

[SQUEAKING]

[RUSTLING]

[CLICKING]

**JONATHAN  
GRUBER:**

All right, let's get started. Today, we are going to complete our discussion of consumer choice by actually coming back and deriving the demand curve that we started the semester with, actually showing you how from the limited set of tools we've given you we can actually derive the underlying demand curves that we see in this class. I'm going to spend the rest of lecture then talking about the elasticity of demand-- what determines the shape of that demand curve. I'll talk about how changes in income affect demand. And then, we'll come back and talk about the effects of a price change, and we'll talk about the theoretical concepts underneath how you analyze a change in price in economics model.

So let's start with deriving demand curves. So we started in this class with the demand supply curve, and I said we'd tell you where they came from. So, basically, we're now going to talk about how do you derive, from the tools we've learned so far, the relationship between price and quantity demanded-- the downward-sloping relationship between price and quantity demanded that we showed you in the very first lecture.

So to do so, let's return to our example from last time. Remember, our example from last time is utility function was of the form  $u$  equals  $P$  times  $c$ . Your parents had given you an income of \$72 with which you could buy pizza and cookies, pizza at a price of \$12 and cookies at a price of \$6. That was the parameters in are example from last time.

And once again, remember, all I've done is giving you stuff here. Obviously, this part is non-controversial as a price for pizza in the market, the price of cookies in the market. There's an income that's the amount of money your parents give you. That's all non-controversial. And this is just a sensible assumption of what someone's preferences might look like.

All I'm saying is with these four things, we are done. With these four things, we can now derive a demand curve. And how's that? Well, let's start by looking at it graphically in figure 4-1.

Figure 4-1, on the left-hand side is exactly the kind of a difference curve analysis that we did last time. So we start with budget constraint bc1. That is something where you can either get up to 12 cookies and no pizza or up to 6 pizzas and no cookies. And we know, from our analysis last time, given this we showed you last time, and you went home and practiced and were so excited you told your mom and everything, we told you how you could show that you'd want 6 cookies and 3 slices of pizza at a point like point a. We showed that last time.

Now, we also talked about how when the price changes. So, for example, imagine that the price of cookies rises to \$9. Well, we know if the price of cookies rise to \$9 is that you could still, on your budget, afford 6 pizzas. So the y-intercept does not change, but the x-intercept changes.

Now, you can only afford 8 cookies, so you move to bc2 sub 2. You used to be able to afford 12 cookies, now you can only afford 8 cookies. And most importantly, the slope of the budget constraint has steepened. Remember, what is the slope of the budget constraint? The slope of the budget constraint-- the slope is minus  $P_c$  over  $P_p$ . That's the slope. And that steepened, because the price of cookies has risen.

So you have a steeper budget constraint. The slope used to be minus  $1/2$ , now it's minus  $3/4$ . So now, that's gone from minus  $1/2$  to minus  $3/4$  with this new higher price for pizza-- higher price of cookies. I'm sorry. The price cookies rose to \$9. That budget constraint has steepened.

What does this do to demand for cookies? Well, we find the highest tangency of your indifference curves with this new budget constraint, and you could solve mathematically to show that that will occur at point b, where you will choose to continue to have 3 slices of pizza but to only have 4 cookies. That is what happens if you take this, you do constrained optimization-- if you change this price to 9, re-optimize the way we showed you last time, you'd end up finding that you would want 3 slices of pizza and 4 cookies at point b.

Now, what if instead the price of cookies fell to \$4? So cookies got cheaper. Well, in

that case, now, you could still only afford 6 slices of pizza. So the y-intercept once again doesn't change. But the x-intercept now moves out to 18, because now you can afford 18 cookies.

So your new budget goes straight is flatter. It's bc sub 3. It's the flatter, outermost budget constraint. Your opportunity set is much larger because cookies are cheaper. You have the same amount of money from your parents, but it can buy more stuff, and you can buy more cookies. so your opportunity set is larger.

So you now can re-optimize with a now flatter budget constraint. The slope, instead of being  $1/2$ , has now fallen to  $1/3$ . When the price of cookies is \$4, the price of cookies over the price of pizza is now  $1/3$ . So an absolute value, the slope is lower.

So you can now-- and we say that if you take the same utility function and optimize at the new price, at a price of cookies of \$4, you will find that you will choose point c. Still 3 slices of pizza, but now 9 cookies. So all three of those points we simply did by redoing optimization I did last time-- by taking this utility function, maximizing it subject to a budget constraint dictated by these parameters. And all I did was change this parameter twice.

Once I changed it up. Once I changed it down. Questions about that?

Well, you've now derived a demand curve. Oh, yeah, I'm sorry. Question.

