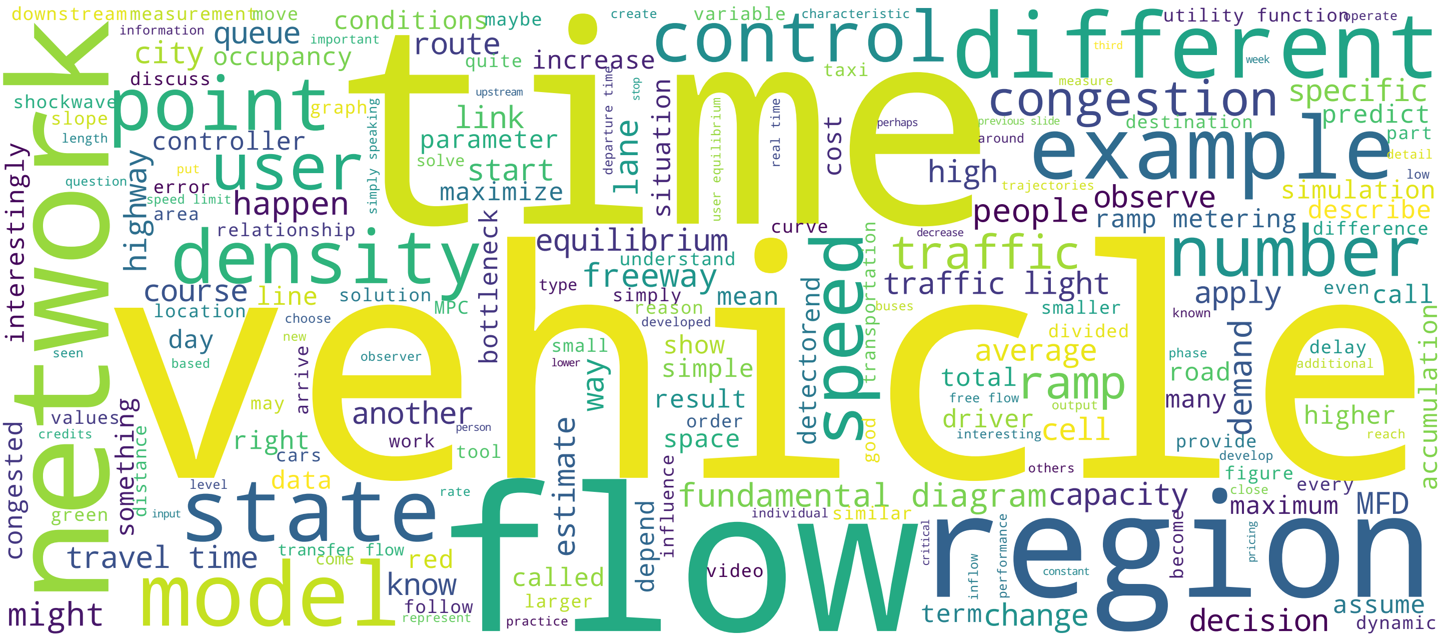
ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Equilibria in Transportation

