GABRIEL SANCHEZ-MARTINEZ: So let's get started today. Again, the topic is fare policy, structure, and technology. So we'll cover policy objectives, the issues that agencies face, fare structure, demand response to fare changes and fare technology. So what are the objectives of fare policy? There are multiple objectives, and they don't necessarily support each other. In fact, they often go against each other.

So the number one objective is to fund operations. That's the reason there's a user fee for service. And I say here at least partially because for the most part, the revenues obtained by fare collection do not cover the full operational costs, let alone capital costs. So here we have some examples of fare recovery ratios based on the 2014 National Transit Database. Now, you might remember that we talked about the National Transit Database earlier in this course.

And here is a breakdown. I looked at all heavy rail and I saw a range of between 0.14 0.78. So between 14% and 78% of operational expenses are covered by fare revenue. The highest one here is in California. For light rail a little lower and for bus all over the place. Here we have the averages. These tend to be higher for rail and lower for bus. So why is that? Why would that be the case?

AUDIENCE: On an operational level, one rail driver is carrying a lot more passengers than one bus driver.

GABRIEL SANCHEZ-MARTINEZ: Yeah. Although you can fill up a bus, right?

AUDIENCE: You can fill up a bus [INAUDIBLE] train carrying 500 passengers.

GABRIEL SANCHEZ-MARTINEZ: Yeah. Yeah. Yeah. Yeah. So to sort of go back to my rebuttal, there are some buzzers here with fare recovery ratios over one. So it's possible to have a bus service that returns profit even. So why is it that system-wide, bus services tend to have lower fare recovery ratios? Because you have a good point, the productivity of rail can be higher. Of course, if rail is

underutilized, then you still have that issue. Any other ideas? [INAUDIBLE]

AUDIENCE: Buses [INAUDIBLE] who can have the most service and cover the most low ridership routes?

GABRIEL SANCHEZ-MARTINEZ: Right. So there's an agency and you system-wide have to cover your territory. That will include buses that are not very heavily utilized. Also, you're providing service late at night and all those things. So there are many cases of buses not being very well utilized, and that brings down the fare recovery ratio. I did not include here demand responsive. Demand responsive is usually around 1% to 2%.

So I'm talking about what here in Boston is called the ride for disabled passengers. And it can cost around $20 per ride, and people pay a lot less. So I think $20 is low. I think it's higher. Sorry. I don't remember the number, but it's closer to $30 or $40, I think.

So the fare recovery ratio for demand responsive transit is much lower. OK. So other goals. Keep transit affordable and promote social equity. So here we have the first conflicts, right? The first objective would mean that you want to raise fares, and if you raise fares then you get more fare revenue. But there's another objective, which is to keep transit affordable and for social equity, and that would indicate that you want to keep fares low. Right?

So also, supporting growth for demand of transit also keeps fares low. Make the fare structure easy to communicate. We'll talk about different fare structures and market segmentation later in this lecture. But the point is that when you do market segmentation, you can get more revenue out of your fare system. When you want to keep things simple, then you're probably going to suggest going for a flat fare structure, where people that have much higher willingness to pay are still paying low fares.

So that objective of keeping the fare structure easy to communicate and simple will reduce fare earnings. And finally, to reduce fare system costs. So there are costs to fare collection and to the fare system as a whole. Fare collection is one of them. So obviously, the capital cost of installing the fare boxes and maintaining the whole AFC system. There is a cost for people who are maintaining those fare boxes and vaulting cash out of the fare boxes and counting the cash and keeping it in a safe place.

And there's customer service. So customer service involves more than the fare system. But some aspects of customer service involve my CharlieCard doesn't work, can I get a new one? Or I already paid for that ride and you need to give me a refund. So these kinds of inquiries or

complaints are coming from the fare system. OK? Questions about these objectives? No. OK.

So how does fare policy intersect with other areas? It intersects with many areas, and that makes fare policy and fare structure a very powerful sort of lever or knob for a transit agency. So obviously, finance. We're talking about funding operational expenses from the revenues derived from the fare system. And then there's operations. So if you have a fare policy that makes people board faster because, for example, it's proof of payments so there's no validation required or you have fare technology that a smart card is much faster than paying cash, then that means that you'll have faster boarding, shorter dwell times, shorter cycle times, higher reliability.

So you might affect operations through fare technology. Some fare structures require fare inspection. So proof of payment is one that people board without interacting with any fare system, so then an inspector has to come in and either for all passengers or more likely for a subset of passengers, a sample of passengers, request proof of having paid the fare. And of course, that involves some cost. There's maintenance of equipment. If equipment breaks down, the bus needs to be taken out of service, et cetera.

Public support. So politicians may promise not raising fares. That's a popular campaign promise. And then of course, that puts a lot of pressure on the agency to do more with less. And we'll talk more about that when we discuss transit finance. There's difficulty gathering support to raise fares. Usually, we'll improve service first and then that justifies raising fares. Right? I don't want my service to get more expensive if it's not very good service.

AUDIENCE: [INAUDIBLE]

GABRIEL SANCHEZ-MARTINEZ: Right. And essentially, if you have lower service quality, then fewer people end up taking it or liking it, and those people are not going to be the ones rallying for a transit sort of fare hike. Then there's also labor's push for higher wages. So that's another sort of political pressure on the agency that increases operational costs and therefore, may require an increase in fares. But both a labor dispute and a dispute with the passengers on the fare hike are the result of unpleasant negotiations or interactions in public.

Administration, so fare technology and fare policy and equity analysis. If you're considering any change to technology or policy or structure, you have to analyze the economic aspects of it and you have to prove that you're not discriminating against any one group, even unintentionally. So disproportionately affecting a disadvantaged community, either by race or

income, that's called Title VI in the US. Then there's another big policy issue is revenue sharing across jurisdictions. Not so much an issue on the east coast of the US, but certainly if you go to the West Coast, you have in the San Francisco Bay Area dozens of operators.

Some of them share the same fare system. So how much does each operator pay for routes that serve multiple jurisdictions? That's one question. The other question might be, if we are separate operators and we each have a route so we take care of that, we still are collecting fares with a joint system. Do we trust each other? And often, actually, the barriers to integration are more about trust and less about technology.

Marketing is another sort of issue the agency has to deal with. How much do they market and what is the message? And customer service, which we already mentioned. It's interesting to note that fares are one of the first things that a person has to sort of understand about a transit system to be able to take them. So if you're a tourist and you go to a new city that you've never been to before you arrive at the airport and you want to take the bus or the train from the airport, the first thing you have to do is buy a ticket, right, and figure out the fare structure and where are the maps and et cetera.

So this is sort of one of the first issues, the first impression that a passenger has about the fare system, about the transit agency, something related to the fare system. OK. What issues do agencies face regarding these topics? One is fare recovery ratios. So we looked at ranges. Typically, fare recovery ratio system-wide across modes is about 1/3. It varies a lot, as we saw.