**AUDIENCE:** Will this also change the indifference curve?

**JONATHAN GRUBER:** No, your indifference curves are determined by utility function. Your difference curves do not change. It changes which indifference curve you end up choosing, because the tangency point changes. But the only way to change the indifference curve would be to change utility function. Indifference curves purely come from this part of it. So indifference curves come from here, budget constraint comes from these three pieces. Yeah?

**AUDIENCE:** Is it possible [INAUDIBLE] logical for different indifference curves in a quite long-range component, is that possible?

**JONATHAN GRUBER:** Well, no. But it is possible to take a bunch of demand curves and conglomerate them to get one demand curve. And I'm going to talk about that later. But, no,

indifference curves you can't really add up. Because, remember, utils are not a thing. So you can't add up indifference curves.

But if we want to add up people, you would add up demand curves. And we've now derived the demand curve. How have we done that? Well, what's a demand curve? It's the relationship between price and quantity.

Well, I just showed a relationship between price and quantity. When the price goes down, quantity of cookies goes up. When the price goes up, quantity of cookies goes down. Well, you just shift over to the right-hand side a figure 4-1. there's a demand curve. I just graphed these three points,

I just graphed, for each of the different price of cookies I gave you, how many cookies are demanded. Well, at a price of cookies of 6, our initial price-- geez, this is really small-- 6 cookies were demanded. When the price of cookies goes up to 8-- I'm sorry, when it goes up to 9-- only 4 cookies are demanded. When the price of cookies falls to 4 at point c, then 9 cookies are demanded. So literally, we've just derived the demand curve.

Starting with these primitives-- your tastes, your preferences-- and your budget constraint, we've derived a demand curve. And That's it. That's where demand curves come from. And that's essentially what is underneath the demand curve. What's underneath the demand curve is the fact that the reason to demand curves slope down is that as the price goes up, you want less of the good. Because with the given utility functions, that price goes up, you want less of the good. And that's why demand curve slopes down.

So we've just derived that. Questions about that? Yeah?

**AUDIENCE:**

Is it always true that regardless of your utility function, you will always want three [INAUDIBLE].

**JONATHAN GRUBER:**

Great question. Did you peek at my notes? No. Because if you had, you would have seen that's exactly the question I would have asked you. So since you asked me, I'll answer it. No, it is not always true. In fact, that is a feature of this particular utility function I've chosen.

This particular utility function I've chosen gives the feature that the demand for a good is a function only of your income and that good's price, not of the other good's price. That's a feature of this. That's why we like this utility function. It has that nice feature.

In general, that's not true. In general, when the price of one good changes, it will affect the demand for all goods, not just that good itself. So with a more general utility function, that would not be true. With this utility function, it gives what's called the flat price consumption curve-- not a term you need to know, but just if you want to be more technical. Which is basically, with this utility function, demand for any good is a function only of its own price and your income. Therefore, when other prices change, it doesn't affect the demand for that good.

But that is not generally true. In general, when you change the price of one good, demand for all goods changes. Questions about that? Yeah?

**AUDIENCE:** Is this why it shows 3 as a constant, and just--

**JONATHAN GRUBER:** Oh, it wouldn't have mattered what number I'd chosen. But the bottom line is as the price of cookies changes, the number of pizza slices would never change. Demand would never change. That's a feature of this particular utility function. It's a nice feature of it.

Once again, that comes to this trade with modeling. I've chosen a simplified utility function with this nice feature that's almost certainly not true. But once again it allowed us to derive a very sensible demand curve without introducing other complications.

Now, this demand curve's particular shape, what determines the shape of this demand curve? And that leads us to the second topic I want to cover today, which is the elasticity of demand. What determines the shape of a demand curve is what we call the elasticity of demand, which we define the elasticity of demand, epsilon, as  $\frac{\Delta Q}{Q} / \frac{\Delta P}{P}$ . It's the percentage change in quantity for a percentage change in price.

So, for example, if quantity falls by 2% for every 1% increase in price, that's an elasticity demand of negative 2. So elasticity of demand, as long as demand curves

are downward-sloping, is less than 0. Because the price goes up, quantity falls. So elasticity of demand is less than 0-- I'm sorry, less than or equal to 0. Yeah?

**AUDIENCE:** Is this the change in quantity over the new quantity or the the old quantity?

**JONATHAN GRUBER:** Great question. When we're doing this, if we did it in calculus, it would be infinitesimal epsilon change. So it wouldn't matter if it was new or old quantity. When you do it discretely, use the old quantity. So I should say,  $Q_0$  and  $P_0$ .

Once again, if you did this in calculus, which is the way we're sort of thinking about in our underlying intuition, it's an epsilon change. So  $Q_0$  and  $P_0$  are epsilon. It doesn't really matter. But if you do it discretely, you'd want to use  $Q_0$  and  $P_0$ . These are great questions. Keep them coming.