Intro to traffic flow modeling and ITS

Raphaël Lamotte



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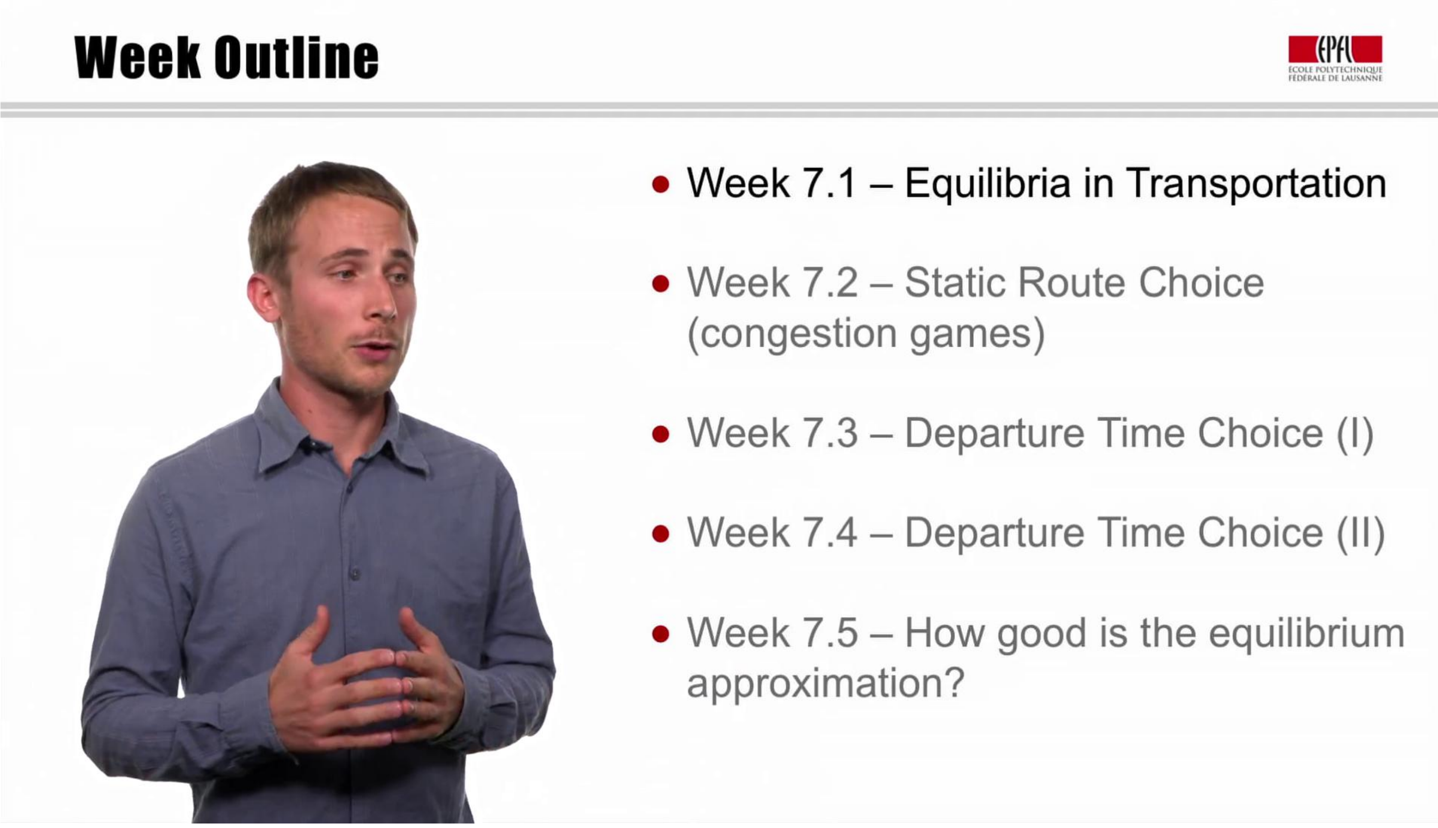
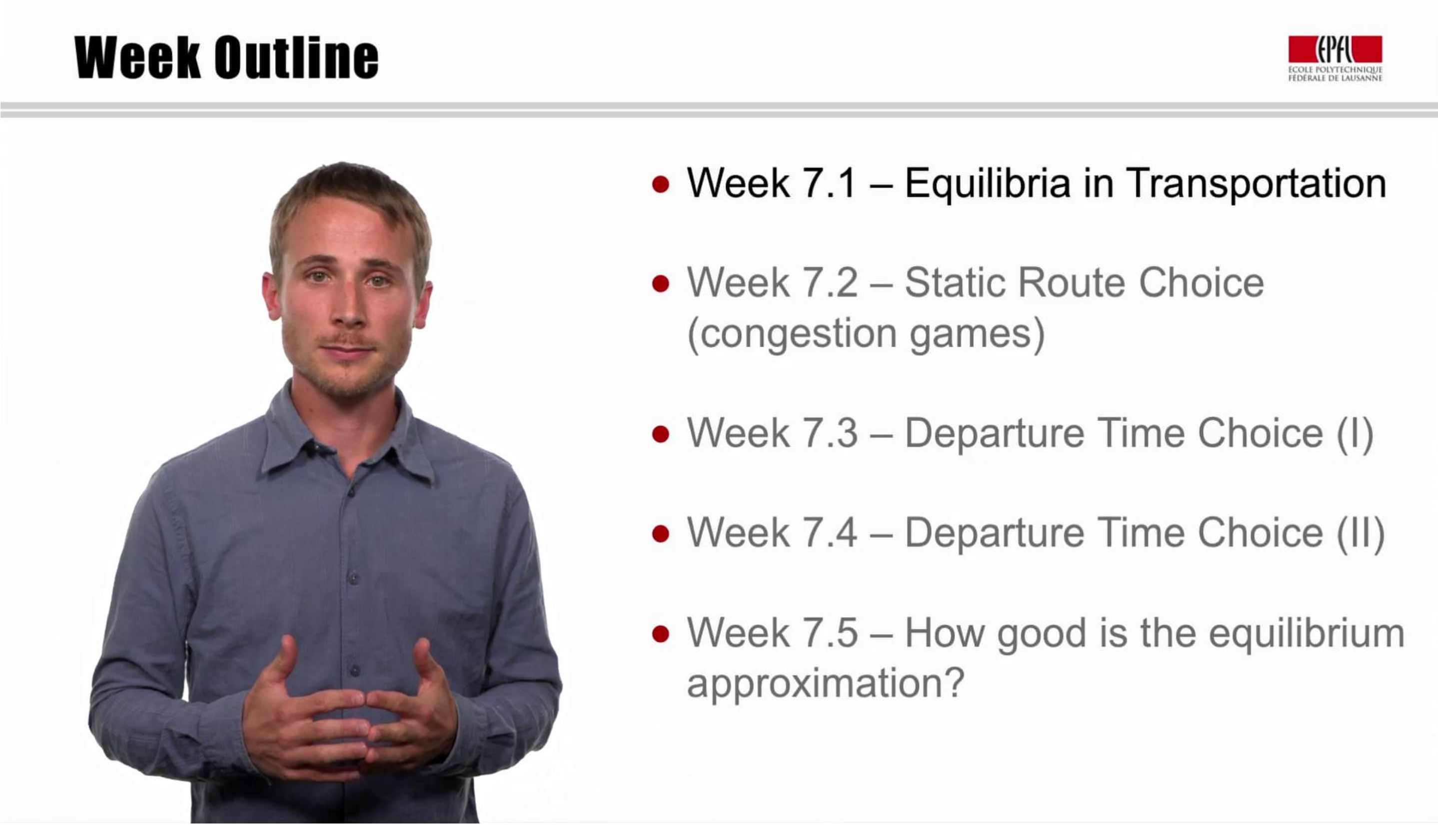


