CHAPTER

2

Choice Sets and Budget Constraints

Consumers are people who try to do the "best they can" given their "budget circumstances" or what we will call their **budget constraints**. This chapter develops a model for these budget constraints that simply specify which **bundles of goods and services** are affordable for a consumer.

Chapter Highlights

The main points of the chapter are:

1. Constraints arise from "what we bring to the table" — whether that is in the form of an **exogenous income** or an **endowment** — and from the **opportunity costs** that arise through prices.

2. Changes in "what we bring to the table" do not alter opportunity costs — and thus **shift budgets without changing slopes**.

3. Changes in prices result in changes in opportunity costs — and thus alter the **slopes of budgets**.

4. With three goods, budget constraints become planes and choice sets are 3-dimensional — or they can be treated mathematically instead of graphically.

5. A **composite good** represents a way of indexing consumption other than the good of interest — and allows us to make the 2-good model more general.

Using the LiveGraphs

For an overview of what is contained on the LiveGraphs site for each of the chapters (from Chapter 2 through 29) and how you might utilize this resource, see pages 2-3 of Chapter 1 of this *Study Guide*. To access the LiveGraphs for Chapter 2, click the

Chapter 2 tab on the left side of the LiveGraphs web site.

In addition to the *Animated Graphics*, the *Static Graphics* and the *Downloads* that accompany each of the graphs in the text of this chapter, we have several **Exploring Relationships** modules that might be helpful as you first think through budget constraints. In particular, you'll find the following under the Exploring Relationships tab:

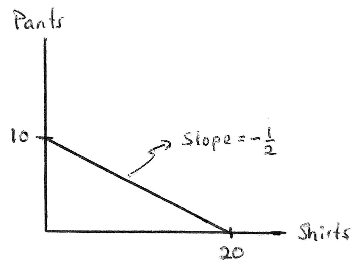
1. A module that allows you to **specify prices and income levels** and then check to see what the resulting budget constraint looks like.
2. A module that allows you to furthermore **change income** to see how the budget constraint is impacted.
3. A module that allows you to **alter prices** and check the impact on the budget constraint.
4. A module that allows you to explore the formation of **kinks in budgets**.
5. Finally, we have a pretty neat module that **summarizes all possible changes to budget constraints** — with both two and three goods.

2A Solutions to Within-Chapter-Exercises for Part A

Exercise 2A.1 *Instead of putting pants on the horizontal axis and shirts on the vertical, put pants on the vertical and shirts on the horizontal. Show how the budget constraint looks and read from the slope what the opportunity cost of shirts (in terms of pants) and pants (in terms of shirts) is.*

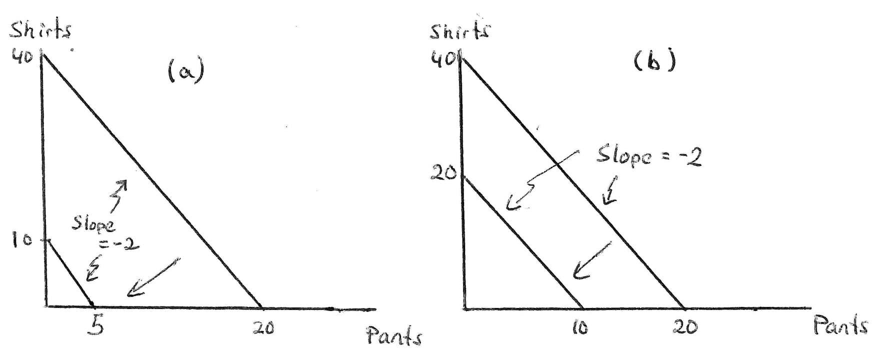
Answer: This is illustrated in Graph 2.1 (top of next page). The slope of the budget would now be $-1/2$. Since the slope of the budget is the opportunity cost of the good on the horizontal axis in terms of the good on the vertical axis, this implies that the opportunity cost of shirts in terms of pants is $1/2$. The inverse of the slope of the budget is the opportunity cost of the good on the vertical axis in terms of the good on the horizontal axis. Therefore the opportunity cost of pants in terms of shirts is 2.

Exercise 2A.2 *Demonstrate how my budget constraint would change if, on the way into the store, I had lost $300 of the $400 my wife had given to me. Does my opportunity cost of pants (in terms of shirts) or shirts (in terms of pants) change? What if instead the prices of pants and shirts had doubled while I was driving to the store?*



Graph 2.1: Graph for Within-Chapter-Exercise 2A.1

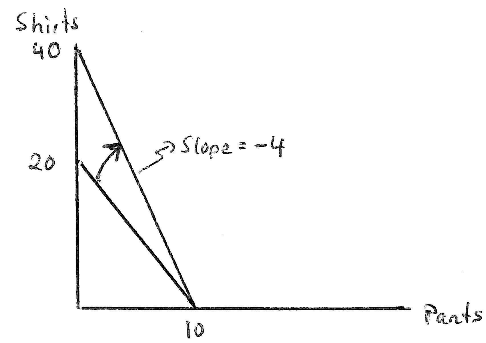
Answer: The budgets would shift parallel as shown in Graph 2.2 below. The slopes of the budget constraints do not change in either case — implying that the opportunity cost of one good in terms of the other does not change.