Now, whenever we think of constant elasticity, it's always useful to think about the extremes. So what are the extremes of this measure? One extreme would be if the elasticity demand was 0. We would call that perfectly inelastic demand. It would be epsilon equals 0.

Now, extremes never exist in the real world. But there are cases that come very close. So can someone, without flipping the page of the handout-- don't do it, because before you flip the page of the handout-- give me an example of a good that might have perfectly, in a very, very, very inelastic demand, where no matter the price, you'd still want the same quantity. Yeah.

**AUDIENCE:** Water. You have to consume it to live.

**JONATHAN GRUBER:** Water-- something that's essential to life like water. What else? Yeah, in the way back.

**AUDIENCE:** Insulin.

**JONATHAN GRUBER:** Insulin is the classic example we use. Yeah?

**AUDIENCE:**

**AUDIENCE:** Sewage removal.

**JONATHAN GRUBER:** Sewage removal is interesting. Although, not quite, because we see a lot of variation around the world in sewage removal. But something like that-- basic

essentials of life. Insulin's a class example we use. Indeed, that's the example I do you use in the next-- oh, I guess I didn't list it ion here. So you could have turned the page.

We think about perfectly inelastic demand-- someone, once again for those of you who don't know about the medical science here, basically, if you're diabetic, you have trouble controlling your blood sugar. Insulin is a medicine you need to take to help you control your blood sugar. Without it, you die.

So you'd think that's pretty inelastic demand. Like, I want to live, so I'm going to want to have my insulin. And if the price goes up, I'm not going to say, nah, I'll just die. You're going to want to still have the insulin.

So we think in that case, quantum would be fixed at some  $Q$ , which is insulin you need to live, and it wouldn't really matter what the price is. So your elasticity would be 0. You have a perfectly inelastic curve. Quantity would not change with price.

Basically, that would happen when there is no plausible substitute. The reason water is not as good as insulin is because I can drink something else. And sewage removal, I can do other things to deal with the sewage in my house. But insulin, there is no substitute. I die.

So basically, the bottom line is, when there's no plausible substitute, demand will be perfectly inelastic. Likewise, we consider-- yeah?

**AUDIENCE:** Can there be multiple companies that sell insulin? So if one, say, increased the price, they would shift to another.

**JONATHAN GRUBER:** OK, but this is a market-- that's a great point. I'm just doing this as-- let's actually image just one company for now. You're right, I'm not doing choice across companies. So that would be inelastic.

We could also do the other extreme, perfectly elastic. So what's an example? Perfectly elastic demand is that epsilon equals negative infinity. So what would cause perfectly inelastic demand? So people raise their hand and tell me. Perfectly elastic demand-- I'm sorry. What would cause perfectly elastic demand?

What would cause it? I'm just going to try to spread it around a little bit. You two

have been-- Yeah

**AUDIENCE:** Would it be something that's very unnecessary, like diamonds?

**JONATHAN GRUBER:** Well, that's interesting. I mean, that's not-- I'm going to come to that. But that wouldn't-- that's something where demand would be less elastic, but not close to perfectly elastic. Because, basically-- well, let me ask the question this way-- what would drive a good to very, very elastic demand in general? Yeah?

**AUDIENCE:** When it has perfect substitution--

[INTERPOSING VOICES]

**JONATHAN GRUBER:** Exactly. Perfect substitutes. Diamonds don't have perfect substitutes. I mean, we're increasingly making fake diamonds that are better and better substitutes, but a real diamond still doesn't have a perfect substitute. So what does? What's an example of something with a good-- with a very good substitute?

**AUDIENCE:** I don't know.

**JONATHAN GRUBER:** Yeah?

**AUDIENCE:** A spork.

**JONATHAN GRUBER:** A spork.

[LAUGHTER]

There is no sub-- I am insulted that you would suggest that the great spork! You need two different things to replace a spork!

**AUDIENCE:** You're never using both at the same time. So if the price increases-- you never--

**JONATHAN GRUBER:** Yeah. But then you have to buy a spoon and a fork. No, I reject your spork suggestion.

[LAUGHTER]

I'm just joking. No, but what else? What else? What is something that has really

good substitutes? Yeah?

**AUDIENCE:** Off-brand medication.

**JONATHAN GRUBER:** Yeah. Something which is an off-brand medication, or I like to think of a fast food, like fast food burgers have pretty good substitutes with fast food pizza. Basically, once again, it's hard to think an extreme example. Nothing's ever perfectly elastic. But things which have very good substitutes-- typically this works well when we think across brands.

If you think about different brands of gum. Jeez. I mean, who the hell cares? Or different brands of fast food. Yeah?

**AUDIENCE:** What about something like a \$5 gift card, where after \$5 nobody's going to buy it.

**JONATHAN GRUBER:** That's a separate issue. Let's come back. That's sort of a separate-- that's like a weird, kinked budget constraint. That's not really about substitution.