Hello, my name is Raphael Lamotte. Today I'm going to teach the last week of this course, in the previous lectures, the demand was always considered as given. And as independent of our elections, it seems reasonable as long as the costs and the troubled times will not change too much. But if we influence it a lot, then people make stuff. I just think that behavior. For instance, if we managed to reduce several times on the highway, then people might start using it more often, or perhaps at different times. So the big question is how we can predict this new demand. And that's where anybody that come into play. So in this first video, I give you an overview of equilibrium in transportation. In the second, I cover a classic example, which is a static choice problem. I use it to introduce important concepts like externalities, congestion games, and the famous brace paradox. In the third and fourth videos, about departure time choice, which is a different type of equilibrium, where people have to choose between traveling at convenient times, but experiencing congestion, and traveling at less convenient times that enjoying shorter trips.

Notes

Summary

0m 05s

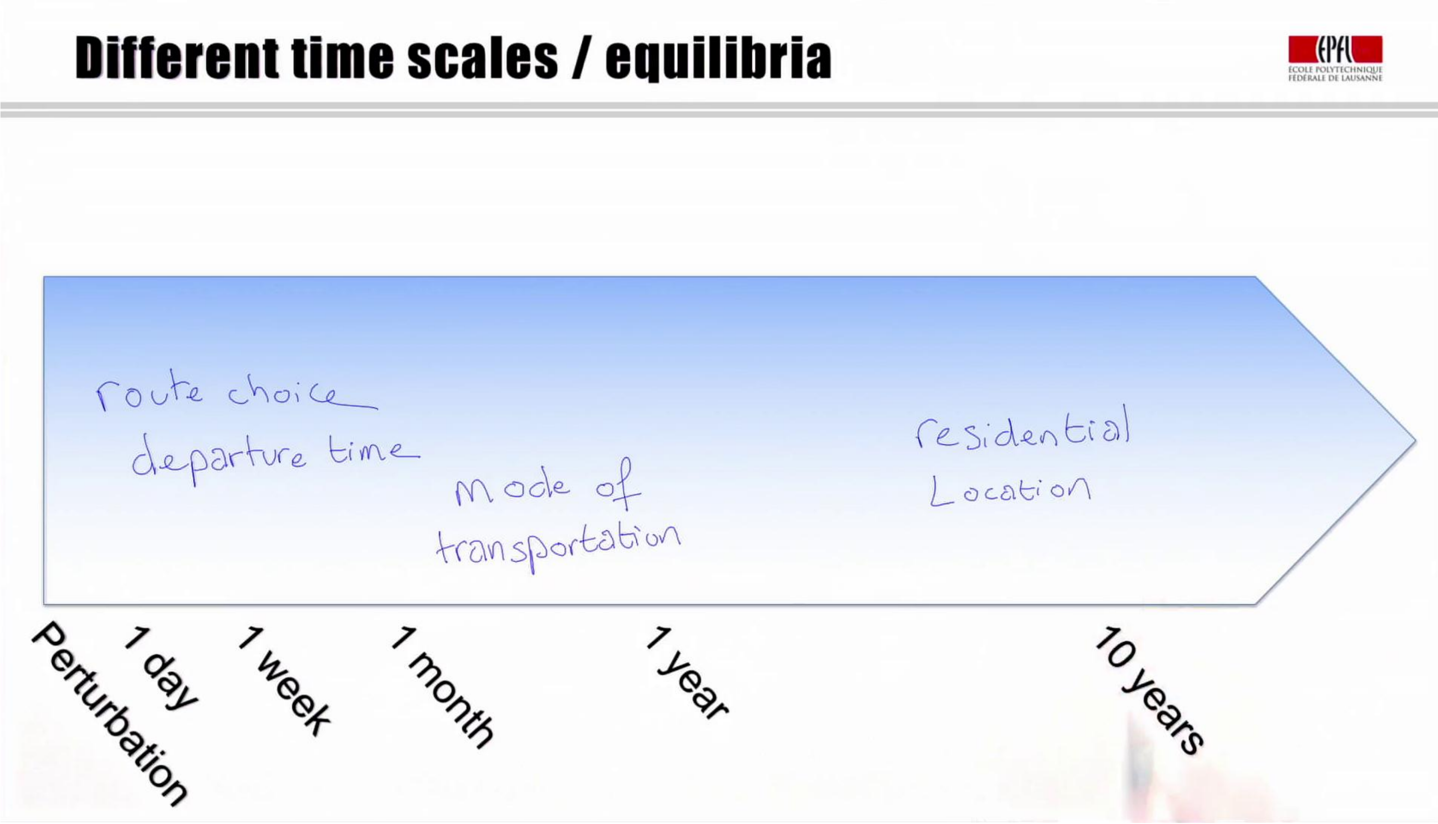


The congestion that result present an important loss for society, and we will see how we can avoid it with road pricing. Finally, the last video aimed at connecting this elegant theories with the practice, it highlights the main difficulties and provides some guidance. So let's start by reviewing the types of equilibria that are commonly studied in transportation.