It's rare to make a profit system. So one of the issues is how much-- well, the first question is, how much of a fare recovery ratio do we need or do we set a goal to cover operational expenses? And is it sort of a strong requirement, as it is in some agencies? Some agencies have laws that say the fare recovery ratio must be at least this much. So if expenses go up, automatic fare hike. Others, it's more of a guideline or maybe there is no policy. So that that's one of the key issues.

The second one is how often to raise fares. I think most agencies are reactive. So a reactive approach is one where you avoid the headache of a fare hike and all the sort of public engagement that goes with it and you only do that when you have to so you are in a financial situation where you absolutely need to raise fare revenues to continue operating. So that happens less than once every year and it's a big effort. Some agencies take the approach of

an annual fare hike with inflation. So it's kind of predictable, it happens every year at the same date.

It tends to make each one easier than one done ad hoc because it's more expectable and there's less public outrage. So gathering and maintaining political support, we talked a little bit about that. Of course, that is an issue that will play out and sort of it will affect how other issues are faced and dealt with. One other issue is do we raise base fares or do we change the relative cost of passes and discounted fare products? So if a base fare is $2, you might have 50% subsidy for seniors and you might have some other discounts for students or other groups.

You might also have passes like a weekly pass, which if you take some number of trips you break even and after that, you ride free. So you might actually leave the base fare the same and change the percentages of subsidy or discounts or the break even point of a pass. And that can affect fare revenues, it can affect ridership, and it can affect people's choice of fare product. So you might bump people towards letting go of fare passes and opting to do pay as you go more often or the other way around.

And that has implications on how people think about the transit system, how much it costs for them. For a pass holder, of course, once they've paid for it, it's kind of a non-salient expense. So you don't think about it every time you're tapping as much as having value deducted from the card every time. So those people might ride opportunistically because they've already paid for it and they might do shorter trips, discretionary trips more so than someone who is paying every fare independently.

And another big issue is investing in new fare technology. That's a headache, a big headache. You can imagine changing the way the old technology, all the analytics and administration depends on uncertain system. And bringing in a new system that nobody understands yet might work or not. So all the maintenance needs to be figured out. And you have to communicate with the public about what impact that has on them, and that could involve changes in the fare structure, not just the technology.

So sometimes technology enables new fare structures or new fare policies. And that can be one of the reasons for bringing new technology. Questions on the issues? [INAUDIBLE]

AUDIENCE: Yeah. I wonder if the rising fare issue is less common in privately operated system than in public operated systems.

GABRIEL SANCHEZ-MARTINEZ:	Can you give me an example? I'm not sure I follow the question.
AUDIENCE:	In systems where bus and rail are exceptions to the private sector.
GABRIEL SANCHEZ-MARTINEZ:	Right. Sometimes the public sector is the one-- so if you look at the case of London, for example, even though buses are operated by private companies in some way it's a contract so the fare policy is still set by TFL, which is the government. That's I think usually the case if you have a push for a unified single brand of the system. Maybe in other countries-- I'm thinking more of Latin America, Africa-- there are sort of independent people running their own systems. And those are usually cash-based so there's no integration whatsoever. Maybe you have a different example.
AUDIENCE:	But No. Still [INAUDIBLE] just [INAUDIBLE] the government. So I wonder if the type of contracts [INAUDIBLE] engage with the private [INAUDIBLE] concessions. I mean, there is a difference. There is a myriad of types of [INAUDIBLE]. I wonder if that allows you more flexibility to sort of delay because you're under a contract with a specific [INAUDIBLE] negotiation [INAUDIBLE]. So I wonder if that give you leverage to delay increasing fares, as opposed to--
GABRIEL SANCHEZ-MARTINEZ:	I'm not sure. Frankly, I'm not sure. Sort of the issues related to concessions in that case depend a lot on the contract structure. So some concessions derive revenue from the fare. I think that's not the best way of doing it. But if that's how the contract is structured, essentially, you say, I want you to operate. You keep the fares. Then of course, any fare question will affect revenues and it will affect ridership too.
	So the private operator will be interested in any kind of fare policy change if that increases their revenues and will be disinterested in any fare policy change that decreases their revenues, or increases the risk of revenue anyway. So that is probably a poisonous topic during the length of a contract and you might have to then do it between contracts. Here I'm speculating, but I imagine this is a case where you pay to run by distance or you might have some performance standards as well, but it's not fare so much.
	So the government keeps the fares and then pays the operators the contracted amount. Then that disconnects the operator's performance from fare revenue and it allows the government

or the planning agency to change the fare structure, change fare technology in the middle of a contract. And so in the former case, I imagine it's quite complicated. Because usually, the contracts are not awarded on cycle, i.e., at a certain moment in time you might have a contract that expires next month; another one that expires in a year; another one that expires in five years. So to implement a system-wide change, it would be very difficult if the contracts depend on the fare revenues. Yeah.

AUDIENCE: So a couple of questions. One, it seems like one of the biggest choices you make is whether to have [INAUDIBLE] whether to have a flat or a zoned fare.

GABRIEL SANCHEZ-MARTINEZ: Yeah. And we're going to talk about market segmentation.

AUDIENCE: OK. And then about raising fares, I see that the MTA in New York battles to raise fares, so I think flow is really hard for them, whereas when I lived London, literally every single year on January 1st, the fare changed.

GABRIEL SANCHEZ-MARTINEZ: Yeah. So that goes back this sort of annually with inflation and strategy where you do it every year and it just happens on January 1st.

AUDIENCE: People get a big grumpy, but [INAUDIBLE] about it.

GABRIEL SANCHEZ-MARTINEZ: Right. Right. And there are many other examples of that kind of approach. I think it's more effective, frankly. Expenses go up every year, so why not? Communicate what the strategy is, make it fair-- no pun intended-- and do it.

AUDIENCE: I read once that King County Transit in Seattle discounts fares for people living below the poverty line or some threshold based on that. [INAUDIBLE] Is that pretty common?

GABRIEL SANCHEZ-MARTINEZ: Yes. So we'll talk-- in market segmentation, one of the things you might segment by is socioeconomic status. Yeah. And there's different ways of doing that. So we can talk more about that when we get there.

AUDIENCE: I have another question. I also have heard it argued that with the switch to all electronic tolling that it increases [INAUDIBLE] obscures how much you actually pay.

GABRIEL SANCHEZ-MARTINEZ:	Yeah. This is a saliency issue.
AUDIENCE:	[INAUDIBLE] switch from cash-base fare system to--
GABRIEL SANCHEZ-MARTINEZ:	Absolutely. Yeah. Especially if you go to passes or a capping scheme, which we'll discuss. So yeah. The more obscure, you make the fare system, the less of an impact it will have on demand response. And that is true in other areas. If you look at it from a macroeconomic perspective, that's true in business.
AUDIENCE:	Wouldn't that mean the more obscure you make it, the less--
GABRIEL SANCHEZ-MARTINEZ:	Well, if people don't understand pricing, it may be you might get a sort of lower reaction to changes in pricing. You make less of a fuss about it. OK. Fare structure, so market segmentation. That's a good segue with these questions. So one possible way of having a fare structure is to have a flat fare structure. That's the simplest one. It costs some amount to ride, no matter what. No matter where from, what time of day, what mode, that's the price.