But the bottom line is-- we don't need any more examples-- the key element-- and we show that in figure 4-3. That's going to be a horizontal demand curve. With a perfectly elastic demand, you have a horizontal demand curve. And therefore, price never changes. It's sort of a weird way to think of perfectly elastic demand. The way it works is if I ever charge a price 1 epsilon above someone else, I'd lose all my business. And if I charge a price 1 epsilon below everyone else, I would have the entire market. Because if it's perfectly elastic, like if one pack of gum-- I don't what-- these stupid gum things-- Orbits and Ellipse or whatever, if they charge a penny more than someone else, no would buy them. They'd go out of business.

That's the idea here. And that's why the price can't change. The price is fixed. So if anyone deviates from that price, boom, they lose the whole market. Yeah?

**AUDIENCE:** So wouldn't the market for dollar bills be perfectly elastic? Like--

**JONATHAN GRUBER:** There's not really a market for dollar bills.

[INTERPOSING VOICES]

**AUDIENCE:** --dollar bills.

**JONATHAN  
GRUBER:**

There's not really-- I mean, you could say the demand for cash in general might be fairly elastic, because you have credit cards and things like that. That's an interesting idea. Yeah. So, basically, when you have perfectly elastic demand, you end up with sort of this constant price, and quantity changes but price doesn't change. So that's kind of the extremes.

Now, in general, we have goods that are more and less elastic. In general, we end up with this range between perfectly elastic and perfectly inelastic. The bottom line is-- here's the intuition I want you to have-- what determines elasticity is substitutability. The more substitutable goods are, the more elastically demanded they are.

So now, I want to go on to another topic which is related. Which is, we talked in our example about what happened when I change prices. What about when I change income? So the third topic I want to talk about is what happens when income shifts, and how does that affect demand curves? When income shifts, how does that affect demand curves?

Well, we could do the same exercise we did before. We did an exercise before. We said, well, let's just use the tools we used before to solve for your new choices at different prices. Let's just solve for your new choice at a different income. So let's go to figure 4-4.

Figure 4-4, once again we start with  $bc_1$ . Same parameters as before-- same setup as before. We choose point a.

Now, let's say I raise your income from \$72 to \$96. You've done well. Your parents are giving you more money-- \$96. Well, in that case you will choose to have both more pizza and more cookies. Given this utility function, you will choose the point b. You will choose point b.

Likewise, if I lower your income from \$70 to \$48, then you will choose point c. So as your income goes up, you'll choose more of both. As your income goes down, you choose less of both. Now, once again, you'll notice this-- well, let me come to that.

So basically, what that says is I can trace out the relationship between how your

income changes, how you demand for cookies change. I can then graph that on the next graph and generate what's called the Engel curve. The Engel curve is the relationship between income and quantity demanded. And we'll come back to why this matters.

The Engel curve is the relationship between income and quantity demanded. Now, here the Engel curve is linear. Once again, that's just a feature of this utility function. In general, it doesn't have to be linear. But here the Engel curve is linear. That's just because of the way we structured this utility function. And the slope of the Engel curve is what we call the income elasticity of demand,  $\gamma$ , which is  $\frac{\Delta Q}{Q} / \frac{\Delta y}{y}$ . That's the income elasticity of demand.

Now, let me just say one comment here about this. Because there's sort of a big cheat that I'm doing here with all this that I need you guys to be aware of, which is constant elasticity versus linear curves. We know a constant elasticity curve will not be linear. If it's linear, it's not constant elasticity, because if it's linear, the elasticity will change along the curve. So the demand curve. I just drew in figure 4-1, that was a constant elasticity demand curve. That's why it was curved.

This Engel curve I drew here would not be constant elasticity, because it's linear. You can calculate for yourself that the percentage change, the income elasticity will shift as you go along this curve. And you can show yourself that. What we're going to do in this class is we're going to draw linear constant elasticity curves, which is, of course, technically wrong.

Just think of them as blown up versions of a large demand curve. Everything is locally linear. Once again, for an epsilon change, everything is linear. So the truth is we'll cheat a little bit and often draw a linear constant elasticity curves. And I want to own that that's a cheat. But if everything is really local, it's not that bad a cheat. So that's kind of how we're going to-- that's a cheat we're going to do constantly through this course. And we'll be very clear-- we make clear any problems or anything if we need you to deviate from that.

Now, what we have here, in addition to a linear Engel curve, is we have an upward-sloping Engel curve or positive income elasticity. We call goods with a positive

income elasticity normal goods. Goods where the more money you have, the more of them you want, we call normal goods. Because that's sort of normal.

However, it is also true that a number of goods in the world actually have gamma less than 0. And we call those inferior goods. Why would a good be inferior? Why, when your income goes up-- yeah?