Notes

Summary

1m 14s

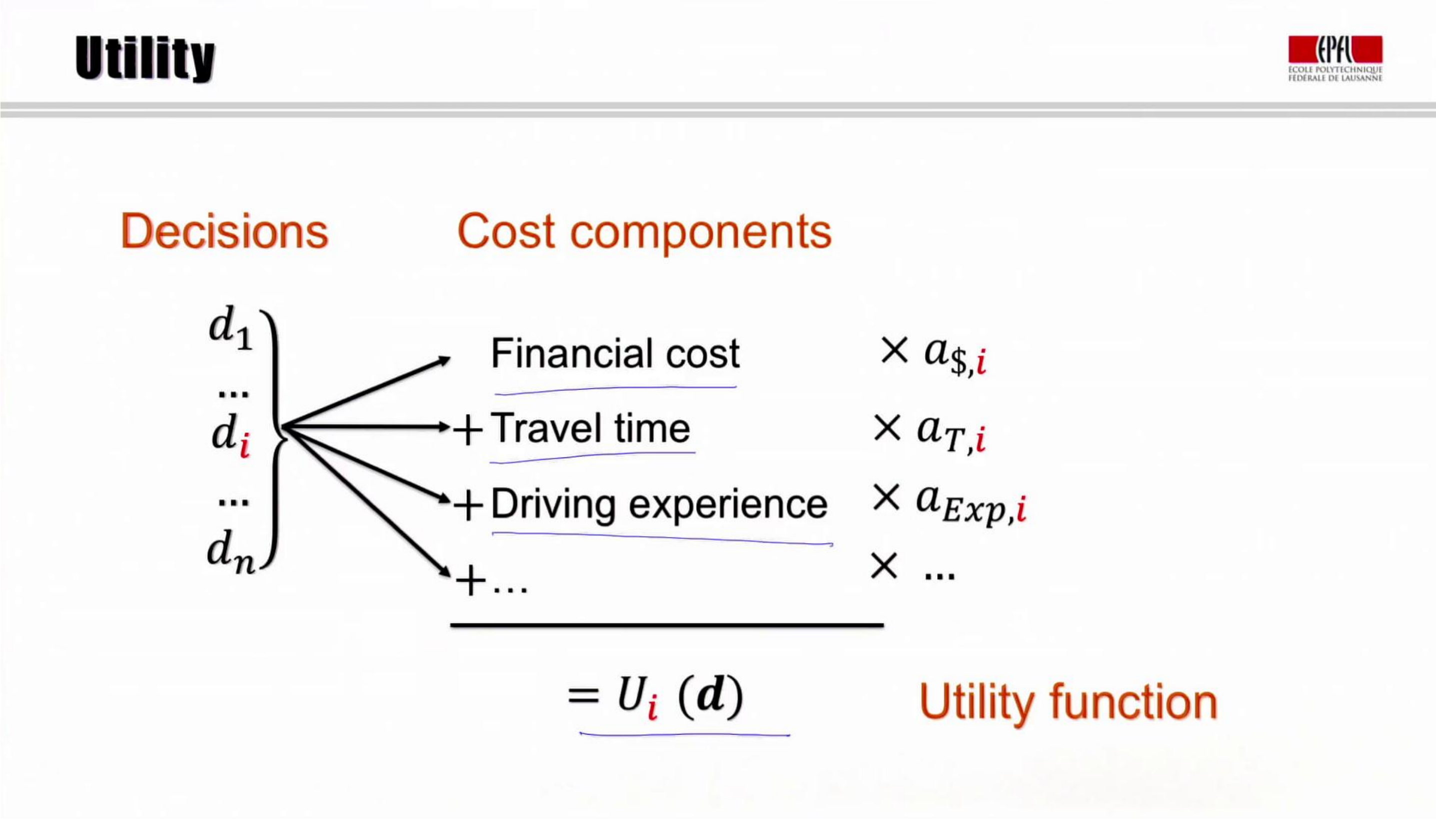


After modification of the road network, people adjust in different ways. After a few days, they might change their route or their departure time. After a few months, maybe they might change their mode of transportation, they might switch from the car to the bike. And maybe after a few years, they might consider changing residential locations.