So again, that's the simplest. I think most agencies, if you look at the profile of all agencies, including small ones, have that fare structure. Bigger agencies tend to have some market segmentation because they are bigger and they serve a wider range of people, they serve a wider geographic area, and they have some congestion problems. So how can we differentiate fare, how can we segment the market? One is spatially.

So you could have a flat geographic structure where no matter where you ride from, it costs the same. You could have zones. So here in Boston, we have no zones outside of commuter rail. We have no zones. When you go to London, there's zones one through nine, but most of the greater London is in the first three, about. So it costs more to cross zones than to ride within a zone. And you can buy passes that are zone 1, zone 1-2, et cetera. So that's one way of doing it.

If you take that to the extreme and imagine many, many zones, you could end up with something called distance-based pricing, where each of the pair has a different fare, depending on how long that ride was. So you can do that if you have a tap-in, tap-out system, you can do that with proof of payment in some cases. It's more common in Europe. And regarding zones, a lot of agencies used to have more zones and are going for reducing zones

and simplifying the system.

It's an interesting, curious trend because they've been doing this at the same time that they've been investing in new fare technology that enables more complex fare structures. But it's a choice of communicating to the public and keeping it simple, easier to understand.

AUDIENCE: And do a couple of years' long advertising campaign to get people to figure out how to cap for the overground system, which is part of the TFL. Because you could essentially go around the entire city just in zone 2. But if you don't tap in in the right way when you transfer trains or something, it will think you went into the city and out. It's a lot cheaper to go regularly than it is to go--

GABRIEL SANCHEZ-MARTINEZ: Right. Because you stay in one zone.

AUDIENCE: It was so confusing. They had people on the platforms explaining it.

AUDIENCE: Is DC Metro an example of distance-based?

GABRIEL SANCHEZ-MARTINEZ: In some ways, yes. They have many sort of things that influence price. So I don't know if you've had the experience of going to CRB and trying to figure out how much money to put on your smart trip card because it varies by time of day or how long you are going to travel. And you don't necessarily know that ahead of time, so you end up loading-- it works in their favor. I just load up $20 or $40 depending on-- I don't really figure out how much my rides will cost and put in just that amount. Eventually, maybe I lose my card and they keep the revenue. OK. Another-- oh, Eli.

AUDIENCE: So you said that you really need a tap-in, tap-out system for distance-based, but for zonal [INAUDIBLE], how do you run that?

GABRIEL SANCHEZ-MARTINEZ: It could be proof of payment as well, not just check-in, though. So in Europe, you have some symptoms, especially it happens more intercity. So you buy a ticket between this station and that station and you have a paper ticket. And you when you board you validate it so essentially, it gets canceled with a timestamp. And if a fare inspector comes, you better have one. Otherwise, you'll be heavily fined. So that's one way of doing it. Any other questions?

OK. Temporal segmentation, so that's pretty straightforward. You've got a flat system where

there is no change in fares across time of day and another one where you have a peak surcharge or an off-peak discount. Same thing, two ways of marketing it. Most agencies prefer to offer a discount on off-peak than to charge more during the peak, but it's all psychological. So why would an agency be interested in doing this and what are the impacts? Henry.

AUDIENCE: It would influence people to maybe think more about taking the trips during off-peak so that there are alternatives that they--

GABRIEL SANCHEZ-MARTINEZ: OK. So nudging people who can do off-peak to do off-peak rather than during the peak. What else? Any other ideas?

AUDIENCE: Just encourage more off-peak ridership in general, like people should probably do this.

GABRIEL SANCHEZ-MARTINEZ: Right. So more discretionary trips. So encourage more off-peak ridership. OK. And why does it make sense to charge more during the peak than off-peak, regardless of how you market it?

AUDIENCE: Some people are [INAUDIBLE] flexible in their schedules and [INAUDIBLE] capture that.

GABRIEL SANCHEZ-MARTINEZ: Exactly. So willingness to pay is higher, either because they are actually willing or because they are captured on time like they have to arrive at some time to work so they don't have many options. And that means that they're much less flexible and that their response will be much lower to a price change. OK. By service, that's pretty simple too.

You could charge the same for bus and rail or you could say rail is a better service so it's going to be more expensive. The MBTA has this option. Regular bus versus express bus, another way in which the MBTA segments the market. So the idea is if it's a nicer service, you pay more. By socioeconomic status. So students might get a discount, seniors, disabled might get a discount. We have some rules here where seniors have to be offered half the base fare, so that's one example of that.

Some of it can be mandated by the government. And then there's social programs. So there's different ways of doing that. It could be as part of your participation in some social program, it could also be a needs-based subsidy where you essentially prove that you have financial need and based on your need, you give some amount of subsidy. So a subsidy could be on or off, you either have the subsidy or you don't or it could be depending on your need, you have more subsidy or less subsidy. And usually, it's the simpler one.

I don't actually know of any example that is done based on your specific case, but you could think of doing it that way. Because if somebody is very, very poor then they might need more subsidy than somebody who is just below the poverty line.

AUDIENCE: [INAUDIBLE] is that because those groups tend to have less ability to pay or what's the logic?

GABRIEL SANCHEZ-MARTINEZ: That is usually the logic. So yeah. Again, it's sort of social equity goal. So seniors and students often can't drive, et cetera. So it's the goal of the transit agency or the transit provider to increase mobility for all groups of people, the way in which that goal is satisfied. Henry.

AUDIENCE: How about programs where you can take out your income pre-tax and [INAUDIBLE]? Is that like a social program?

GABRIEL SANCHEZ-MARTINEZ: No. I do have that in another lecture, yeah. Because that is done for people-- often, they are employee who have a decent salary. So that's an incentive. And that incentive exists for a car as well. So that's a different strategy. Another way of segmenting is by willingness to prepay. So in other words, are you willing to buy a pass? So if you can commit to a whole month, then you get some discount.

And this depends heavily on what the break even point is. Usually, passes-- it used to be the case that passes had heavy discounts. So even without having a commute two times a week for five days, you would still get a discount. Now it tends to require sometimes between two and three trips daily to get that break even point. Some people still decide to go with that because it's more convenient, it's less salient. So it's another way of discriminating or segmenting the market. Any questions on market segmentation?

AUDIENCE: [INAUDIBLE] so speaking of [INAUDIBLE], the subsidies given by government?

GABRIEL SANCHEZ-MARTINEZ: It depends. So it could be that the agency has a mandate they have to do this. That is often the model. From an agency's perspective it would be much preferable to have the subsidy come from someone else. Because then that would allow the agency to focus on operating, It would set fares to what it needs to cover operational expenses. And then if it's a social program, well, why doesn't that social program provide the subsidy? If it's disabled, maybe there's some other government entity that can provide that subsidy.

For students, why not the schools or the Department of Education. So that's an interesting sort of policy debate and we could talk about it for a long time because some people are very

much against it and some people think that's a good idea. Yeah.