**AUDIENCE:** [INAUDIBLE].

**JONATHAN GRUBER:** Exactly. Any examples anyone can think of? Yeah?

**GRUBER:**

**AUDIENCE:** Maybe at a fast food restaurant. The minimum amount of food you have to eat. And then, like, [INAUDIBLE] your fast food, and then I have to get more money--

[INTERPOSING VOICES]

**JONATHAN GRUBER:** Exactly. Great example. Yeah, in the back.

**GRUBER:**

**AUDIENCE:** Omega watches versus Rolex watches.

**JONATHAN GRUBER:** I wouldn't think of either of them as inferior. Relative they may be inferior. But, obviously, when your income goes up, you're not going to suddenly-- you're going to want more of both. Whereas fast food you actually would want less of it as your income goes up. Literally, you will eat at McDonald's less if you're richer. You're not going to have fewer watches if you're richer.

So the bottom line is that inferior goods, you're actually getting-- it's a bit subtle. You have different goods of the same kind. Let's think about classes of goods rather than brands of goods. Once you get across brands, you're right. Let's think about classes of goods.

Watches-- luxury watches, in general-- are clearly not inferior. Fast food may be inferior. Literally richer people may eat probably less fast food than poorer people. Yeah.

**AUDIENCE:** Would something like your refrigerator count, where after you buy one you don't really need more of them.

**JONATHAN GRUBER:**

Well, that's like a quan-- that could be right. But yeah. I think not, because the bottom line is rich guys are much more likely to have two refrigerators than one. So it's a discreteness problem. It's too discrete to really use as an example. But I think fast food is a great example.

The class example we use is potatoes. Where in the old days, before fast food, that was the cheap, filling, shitty-tasting food stuff that guys sort of ate all the time. And now, when they have money, they say, I'm going to move on to steak, and they eat less potatoes. So something where essentially you'd rather shift to something else if you have more money is inferior.

Now, moreover, within that, within normal, we're going to draw a distinction between what we call luxuries and necessities. Luxuries are going to be good where gamma is greater than 1. And necessities, gamma is less than 1. So we're going to say-- essentially, the question is, proportional to your budget, what happens if your income goes up?

In other words, do you spend more and more-- they're both normal goods. The richer you are, the more you buy of it. But a luxury good is you spend even larger share of your budget on that good as you get richer. So that would be luxury, like watches, boats, maybe refrigerators, et cetera-- things where the richer you get, the more of your budget you spend on it.

Necessities are things like food, where clearly rich people spend more on food than poor people. But they spend a smaller share of their budget on food than poor people. So it goes up, but doesn't go up proportionally with your income. It goes up less in portion with your income. Yeah?

**AUDIENCE:**

[INAUDIBLE] for as some sort of human necessities, in the sense of if you're more wealthy, you might buy more name brand food or something like that, instead of more--

**JONATHAN GRUBER:**

Yeah. Once we get into brands, you can absolutely see that. You can think of luxury brands and necessity brands. Absolutely. But if we stay with categories of goods, then let's think of jewelry as the [INAUDIBLE] example here and food as the canonical example here. Yeah?

**AUDIENCE:** Do you have an example of something that's near the border between luxuries and necessities.

**JONATHAN GRUBER:** You know, there is a huge industry in estimating these elasticities of demand. So I'm sure there's an answer to that. I don't have it off of my head. All right.

So now I've given you the underlying tools of consumer demand theory. I've told you how to decide what quantity a consumer wants. I've told you how you can use that to derive demand curve. I've explained the shape of the demand curve. I then talked about what happens as your income changes and talked about the shape of the income elasticity.

Now, I'm going to put this together to come back to revisit something you think you already know the answer to. Which is, what happens when a price changes-- the effects of a price change. Now, you might say, well, that's sort of silly. We already did that once this lecture. We already did, when we derived the demand curve-- the effects of price change-- we did some price changes, right? I showed you what happened as the price of cookies change.

But, in fact, we cheated a little bit. We didn't cheat-- we gave you sort of the bottom line but didn't get into the elements of why people react the way they do to price changes. Now, we're getting in some sort of deep theory. Now, I'm going to talk about something-- it's deeply theoretical in the sense that in some sense if all you care about is what happens in the real world, they just care about when a price change happens how does quantity change, I'm going to use some theoretical concepts, which are going to become very powerful later on in the course, which are important understand now. Which is, how is the underlying decision calculus changed by price-- changed when the price changes?

And the way we're going to do that is that we're going to decompose your response to a price change into two effects-- the substitution effect and the income effect. We're going to separate your response into two effects. So the separation is going to become very important later on.

The substitution effect, we're going to define as the change in the quantity of a good when the price changes holding utility constant. So it's  $\Delta Q$ --  $dQ/dp$  for

shorthand-- but holding utility constant at some fixed level  $\bar{u}$ . The change in quantities price changes-- so it's the elasticity of demand-- but at a constant level of utility.