Notes

Summary

1m 39s



To understand how people take these decisions, we need to know their preferences. And that's why we use utility functions. Utility function is something that captures all of the aspects that matter to the users like the financial cost, the travel time, or the quality of the driving experience. It aggregates them all in a single function, UI of the state. And this function describes how good the state is for the user I, if the state is preferred over another than the utility should be larger for the state that is preferred. Not that the utility of a person does not depend only on the decision of that person, it depends on the decisions of other users. Utility functions can be quite General, they don't need to be linear like here. This is just a simplification that is going to be useful in the next slide.

Notes

Summary

2m 11s

Welfare

- Question: how to sum utilities of different persons?
- The "fair" solution: max $\sum_i \frac{U_i}{a_{T,i}}$

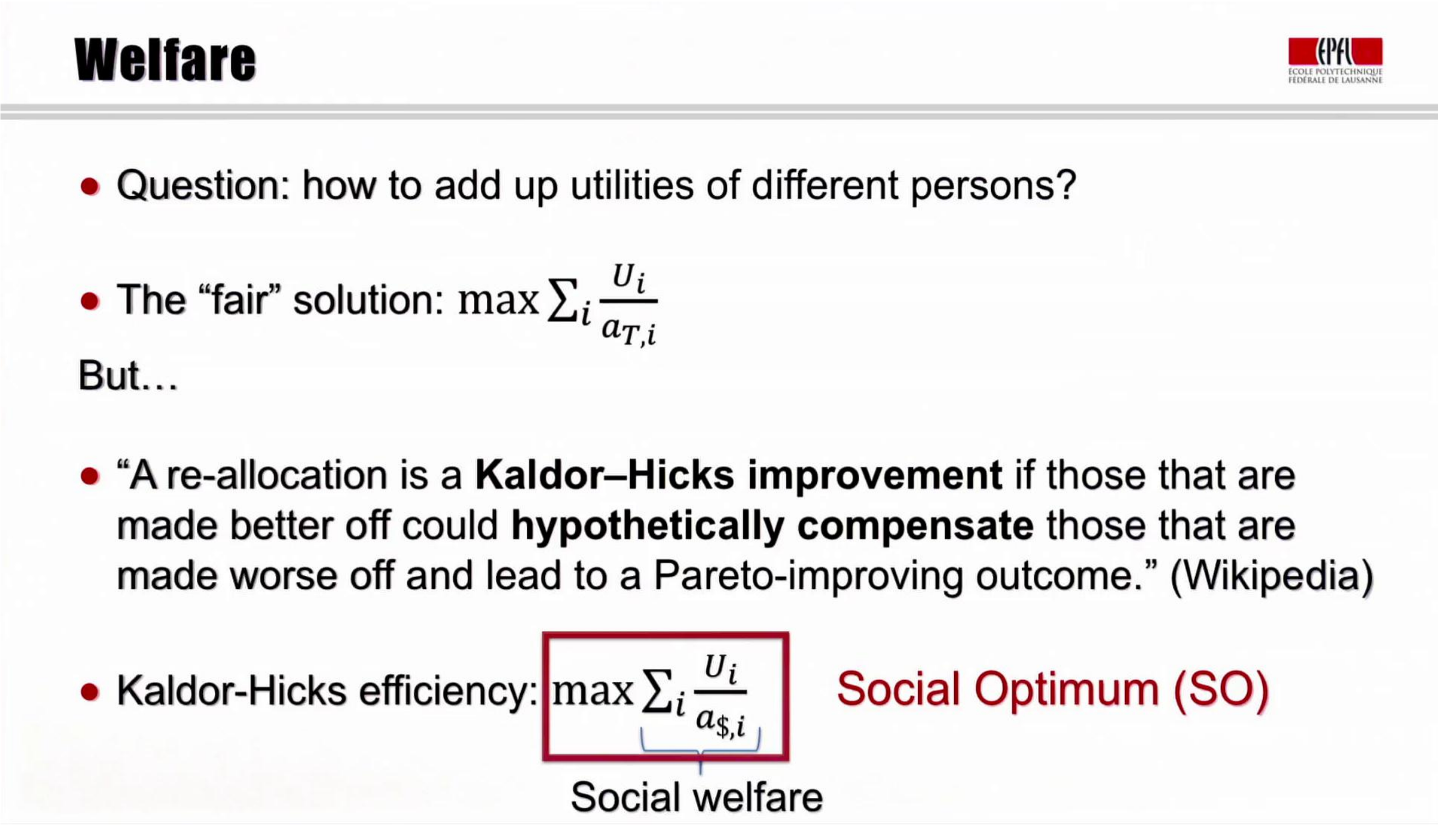
But…

So once we have models of what people like transportation authorities who simply try to maximize this utilities, the problem is how to combine utilities of different persons. One solution that might seem