AUDIENCE: Also another thing about the various groups that are entitled to subsidies is that you have to have some mechanism within your technology that verifies that a person is [INAUDIBLE].

GABRIEL SANCHEZ-MARTINEZ: To prevent fraud. Yeah. So smart cards are helpful with that because you can embed the transit chip into a student card, for example. And that's what we have here at MIT. OK. Fare elasticities. So they can range from -1 to 0. We know that demand of transit is inelastic. So it means that almost always, virtually in every case, if you raise fares, you increase your revenue and your ridership decreases not by too much, not by so much that your fare revenues go down.

So here are some examples of typical elasticities. They usually are closer to -0.3 or -0.4. For rail, it's a little less, so -0.2, -0.15. For off-peak, it tends to be twice as much because more trips are discretionary. For work trips, it tends to be much more inelastic, as we discussed, so even half of their base one. And there's something interesting that is maybe not as important anymore, but I wanted to add it here.

There is a higher demand for free transit than there is for very, very cheap transit. Even if you have to pay, say a cent, to really get to the extreme, the simplicity of not having to deal with paying fares, not having to interact with a fare system, and from the marketing point of view, it's free-- you can just take it whenever, you don't have to be ready to take it-- then that sort of drives demand up. So that's an interesting finding. A lot of agencies have moved away from that because these are usually smaller agencies. But of course, operational costs increase and at some point, you need to cover them somehow.

So these inelastic values mean that raising fares is an effective way of increasing revenues. Not so much to increase the demand, although sometimes some aspects of fare policy are changed to increase the amount. You know you're going to get a small response to that. From a microeconomics perspective, if you think about market segmentation and running transit like a business, then you would want to charge more for longer trips; trips in more convenient, reliable, comfortable, and frequent modes; peak period trips; trips where other modes are inconvenient or costly, therefore this is the best option and why not charge more for it; and trips subsidized by third parties because then you could capture some of the increased fare from an outside source. All right.

So of course, not everybody would agree that this is what agencies should do. But if you are thinking of running an agency as a business, this is exactly what you want. If you have more willingness to pay for whatever reason, your fare is higher. And that means that fare revenues go up and your fare recovery ratio goes up. And that means you can operate more service or you can operate more reliably or you can get nicer vehicles, et cetera. All right.

So transfer pricing and policy. Another issue, some agencies don't have any sort of integration between rides so every time you board a vehicle, you pay a full fare and there's no free transfer. Some agencies have a reduced price transfer or a free transfer. And free transfers can be done in different ways. One of the most common ways is to have a time-based free transfer. So you tap and you get, say, an hour or two hours of free transit starting from that point.

So if you transfer, you'll presumably be in this two-hour window and the next time you tap, it'll be a free transfer. Here in the MBTA, the price is higher for rail and bus. So if you transfer from bus to rail, you pay the difference. If you transfer from rail to bus, both are free. Interestingly, with this time-based rule, you can often do something very quickly and return and these are actually two different trips and you would still get a free return trip and it's not a transfer.

So with more complex fare rules, you could say you should get free transfers within this window, but not if you are on the same bus route or if you are tapping into the same station or things like this. You could think of the rules used for transfer insurance when we discussed all the [INAUDIBLE]. These are not fare transfers. Those were sort of a logical trip transfers and you could apply those rules. You could put them into a fare engine and not give free transfers when it's not a transfer.

OK. Pay-as-you-go, passes, and capping. OK. One question before we-- Daniel. Yeah.

AUDIENCE: Is there-- how do agencies determine if it's unlimited free transfers within the same trip or [INAUDIBLE]? Because [INAUDIBLE] bus, rail, bus [INAUDIBLE] have to [INAUDIBLE].

GABRIEL SANCHEZ-MARTINEZ: You usually don't have to because they set the window wide enough so that you can get your whole three-four trip done in that two-hour window.

AUDIENCE: [INAUDIBLE] trips and I've been charged [INAUDIBLE].

GABRIEL SANCHEZ-MARTINEZ: Oh. In theory, I think you could go to customer service and say, this was a transfer. Your policy is free transfers. You need to refund me. Yeah. I don't know the details of it, but I imagine that's the case, that you could argue that you deserve a refund.

AUDIENCE: [INAUDIBLE] paid fare policy [INAUDIBLE] reach your [INAUDIBLE].

GABRIEL SANCHEZ-MARTINEZ: OK. I haven't, clearly. It would probably be very interesting, actually. Any other questions on transfers? Transfers are more of an issue when there are multiple operators in a region. And we'll talk a little bit more about that. If it's one operator, that's sort of less controversial. OK. So pay-as-you-go passes and capping. So pay-as-you-go is the simplest way of paying for trips.

You can do that with cash or with tickets or smart cards that have a balance. So you load up some value onto the card and every time you interact with a fare box or fare gate, some amount of that balance is deducted from the card. That's pretty clear, hopefully. Then there's passes. So the idea of a pass is that you sort of prepay for three days, for a week, sometimes for a day, sometimes for a month.

And it's a fixed price so you ride with zero marginal costs after paying that fixed price. If you ride frequently enough, then you break even and anything beyond that is a free ride. So it's interesting to note that because passes are convenient, some fare revenue is derived from past sales for people that don't break even. That could happen for several reasons. One of them might be it's more convenient and I'm not going to figure out every month if I'm going to be having the pass or not the pass.

It could also be that some people receive a subsidy from somewhere and what they spend on the pass is lower than the pass value. And so for them, the real break even point is lower and you may not necessarily be considering that when you do this break even point calculation. So in some cases, going back to transfers, agencies that don't have free transfers, you can get them indirectly through a pass. Because they might say, well, you break even at 10 rides per week so that's your five weekdays times two of going and returning. And if you have no free transfers policy but your trip requires one transfer, then you're going to very quickly reach that limit and you're going to ride free after that.

So in practice, that would be a free transfer policy, although not directly. So passes increase convenience, we know that. The reduce saliency so you're not thinking about how much money you're paying every time because it's more convenient. They can be subsidized by

employers, by universities, by governments. So here we talk about the pre-tax benefit that Henry brought up. And then there are social programs, like access to jobs programs, that give passes subsidized or sometimes even free for people that are economically disadvantaged. Questions on passes?

I think we're all familiar with passes. OK. So capping is less common, it's a newer thing. It's more common in Europe. London has it, Germany has it in many places, the Netherlands. So the idea is that when you have a complex fare structure where the prices are difficult to figure out, then the agency says, don't worry about calculating which fare products you need to buy; we'll do the math and give you the best price. So that's called best price guarantee.

And the idea is that instead of committing to getting a pass or not a pass, you pay as you go but when you reach a certain daily limit, no more is charged during that day. So you can keep riding. And that doesn't stop there. So the card keeps counting the trips in one week, the trips in one month. And so you might have multiple caps and you might reach different caps on one session sort of with one card.