The income effect is the change in quantity of a good as income changes. Change in quantity,  $dy$ . Which is the income elasticity we talked about-- the change in quantity as the income changes. And this is actually multiplied by the initial level of income. We'll learn about this in a section. But that's technically how the income effect is defined. And you'll come into a section about why that is.

But we're going to decompose this. So that's sort of confusing. So let me start with graphically to understand it. So let's go to figure 4-5, one of our more complicated figures.

We start at budget constraint 1-- same parameters as always. All the math here-- all this graphic stuff follows from the math using that utility function and these price and income-- same as before. So we start, as before, at point a. Your tangency is the best package you can have, given that utility function, is 6 cookies and 3 slices of pizza.

Now, let's imagine the price of cookies rises to \$9. The price of cookies in our example goes from \$6 to \$9. That's the example we're going to analyze. Now, we know from before that will ultimately move you from 6 cookies to 4 cookies while holding pizzas constant at 3. So we know where you'll end up. You'll end up at point c. We did that before.

But actually two things are happening to get you there. The first thing that's happening is the substitution effect, which is the change in prices with utility constant. And how do we measure that? We want to ask, given that the price changed but the utility is constant, what's the new quantity you choose? What does utility constant mean in this graph? What does it mean to hold utility constant?

Let's get some other folks involved here. What is it mean? Yeah?

**AUDIENCE:** Same indifference curve.

**JONATHAN GRUBER:** Same indifference curve. So what we want to do is ask, given the new prices but the old indifference curve, what quantity would you choose? Well, the way we do that is

we find the tangency between the new slope of the budget constraint and the old indifference curve. And we do that by drawing sort of an imaginary budget constraint bc prime. bc prime is a sort of imaginary budget constraint. It's not a real budget constraint, but it has the slope of the new budget constraint, but it's tangent to the old indifference curve.

That's the key thing. bc prime, the imaginary budget constraint, the dashed line, has the slope of the new budget constraint, same as the new price ratio. So the slope is the new price ratio. The slope is at the new price ratio, but it's tangent to the old indifference curve. So bc prime is basically going to the tangent [INAUDIBLE] indifference curve at point b.

So what we're saying is the substitution effect moves you from point a to point b. That is holding utility constant but at these new prices, you would choose to have fewer cookies and less pizza. We call this notion compensated demand. That is, I'm compensating you. I'm holding utility constant.

I'm saying price of change sucks for you. You're worse off. Your opportunity set's restricted. But I'm going to compensate you by holding your utility constant. So call this compensated demand.

Your compensated demand would mean that when the price goes up, you would choose to reduce your consumption of cookies from 6 to 4.89. Now, here's the key thing about substitution effects-- we can sign them definitively. They are always negative. The substitution effect is always negative.

The income effect could go either way. We'll show that. The substitution effect is always negative.

We can see this in two ways. Graphically, think about it this way-- you have to be tangent to the same indifference curve with a higher sloped line, so you have to move to the left. If you get a tangent to the same indifference curve with a line with the higher slope, it's got to be to the left. So that's a graphical intuition.

Mathematically, it's worth writing out the steps, because it helps. That's why we teach this, it helps remind us of our consumer theory.

Step 1, you're at this new tangency. Step 2, we know that at any such tangency

that's optimized, the marg utility of cookies over the marg utility pizza equals the price of cookies over the price of pizza. We know that's true with any tangency, because that's the optimal choice. Step 3, we know  $P_c$  over  $P_p$  is up. I just said that. And this assumption is the price cookies up.

Therefore, that leads to step 4. Which is that  $M_{Uc}$  over  $M_{Up}$  must be up, because it's still equal. Well, how do you raise the ratio of the marg utility of cookies to marg utility of pizzas? How do you accomplish that? By having fewer cookies and more pizza.

So that means-- that implies-- that cookies are down and pizzas are up-- and/or pizzas are up. How do you get that ratio to be higher? Well, remember, this is why do this math here. Remember the key intuition-- more cookies means lower marg utility of cookies. The more cookies you have, the less you care about the next cookie.

So I want the marg utility of cookies to be lower. If the marg utility of cookies, I'm sorry, to be higher, I've got to have fewer cookies, or I've got to have more pizza, or both. So the substitution effect is always negative. If I'm going to hold utility constant, and change prices, and raise the price, you'll always want less of that goods on the substitution effect. Question about the graphics of the math?

Now, let's come to the income effect. The income effect says, holding prices constant-- so I shouldn't put this here. The income effect is this at a constant price. I should have added that. So the income effect is the change in quantity demanded as income changes holding prices constant.

So now we're saying-- the income effect is saying, look, the price changed. So therefore I shifted my consumption away from cookies. But the other thing that happened is I got poorer. Maybe I'd say you didn't get poorer, your parents didn't send you less money, but remember your opportunity set restricted. You effectively are poorer because this price went up.