fair, would be to give the same value to everybody's travel time. This can be done by dividing everybody's utility function by the coefficient associated to travel time. The problem with this solution is that it's not necessarily good if we have people with different values of time, imagine somebody is late, and it has a very high value of time and others do not mind waiting a bit. Maybe the best Sun was a very high value of time would be ready to give money to the others just to pass before them. And maybe everyone would be happier with the solution. So why don't we implement this? It's actually called the Micherdericks criterion.

Notes

Summary

3m 01s



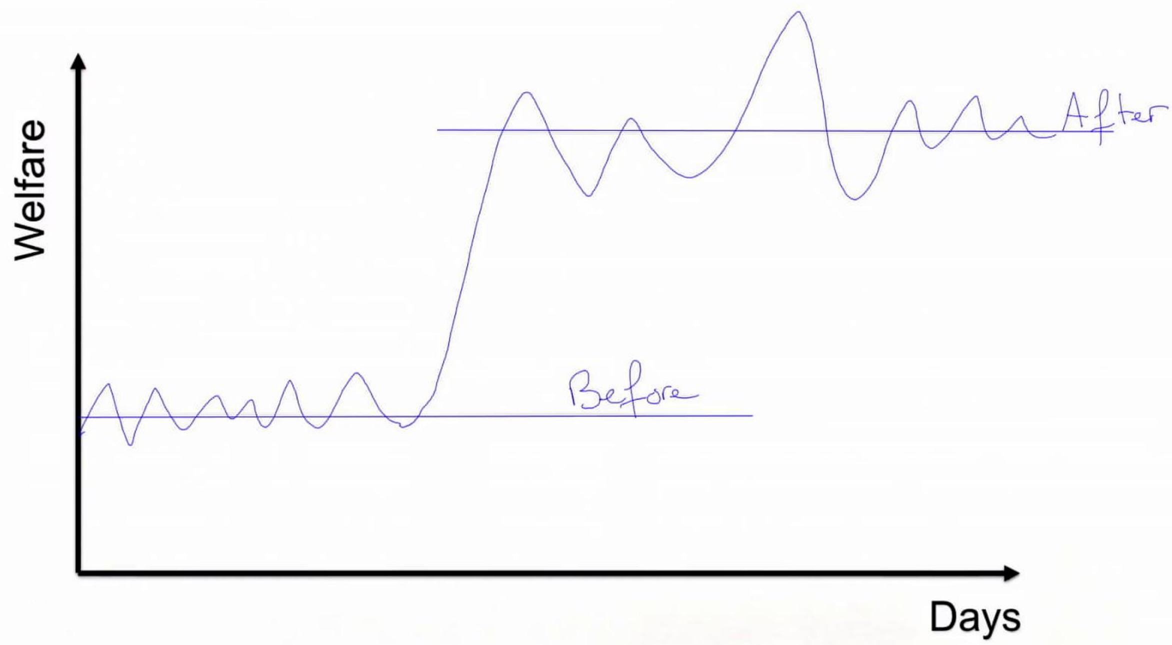
Micherdericks improvement is of the location such that users that they made better have good hypothetically compensate those that are made worse. And altogether is its totality improvement, that's a situation where everybody is happier. This suggests another alternative based on the Micherdericks criterion, we should divide everybody's Utility by the coefficient associated to the financial cost. This way, utility is expressed in military units. And if we maximize the system, we know that no further caloric improvement is possible.