So essentially, you end up getting the equivalent of a pass if it was worth it and not otherwise. Obviously, that means agencies lose some revenue from people who didn't make the right decision, but it's one way of having a complex fare structure that heavily segments the market and therefore does obtain more fare revenues. And it allows for simple communication with people by saying, don't worry about it; we know it's complicated, but we'll figure it out for you. That's one argument.

In London, one of the reasons capping was introduced was with the movement to contactless bank cards. So essentially, you can pay with your Visa or MasterCard. You can have it on your phone, Apple Pay or Android Pay, you tap, it works. So obviously, a normal Visa might not have the logic inside the card's computer to hold a pass or anything like that so the card becomes a token. One way of dealing with that is to say, it's capped. We'll keep track of your usage for the month and when you reach the monthly cap, we'll stop charging you for it.

So it simplifies the move to or towards contactless bank card usage. And we'll talk more about that. Yeah.

AUDIENCE: So since London introduced this, have they seen a drop in the number of pass purchases?

GABRIEL Yes. Well, they've seen an increase in-- the penetration for contactless bank card use has

SANCHEZ-MARTINEZ: been increasing steadily. And if you go to London, my last experience there was on the train ride between the airport and the center of London, I heard several people talking about how convenient it was. So people are excited about this. And it's great for a city like London that has a lot of people that are occasional users, a lot of business travelers being able to not have to think about it and just pay with a credit card. It really helps.

And it has several other benefits. I'll discuss them more in detail when we get to smart cards.

AUDIENCE: If you say that it's capped and you said that there's a trend away from passes, people are not buying passes. But isn't that essentially saying that actually, no; people are buying more passes than ever.

GABRIEL SANCHEZ-MARTINEZ: Well, it's capping so it's not--

AUDIENCE: It's capping, but it comes--

GABRIEL SANCHEZ-MARTINEZ: It's equivalent to a pass. The math works out so that it a pass, but you're not selling a monthly pass. Yeah. It's not a pass. You're paying each ride.

AUDIENCE: --acts like a [INAUDIBLE]. It induces [INAUDIBLE].

AUDIENCE: Yeah. But I think if you go to London every couple of months and you can just show up in London and you don't have to fill up an Oyster card or anything. You can tap your card and use it like you normally would. If you ride too much in a day, they cap it as well, which is something they don't do on a monthly pass.

GABRIEL SANCHEZ-MARTINEZ: Yeah. OK. We'll discuss more on the contactless bank cards. This is a very interesting trend that we're seeing. So fare policy demand analysis, we talked a little bit about this on ridership forecasting. Just a little recap, the traditional four-step modeling process is not usually appropriate. And that's because A, it has insufficient spatiotemporal resolution and B, the planning horizon for a fare hike is kind of short- to medium-term so you're not thinking about land use changes that will generate new trips.

So therefore, total amount is, we can assume, fixed. And what you want to play with is the modal split and the assignment to specific trips. The other thing is that these four-step models

usually don't have all the details of all the fare products in them. And for an agency, it's important to know what people will do about getting a pass or paying as they go. So usually, fare elasticity analysis is simple; in reality, a passenger is considering multiple things at the same time.

So which mode are they going to take, are they going to drive their car or are they going to take transit, are they going to take bus or rail? Fare products, are they going to go for the pass or are they going to pay as they go? And maybe there are multiple passes, which one? And then costs, not just in absolute terms. So usually, elasticity only looks at the percentage increase in fares for this mode. But what if car costs have gone up by more than that.

So really, it's relative to your alternatives and each person might have a different choice. For some people, transit might be the only mode of choice [INAUDIBLE] the only mode in the choice set because they don't own a car. For others, there may be multiple options. So the other aspect of it is that exogenous factors influence demand response and they're not usually controlled for. So fuel prices, employment, residential development, tax policy, sociodemographics, new modes-- the introduction of TNCs like Uber and Lyft and other companies have potentially affected ridership, we think they have. And most of these elasticity models don't really sort of control for that to get the real fare elasticity, and that would be what you would want to do, an accurate model.

OK. Communication of fare policy. So obviously, to the public it needs to be communicated. You can do that on your website, you can have near fare vending machines there's usually you know an explanation of the prices, you have a customer service booths. If there's going to be a fare change, again you post things on the website; there's flyers and posters everywhere; public hearings, of course, to sort of hear complaints and defend the hike.

And I wanted to add one sort of third emerging but very important aspect that we haven't figured out, and it's via APIs or standard feeds for trip planners. So if you have an app or if you use Google Maps to get transit directions and you want it to calculate what your fare will be, unless the agency has a simple fare structure, that can't be done. Even for agencies that have a simple fare structure, most of them don't provide the two files in GTFS that allow that calculation to happen.

And for agencies like London that have a capping scheme, the GTFS specification does not provide the means by which to input the fare rules that would accurately calculate the person's

fare. Because you would need to keep track of how much they've taken service over a week, over a day, et cetera. So that we haven't figured out. Third party apps like the transit app would love to be able to calculate fares accurately and display them. Because they can do that for Uber and they can do that for other modes, so why not for transit as well?

And although they would prefer to do that in-house, one alternative to that is to define some sort of standard API where it's up to the agency to calculate what that would be. But you make an API call and you say, this is the hypothetical trip that I'm planning. Give me how much [INAUDIBLE] and the agency would respond. But for performance reasons I think the transit app would prefer to be able to do that with their servers so that there's a quick response.

Partnerships, another sort of emerging trend. So employer partnerships is one example. I'll give you the example of MIT, actually. MIT has something called AccessMyCommute. Our lab was actually involved in that. So every MIT student or employee badge has a Charlie chip embedded inside. You can look at the back and it says, Charlie inside. And to employees, it's marketed as an unlimited use pass. So I can use my MIT ID and ride the MBTA. MIT gets billed on a pay-as-you-go basis.

So the reason that was the agreement is that a lot of people don't use transit enough to justify the value of a pass. So there was no way that MIT would agree to pay a pass for every employee. And it's in the interest of MIT to foment, to encourage ridership, so to decrease saliency, in this case to the extreme by making it free. So one way of doing that is to say, market it as a free pass. There is a mix of people that had passes and people that ride less often.

AUDIENCE: Could MIT reach a point where it might actually want everyone to the pass without the [INAUDIBLE] employees knowing it [INAUDIBLE]?

GABRIEL SANCHEZ-MARTINEZ: I don't think so because many, many employees-- yeah, it's not close. And some people ride a lot more so MIT in some ways for some employees is paying more because they're paying by ride. But many people that have a subsidized pass because their break even point is so much lower don't really break even. And so it works out to--

AUDIENCE: The next project that project might do is to find a way to predict based on the employee [INAUDIBLE] this information and they make a prediction for what he's going to do. And you might save MIT a fair amount of money.