How do we represent that? Well, we can exactly represent that by the shift from  $bc$  prime to  $bc_2$  Because  $bc$  prime and  $bc_2$  have the same slope. That shift is just the income effect. So that's holding the prices constant. The price ratio for  $bc$  prime and  $bc_2$  is the same. But you're now effectively poorer, because at the same income

you can afford fewer cookies.

So you're effectively poorer. So now your income's effectively fallen. And at that new budget constraint with that new lower effective income and higher price ratio, you choose point c. So we go from a to c, just like I told you before, but we actually get there in two steps. One step is sort of the relative change in prices caused you to say, ooh, I want to get away from cookies. The other say, I'm poorer, so I want less of everything, including cookies.

So one is the price effect, one's the income effect. And these two effects matter. Now, in this case, they don't matter, because they work together. In this case, you might say, well, look, why do I care? The bottom line is, the number of cookies fell by 2. Substitution effect work together, why do I care?

Well, you might care, because if the good is inferior, then the income and substitution effect work against each other. If the good is inferior, then the income substitution effects work against each other rather than with each other. To see this, let's go to figure 4-6.

Now, we're going to totally change our example. Now, we're going to be choosing between steak and potatoes. Totally different example-- steak and potatoes. You start a budget constraint bc1. Potatoes are \$1, and steak is \$5. So in our new example-- I'll put this up here-- we've got the price of steak is \$5, the price of potatoes is \$1, and your income is \$25. That's our new example.

In that case, you will choose-- and this is a different utility function. This is a totally new example. I'm not going expect you to understand the underlying math here. I'm just showing an example of something that might be true.

So you choose point a. You choose 7 and 1/2 potatoes and 3 and 1/2 steaks given those prices. Now, we're going to say, what happens if the price of potatoes goes from \$1 to \$3? The price of potatoes goes up. Well, two things happen-- first of all, the change in compensated demand moves you from point a to point b. How do we know that? Because you draw a new imaginary budget constraint that has the new price ratio, but it's tangent to the old indifference curve. So you're point a to point b.

So the substitution effect lowers your demand for potatoes from 7 and 1/2 to 4. But the income effect raises your demand for potatoes. Now, the income effect means you actually move back from 4 to 5. On net, you're still having fewer potatoes, but the substitution effects went opposite ways.

Why? Why did the income effect cause you to want to have more potatoes? The substitution, you wanted have to less. Yeah?

**AUDIENCE:** Because the price of potatoes went up [INAUDIBLE].

**JONATHAN GRUBER:** Close. Price of potatoes went up. So you're effectively what? Poorer, right? And when you're poorer, how does that affect your consumption of inferior goods? You want more of them.

So price of potatoes went up. So effectively you're poorer. Now, when you're poorer, in our previous example with cookies you wanted fewer cookies than a normal good. But potatoes are an inferior good. So as you're poorer, you want more of them. The income effect goes the opposite way of the substitution effect. That's where this starts to get interesting.

If the income effect always goes the same way as substitution effect, this is sort of just a purely useless theoretical exercise. It gets interesting when income effect goes the opposite way of the substitution effect. Yeah?

**AUDIENCE:** Isn't it like the [INAUDIBLE]?

**JONATHAN GRUBER:** Hold on. I'm getting there. I'm getting there. OK. Yeah?

**AUDIENCE:** [INAUDIBLE].

**JONATHAN GRUBER:** Utility-- well different utility functions will give you-- you have to have a different utility function to get the good to be inferior. So your utility of steak and potatoes is not going to square root of-- you won't get inferiority with square root of  $p$  times  $s$ . So it's a different utility function, and I mentioned that I think. It's a different utility function. Yeah?

**AUDIENCE:** It's the different functions that makes potatoes be an inferior good mathematically.

**JONATHAN GRUBER:** Exactly. So basically, your intuition-- I give you intuition why they're inferior. But, mathematically, it would occur because we'd have a utility function. The utility function would generate an inferior would be a different looking utility function.

**AUDIENCE:** [INAUDIBLE].

**JONATHAN GRUBER:** Not off the top of my head. But we'll do it in section. So the bottom line is-- yeah?

**AUDIENCE:** When you're setting that price of steak and potatoes, is it that they both provide similar nutritional value? So one potato does not necessarily equate to one steak. But the price that are setting, \$5 worth of steak is equivalent, in terms of my health, and will fill me up as much as--

**JONATHAN GRUBER:** No, no, no, no. I'm not saying that at all. I'm not writing down a health function. I didn't write it down. This is a utility function. So it's about filling up, it's about taste. Steak may leave me hungrier, but it's way better. So it's about what fills me up. Literally, all I'm saying is, given my utility function-- and I don't have the utility function written down-- I was choosing a balance of mostly potatoes and some steak. Now that the price of potatoes goes up, I end up wanting fewer potatoes, but not as few as you might think from the substitution effect, because potatoes are inferior. Yeah?