Notes

Summary

3m 51s

Equilibria as useful approximations



Not however, that this is not necessarily fair, as a compensation does not need to actually happen. So now imagine that some Transportation Authority tries to maximize welfare, before doing any change, maybe welfare as some natural oscillations, and maybe after implementing a change will start seeing different values. So we cannot really try to predict these oscillations, its way too difficult. What we would like to do is to predict the average, so maybe one average before, and one after. But even calculating this averages is not that easy. And that's why we need the concept of equilibrium.

Notes

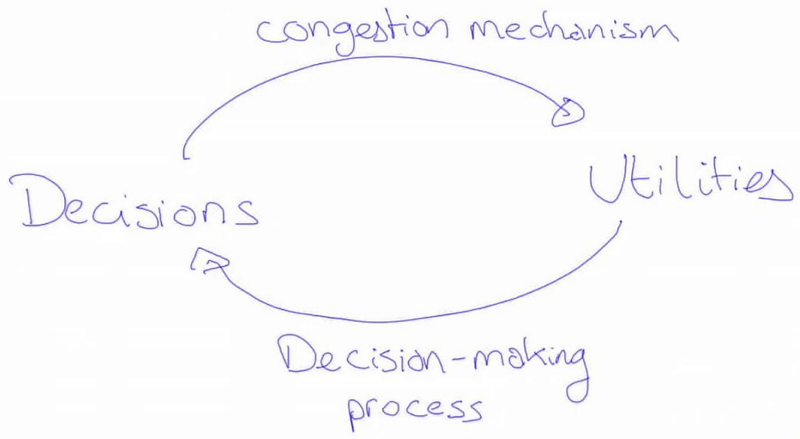
Summary

4m 25s

Equilibria as useful approximations

User equilibrium (UE):

"no user can be better off by unilaterally changing decision".



A user equilibrium is a situation such that no user can be made better off by unitary changing decision. Why is it likely to correspond to the average of the previous slide, let's consider the following cyclic process? So let's start from decisions on a given day. And from these decisions, we can apply the congestion mechanism. And this leads to new utilities. From this utilities, people can update the decision via the decision making process. So imagine now that the initial decisions correspond to a user equilibrium, if we apply as a condition mechanism, we will get utilities such that the decisions that were taken are already optimal. So if users that maximize their own utility go through the decision making process again, they will reach the same decisions again. So here we have a fixed state.

Notes

Summary

5m 11s

So now that we have the tools to predict the response our system to any preservation, we could try to guide it towards better equilibrium. One way to do it is with pricing. So by setting different prices and different alternatives, we can influence people decision. This is very efficient in theory, but in practice, it's often difficult to find the right prices when demand varies a lot. And alternative to pricing is mobility credits. These are credits that are issued by the government and that gives the right to speculate on a given route at a given time. The advantage is that the government can control the number of credits. This credits can then be traded among users. So that the price is fixed by the market. The drawback is that people to be quite well organized and the trading activity that is involved is also quite time consuming. But last alternative that is perhaps the simplest is just to ensure that the design of the network is such that it can it be naturally efficient, will see that we can do this with very simple modifications. So thank you. That's the end of this introduction. I hope you liked it. And in the next videos we will cover different examples of equilibrium in transportation. Thank you.

Notes

Summary

6m 22s