GABRIEL SANCHEZ-MARTINEZ:	Yeah. Well, one of the reasons MIT decided to do this is because parking is very expensive, real state is very expensive-- very expensive. And that's, of course, not true everywhere. It's not true in most places. Most places have free parking, plenty of land. But in a place that has high density, building new parking is very expensive and you could use that real state for something else.
	In fact, MIT has taken a parking down near Sloan and is making a new building there. So it costs less to provide transit to people and to encourage people to take transit than to build new parking and maintain parking. Here's another example. So the Chicago Transit Authority has partnerships with other transportation providers. And they do that by providing-- there are some passes and some fare products that allow riding in PACE, which is the original bus provider; Metra, which is the commuter rail provider; and Divvy, which is the bike share.
	So you can buy things that-- there are some partnerships that allow some integration here. And there is a trend towards mobility as a service. So the idea of mobility as a service is that you make a monthly payment for a bundle of transportation options. Here's an example. You could have unlimited transit pass five bike rides and five TNC rides. So you provide this bundle. The person is purchasing my transportation from home to work and back on a combination of both. So if it's today it's inconvenient to take transit, that day I will use the bike share or the TNC.
	The word is out on whether this will work or not. Many agencies are interested; most of them don't want to talk about it. And we'll see what happens as time goes by.
AUDIENCE:	Is the reason that MIT is hesitant to extend the transit benefit to grad students because grad students tend not to be parkers so we don't have that bargaining?
GABRIEL SANCHEZ-MARTINEZ:	That is sort of a reason for why they shouldn't or wouldn't, but I'm not sure that it is the actual reason. I think this was always conceived as an employee benefits program.
AUDIENCE:	Aren't we like employees?
GABRIEL SANCHEZ-MARTINEZ:	Not quite. So yeah. So I don't really know the actual reason. Sometimes decisions are made for-- you justify them in all sorts of ways and then someone decides. So many other factors play in. OK. Fare control. Tap in, you know what that is. You interact with a fare box or fare gate only when you're entering the system or vehicle. Tap in and tap out, you do that when

you enter and exit. Usually, tap in and tap out is for systems that have zones and you tap out so that we know if you've traveled multiple zones or not and therefore, we know how much to charge you because of the segmentation by geography.

It also happens when there are multiple agencies sharing the revenue. So intercity bus in some cities, if a person takes a bus route within a city, then that revenue would go to that city. If the person travels across cities, then the revenue would be shared across cities. So that's one way you might want to do this. I know that it does exist in some places for bus where you have to tap in and tap out, although it's much less common for bus than for rail. Henry.

AUDIENCE: If the tap system introduces a day pass, for example, where [INAUDIBLE] go to multiple--

GABRIEL SANCHEZ-MARTINEZ: Yeah. Yeah.

AUDIENCE: [INAUDIBLE]

GABRIEL SANCHEZ-MARTINEZ: Yeah.

AUDIENCE: Then would they just [INAUDIBLE].

GABRIEL SANCHEZ-MARTINEZ: I don't know how they do it. Funding formulas are a huge debate. And as an engineer, I would propose to look at their OD and figure out the most fair way of allocating that revenue. But how would they actually do it is probably simpler. Another thing about tap in and tap out is that you may require internal vending machines. It may increase your capital costs. Why is that?

Because you have multiple costs. The price of your ride depends on how far you ride and if you cross zones or not. So you might have just enough balance to enter, not enough to exit if you cross multiple zones. So you might have to top up the card before being allowed to exit. That means you need a fare vending machine that a person can use to top up if they don't have a pass. It means that you might need a station attendant to deal with somebody. If the fare vending machine is not working or my bank card is not working and is being rejected, I need to get out of the station.

I'm trapped. So what do I do? So it can increase costs in that way. You had a comment? OK.

No. Right. So that's one potential issue. Something that some agencies do is allowing a negative balance. So when we are softening the blows to allow when you tap out to go below zero. Next time you fill up the card, you top up, if you put in $20 and you had a $1 deficit, your balance is now $19. You can't do that if cards are [INAUDIBLE] because people will then toss the card and get a new one.

So you make people buy the. The cards are maybe $10 and a $5 balance or something. So there's a disincentive to tossing the card and getting a new one. And by the way, smart cards cost money. They're not that cheap. Some agencies have paid $10 per card for their card. Proof of payments, we sort of discussed that. You buy a ticket. It might be OD, it might be flat fare. It doesn't matter, you buy the ticket that you need. And then when you board, there's usually some validator that prints a time stamp.

It can be electronic as well. And what it requires is fare inspection. So at random, a fare inspector will board the vehicle and have a handheld device requiring people to confirm. If it's an electronic system, then they'll tap on here and I want to make sure that you've actually validated. If it's paper, then they would look at the paper and make sure that you've canceled it or validated that paper ticket. And otherwise, big fine. So the discouragement to fare evasion is through fining and through policing.

But the research shows that there are still higher fare evasion rates on systems that are proof of payment. People opportunistically board and they don't pay anything. OK. Fare technology. So we've talked about structure and policy, let's talk about technology. So this is how an AFC system is usually set up. You have a fare engine. It's a server that has all the fare rules in it so it can calculate fares based on a sequence of taps. And it's connected to different things.

So a fare vending machine, that's where you purchase your card or your ticket. So these are usually fiberoptic connections or hardline connections and so they're fast. It's a real-time validation. As soon as you buy a card and add value to it from a fare vending machine, that balance is usually updated. If the fare engine has a balance in it, it will be updated in the fare engine.

That's not always the case. There's many kinds of systems. So customer service booths are also connected, fare gates are usually connected as well. So when you tap into a fare gate, there's a quick communication with the fare engine saying, is this card valid, yes or no? Is there a balance? If so, deduct balance. This is how much balance needs to be deducted. And

the fare gate opens.

Or maybe the fare engine says, no, the card's not good. Sound the alarm, don't open. There are other ways of doing it. So the card itself might hold the balance and the fare gate might have the logic to decide whether to open or not. But there's a whole range of ways in which this can be configured. Fare boxes and validators are usually on vehicles, although there can be handheld validators. Again, a validator is more often used for proof of payment.

A fare box is used when it's pay-as-you-go or pass, so that's what we have here in Boston. There's two ways of doing this. It used to be the case that they were not communicating in real time with a fare engine. So the card and the fare box have a little chat and decide how much value to deduct. Later, the bus reaches the garage or it's being cleaned and at the garage there's a garage server that wirelessly probes the fare box and extracts all the data from it. And only then will the fare engine receive the information about what transactions have been done in that fare box.

So you might have, again, a real time validation. It can be a little slow over the air. So what happens, and this is being done London, for example, with contactless bank cards, what happens is that maybe the first time the card is seen, there is this dialogue and validation. After the card is marked as trusted, then it can just validate immediately and the actual deduction can wait a little bit and be sent in batches to the fare engine.

There's a cash vault. That's where if your system accepts cash when the bus or fare box reaches the garage, that cash vault is taken out and the cash needs to be counted and moved out of the fare box and to a safe place. Smart cards themselves are computers. They are small computers with a battery and a clock and some amount of processing power. So they have some memory, so they can hold some history about your last trips. They can hold how much balance there is in some cases.