**AUDIENCE:** [INAUDIBLE] the price is more constant [INAUDIBLE]?

**JONATHAN GRUBER:** No, no. What I'm saying-- the income effect is holding the price constant. What happens to your demand? So holding the price constant-- what I mean by that is moving from bc prime to bc2 is the income effect, holding your price constant. So the price change is reflecting the substitution effect. That's reflected in moving for bc1 to bc prime. The income effect is holding the price constant that is, given that same slope of that imaginary new budget constraint, you're now poorer. So that's why.

So once again, it's a hard thing to wrap your mind around. It's theoretical. But the notion is when a price changes two things happen-- it changes the relative desirability of two goods, and it changes your income-- your effective income, your opportunity set. Two things are happening. Yeah?

**AUDIENCE:** First, when the price first changes, you needed a substitute, so you keep--

**JONATHAN** Oh, no. They both happened at the same time. Let's be clear. This isn't sequential.

**GRUBER:** This happening in real time. It's not like you said the price went up, I'm going to compute my, you know-- it's happening in real time. It's just we're decomposing into two effects. And the reason we're doing that is because once goods are inferior, this decomposition becomes interesting.

So I like to think about this in sort of a simple table to help remind you how to think about this. So let's think about a simple table. Here we have the price change. So the price can go up or the price can go down. Up and down. Here we have the substitution effect, here we have the income effect, and here, we have the total.

Well, in the case of a normal good-- if a good is normal-- then we know the substitution effect when the price goes up leads you to want less of a good. The income effect also leads you want less of a good. So you definitely want less of the good. These are all equals. There's always corner cases.

Likewise, when the price falls, the substitution effect makes you want more of the good. When the price falls, you're effectively richer. So the income effect makes you want more of the good. So you clearly want more of the good. That's the easy case.

The more interesting case is, what if it's an inferior good? Now, if the price goes up, the substitution effect is the same. Substitution effect is always negative. Higher price means you substitute away from the good. But the income effect is now positive. So the net is unclear.

Likewise, if the price goes down, the substitution effect is always positive. You always want more of the good if the price goes down. But the income effect is now you want less of the good. Why? Because you're richer.

If the price of a good falls, you're richer. Richer means you want less of that inferior good. So the net effect is unclear. So the interesting case becomes inferior goods. Questions about the table?

So this raises the question, are there goods-- what does this imply? If the income effect dominated the substitution effect, you could get what? Yeah?

**AUDIENCE:** The higher prices, the more you buy.

**JONATHAN GRUBER:** Yes. You could get an upward-sloping demand curve. You could actually, theoretically, get an upward-sloping demand curve. And we call this a Giffen good. A Giffen good is a good where you get an upward-sloping demand curve, where actually the inferior income effect is so large it dominates the substitution effect, and you actually get an upward-sloping demand curve-- that a higher price leads people to want more of the good.

Now, in fact, this is named after some guy, Giffen, I guess. And it probably was a guy, because it's old. But, in fact, it's convenient, because it's close to where gryphon. And gryphons are imaginary, and so are Giffens. It's actually hard to find examples in reality of Giffen goods. It's actually pretty hard to find examples from reality.

But there was one interesting experiment that was run, which is sort of the first convincing evidence that in some situations Giffen goods could exist. So I ran the follow experiment. They run a study in China, where very, very poor households-- most households in China are poor, but they divided it into super poor versus moderately poor households. And they basically gave them coupons which lowered the price of rice, which was their staple good. Basically, they eat rice, and that's sort of their basic good they eat.

And they basically lowered the price of rice. What they found is that for families that weren't super poor, they found a typical downward-sloping demand curve. Giving them the coupon off rice meant they bought more rice. But for the very, very poor families, they actually did find an upward-sloping demand curve. Giving them a discount on the price of rice actually caused them to have less rice.

Because, literally, that's all they ever ate, was rice. So by definition they could've had more, because they didn't eat anything else. Now that you're essentially saying, look, you used to eat all rice, you'd spend your whole budget right, now I've basically giving you extra money. Because all that rice you used eat, you can now have cheaper. Are going to spend that to buy more rice? No, you're buy something else. And that's a Giffen good.

So if you think about sort of a corner solution where people are buying all the good

that's inferior, then by definition if you give them more money, they're going to move on to another good. Or there's at least a possibility. And that's the Giffen good example. But we have to search pretty darn hard.

Typically in the demand context, we think that demand curves are downward-sloping. However, when we get to other contexts, we're going to find it's more normal to find that these income and substitution effects fight against each other and lead to strange-shaped curves. And we'll come back to that later in the course. OK, I'll see you all Wednesday.