They are able to encrypt and decrypt communication so that it's harder to break the security and say add balance your card. And I want to add although this is not necessarily part of the fare system, data [INAUDIBLE]. Increasingly, we are doing a lot of analytics. So usually, there's some connection between the live production system and a data warehouse where on a daily or a weekly basis, there's an extract of data into a data warehouse. And that allows analysts to run heavy queries on a server that is dedicated to analysis and not on the live system [INAUDIBLE] whether or not to open a fare, if that makes sense.

OK. Fare media. Any questions about fare technology and the framework of how this is set up? There are lots of variants and I didn't get into the details of how any one system works. OK. So fare media. Cash, we all know what that is; tokens. So I don't need to go into how cash is minted or anything, right? So tokens are little coins that you buy with money and it's like a ticket in some ways. It has some value and sometimes it's possible to be able to have to pay two tokens for a ride, although usually it's just one.

They're being phased out because they can print paper tickets with magnetic stripes and there's more data to it.

AUDIENCE:	[INAUDIBLE]
GABRIEL SANCHEZ-MARTINEZ:	Yeah. So they still exist.
AUDIENCE:	[INAUDIBLE]
GABRIEL SANCHEZ-MARTINEZ:	Yeah. They still exist. Yeah. This is a Boston token, by the way, this one right here.
AUDIENCE:	[INAUDIBLE]
GABRIEL SANCHEZ-MARTINEZ:	No. I'm pretty sure this is an old Boston token. Yeah.
AUDIENCE:	[INAUDIBLE]
GABRIEL SANCHEZ-MARTINEZ:	Yeah. Yeah. Maybe I'm wrong, but I think that's the case. OK. Tickets. So tickets are they're printed on paper and they have a magnetic stripe. They don't have a computer in them. The magnetic stripe holds information that can be encrypted. So it can be, but it's not always encrypted. It's a little easier for there to be fraud with tickets. So if there are questions on tickets, I'll talk more about them.

Smart cards I've talked about. Mobile ticketing is another option. So that's a recent development. You have an app, you pay for a ticket for your ride on the app. And it's usually

kind of a proof of payment system where a fare inspector comes along and scans a QR code on the app, proving that you've purchased a valid fare for that OD pair, for example. This is being used here in commuter rail in Boston.

And then the sort of newest form is contactless bank cards. So that's a wireless Visa, MasterCard, credit charge card, debit card and you tap it on the-- there you go. You can pass it if you want. Can I see it? So you tap it just like you would a Charlie card or an Oyster card in London and there's the dialogue between the fare and the card. Strong encryption. As I said, the full validation process doesn't always happen, especially in bus, because you can trust the card.

There is a separate antenna. Of course, the frequencies and the protocols are different. But there are good standards for this and London has moved to this. CTA's system is based on this technology, even though they opted to only use token cards. So it's the same technology, but it's branded as their own thing. And I don't know if they can-- now it does, right? But at the beginning, it wasn't.

AUDIENCE: I met someone who had a problem--

GABRIEL SANCHEZ-MARTINEZ: Yeah.

AUDIENCE: [INAUDIBLE]

GABRIEL SANCHEZ-MARTINEZ: Yeah. So with this, as you have more and more cards on your wallet that are contactless, you should get like a copper-lined wallet or something, to like copper sleeves. They exist to sort of prevent two reads from the same card.

AUDIENCE: So if I have a contactless bank card, can I just walk up to one of those systems and tap in?

GABRIEL SANCHEZ-MARTINEZ: Yeah.

AUDIENCE: [INAUDIBLE] absolutely nothing?

GABRIEL Absolutely nothing. You just get on the bus. Yeah. It used to be the case in Chicago that it was

SANCHEZ-MARTINEZ:	kind of their own thing and you were given a card. It was the same thing as a credit card, but just as a token with no balance or account on it. And now they've enabled this. So that's the new way.
AUDIENCE:	But there are other issues about that because there are issues of what if the card is from a different country and things like that?
GABRIEL SANCHEZ-MARTINEZ:	Again, you do validation. There are policies. That's what these card companies do. They're good at it. There is insurance for fraud. So they-- yeah. Yeah.
AUDIENCE:	It's a big push from Visa and MasterCard to get [INAUDIBLE] contact list because [INAUDIBLE] money [INAUDIBLE]. So every way they can make it easier to spend money is better for them.
GABRIEL SANCHEZ-MARTINEZ:	Eli, you have a comment?
AUDIENCE:	And in Chicago, it doesn't process transfers or passes. They're just charging you a la carte, one trip.
GABRIEL SANCHEZ-MARTINEZ:	So there's they don't have a capping scheme.
AUDIENCE:	Right. And it doesn't [INAUDIBLE].
GABRIEL SANCHEZ-MARTINEZ:	So if you want a pass, that's not an option for you is what you're saying.
AUDIENCE:	You need to actually [INAUDIBLE].
GABRIEL SANCHEZ-MARTINEZ:	OK. Yeah. So that's an interesting comment which no one heard. I'm sure the comments on the back are also interesting.
AUDIENCE:	They're just asking me about [INAUDIBLE].

GABRIEL SANCHEZ-MARTINEZ:	I'm generally interested. Can you share with the class?
AUDIENCE:	They were just asking whether you actually have to [INAUDIBLE].
GABRIEL SANCHEZ-MARTINEZ:	Oh. OK.
AUDIENCE:	You do have to take it [INAUDIBLE].
GABRIEL SANCHEZ-MARTINEZ:	As opposed to EMV, yeah.
AUDIENCE:	But [INAUDIBLE] Chicago have it because I thought it [INAUDIBLE] penetration [INAUDIBLE].
GABRIEL SANCHEZ-MARTINEZ:	But I think they will increase. And that I think could be driven by agencies in big cities, actually. That's one example of that. The US has been a little late in adopting credit card technology in general. All right. Smart cards. So I've already talked a little bit about them. They enable more complex fare structures, they allow faster boarding and higher gatebank throughput because the validations are much faster than a ticket. A magnetic stripe ticket needs to be fed in and read multiple times sometimes and it takes more time to do that.

Certainly, cash is slower. So account registration is one of the benefits of smart cards. You don't have to do this, but you often can. So you open an account and that gives you balance protection. If your card is lost, you can log into your account and remove that card. The balance could be retained on the account so you can get a new card associated with that account and you have your balance.

Autoload is another convenience. You might have a rule that says, if my balance drops below $5, charge $20. So if it's top up or pay-as-you-go, then this one feature. Of course, it's much better for us sort of researchers and data nerds, better data for analysis and planning, longitudinal studies. You can track a token longitudinally and understand more about behavior. It's embeddable in employee and student budgets, as we've seen.

They are more expensive than tickets. Now there are some smart tickets so you can print a |

card with a chip circuit inside. Those are a little cheaper. One issue with smart cards is that a lot of these systems are proprietary. And there are some standards, but there are several standards-- too many of them-- and they don't all work everywhere and so you can't really use a card from one system on another system. That's usually not the case. There are some exceptions to that.

There is a move towards open source hardware specifications. New York is a good example of that. They recently did some procurements where they asked all the parts to be-- it was for an AVL system in this case-- to be open source hardware and communications technology. That means they're not locked into that vendor. So if they need to replace one aspect of that system, they can hire someone else that also complies with that standard and that part can be replaced. That lowers costs, increases competition, and it means again that they're not locked into that vendor. Lee.

AUDIENCE: [INAUDIBLE] security at all or [INAUDIBLE].

GABRIEL SANCHEZ-MARTINEZ: Usually, the systems have strong standard encryption. Part of the standard is what encryption is used and what encryption algorithms are used, hashing, et cetera. Yeah. So the Charlie card has pretty weak encryption, 40 bits I think, and the same key on every card. So a long time ago, someone cracked the key by brute force and that's the same key on every Charlie card. So once that key is public, anyone with the equipment could load a fake balance to the card because the cards are the ones having the balance in the AFC system here and not the fare engine.

That means that effectively, you can lie to the fare system and say that you have more money than you have. Much harder to do with any modern system, certainly contact with a bank card which has a very strong encryption and unique keys per card.

AUDIENCE: Did MIT students get caught doing that?

GABRIEL SANCHEZ-MARTINEZ: The MIT students were the first to do this. They were caught and there was some issue. Which I think it ended up being just a slap on the wrist, but there was a lot of issue with it. Because they wanted to publish a paper or publish something and then that was an issue. OK. So integration across agencies of a region is possible. That's one of the reasons for moving towards smart cards, especially in regions that have many providers.

But it's challenging, and usually the challenges are less technical and more about trust and

business and who gets to decide what color the card is or exactly what the fare policy will be. This is another interesting thing. In some countries, and I'm thinking specifically of Japan and China, there are examples of retail stores that have partnered with a transit agency and you can use the card at retail locations.

Hong Kong is an example of that. There's more than 100 retail locations that accept Octopus. And in Japan, I know that there are entire cities where there's like a whole mall and this is what most people use as a charge card. So that's interesting. If you don't have very tough privacy laws, as you do in Europe and the US-- I'm not sure what they are in Japan, but there was some research where they were combining all the data from shopping and transit to get really interesting behavioral analytics.

And you can do interesting things like offer discounts at stores if you do something in transit. So there's a lot of very interesting [INAUDIBLE].

AUDIENCE:	Our company did the same thing and once [INAUDIBLE]. So after that, we are very careful about dealing with [INAUDIBLE].

GABRIEL SANCHEZ-MARTINEZ:	Yeah. Yeah. Thanks for sharing. So contactless bank cards. We started talking about this, we've mentioned that multiple times. Here's the logic for it. A transit agency would prefer not having to deal with the complexities and costs of fare collection. Essentially, if you have a fare system, it's like having a small bank. It doesn't give out loans, it doesn't do other things that banks do, but you are dealing with money and the cards and customer service related to cards and all those things.

Banks do that, and they do it very well. So why not outsource that part of the business to banks? There are multiple banks so they can get competition. So credit card companies specialize in payment; contactless bank cards are very secure, much more so than say the Charlie card; you can use cards like this in several ways. So you could directly use them for payment as you would at a retail location or you can use the token that identifies that card, tying it to an account. And then your fare engine can calculate what the fare will be and capping and all that.

And then on a regular basis, there would be a charge to your credit card or account for whatever total was calculated. So that also enables Apple Pay and Android Pay. If you can put your credit card on your phone, then you can use your phone to get into the system. In London, people love that. It reduces fare collection costs. So why? Not necessarily obvious. So

it simplifies customer communication. You don't have to issue new cards to people, you don't have to explain how you pay because people know how to use cards.

It relies on open standards so there's more competition on the market. There's several banks, for example, and you could have banks compete for who will give you a better deal in terms of fees on these cards. It outsources some aspects of customer service to banks. So if my card stopped working, who's going to get the phone call, the transit agency or the bank? And it eliminates costs of sort of creating and distributing smart cards.

So there's several ways in which this is reducing costs. London has successfully been able to reduce the number of station attendants and especially of booths where they sell Oyster cards and have customer service related to Oyster cards. They've been able to close those and save money. And then there's an equity issue, and this is what is always sort of brought up when you talk about contactless bank cards, which is what about the unbanked? The poorest people are the ones who don't have a bank account.

So what can you do about that? Does that make this not work? So there are multiple ways of addressing that. An agency can issue cards that have preloaded balance. So that person could interact with the agency, not the bank. They don't necessarily need a bank account. You can have banks offer free accounts. So you can try to encourage people to open accounts that have no fee, no minimum balance. So some [INAUDIBLE] special accounts created for that.

And one other issue is that you must be able to obtain these cards at many locations. If you move towards a system like this and you can only get one of these sort of equity issued cards if you want from one station downtown, that means that the person who depends on two or three buses to get into downtown can't easily get a card. So you must be able to maybe get these at several retail locations or have fare vending machines in multiple places, especially in zones of high concentrations of people that depend on transit and don't have bank accounts.

OK. So there are ways of dealing with that. Boston is considering now what they call AFC 2.0. They're sort of branding it that way. And they're probably going to be moving forward with the London model of using contactless bank cards. So we'll see how it plays out and we'll see what that does to the payment industry in general in the US in terms of that means more people will have these. Does that mean that a lot of readers at retail locations will start accepting that, and what will that do? It's a question. We'll see what happens.

OK. Last topic is fare analytics. So obviously, lots of data is generated by these systems.

We've used it for all the [INAUDIBLE], you've looked at it in your homework. So here's an example from one of the students in the transit lab who has one more year to graduate, but he's done great work. His name is Andrew Stutz. And one of the examples of his work is dashboard, where you can look at all sorts of fare transactions by fare product, by pass or no pass, by user type.

And you can sort of filter and see exactly who's using your system how often. Let me see if I can show that to you live. OK. So here's AFC validations for October 2015. So if I want to see, for example, here we're looking at everything. So we're looking at tickets and cards and passes and monthly passes and pay-as-you-go. So if I want to look at stored value, so no passes, I'll sort of filter that out.

Then of course tariff type becomes 100% pay-as-you-go. And then you see the breakdown between cards and tickets for stored value use. We see the trends by time of day here and by date. So you can see that weekends are lower and the user type right here. So adults very high and then senior students below that. If you want to look at passes, for example, we could then say passes and monthly passes in particular. You see that most of those are cards, not tickets. Makes sense.

Higher number of students than we saw before, et cetera. So you can really sort of play with this and understand how the market segments itself with these different fare products that people are purchasing based on the fare policy. And there's another dashboard for fare revenue. So these are fare revenues by month across many years. And you can see the total up here. But you can break it down again.

So you can look at how much of it is monthly passes and you can see how much of it is normal commuter pass versus commuter rail. And you can see, if you're interested in students, here's your students. So you can really slice and dice it any way you want to. And there's many more applications, but I just wanted to demonstrate a few. OK. So that was it.

I'm not going to lecture anyone for this semester. So I'll still come. And I'll let you know about the test as soon as I have more information on it. Any questions on fare policy, fare structure, fare technology? No. All right. Thank you.

[APPLAUSE]