Graph 2.2: (a) $300 lost and (b) both prices doubled

Exercise 2A.3 *How would my budget constraint change if, instead of a 50% off coupon for pants, my wife had given me a 50% off coupon for shirts? What would the opportunity cost of pants (in terms of shirts) be?*

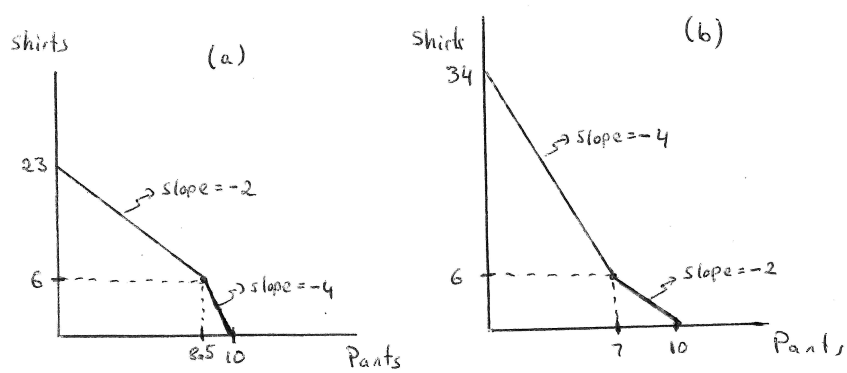
Answer: The budget constraint would change as depicted in Graph 2.3 (at the top of the next page). The new opportunity cost of pants in terms of shirts would be 4 — i.e. for every pair of pants you now buy, you would be giving up 4 (rather than 2) shirts.



Graph 2.3: 50% off coupon for shirts (instead of pants)

Exercise 2A.4 *Suppose that the two coupons analyzed above were for shirts instead of pants. What would the budget constraints look like?*

Answer: Panel (a) of Graph 2.4 depicts the constraint for a 50% off coupon that applies only to the first 6 shirts bought. If you buy 6 shirts with this coupon, you will have spent \$30 and will therefore have given up 1.5 pants. Thus, over this range, the opportunity cost of pants is 6/1.5 = 4. After spending \$30 on the first 6 shirts, you could spend up to another \$170 on shirts. If you spent all of it on shirts, you could therefore afford an additional 17 shirts for a total of 23.



Graph 2.4: 2 coupons for shirts (instead of pants)

Panel (b) depicts the constraint for a coupon that gives 50% off for all shirts after the first 6. If you buy 6 shirts, you therefore spend \$60 (because you buy the first 6 at full price) – thus giving up the equivalent of 3 shirts. At that point, you have up to \$140 left to spend, and if you spend all of it on shirts at 50% off, you can afford to get 28 more – for a total of 34.

Exercise 2A.5 *Revisit the coupons we discussed in Section 2A.3 and illustrate how these would alter the choice set when defined over pants and a composite good.*

Answer: The graphs would look exactly the same as the kinked budget constraint in Graph 2.4 of the text – except that the vertical axis would be denominated in "dollars of other good consumption" with values 10 times what they are in Graph 2.4. This would also have the effect of increasing the slopes 10-fold.

Exercise 2A.6 True or False*: When we model the good on the vertical axis as "dollars of consumption of other goods," the slope of the budget constraint is $-p_1$, where p_1 denotes the price of the good on the horizontal axis.*

Answer: True. The slope of the budget constraint is always $-p_1/p_2$. When x_2 is a composite good denominated in dollar units, its price is $p_2 = 1$ since "1 dollar of other good consumption" by definition costs exactly 1 dollar. Thus the slope $-p_1/p_2$ simply reduces to $-p_1$.

2B Solutions to Within-Chapter-Exercises for Part B

Exercise 2B.1 *What points in Graph 2.1 satisfy the necessary but not the sufficient conditions in expression (2.1)?*

Answer: The points to the northeast of the blue budget line – i.e. all the non-shaded points outside the budget line. These bundles satisfy the necessary condition that $(x_1, x_2) \in \mathbb{R}^2_+$, but they do not satisfy the sufficient condition that $20x_1 + 10x_2 \leq 200$.

Exercise 2B.2 *Using equation (2.5), show that the exact same change in the budget line could happen if both prices fell by half at the same time while the dollar budget remained the same. Does this make intuitive sense?*

Answer: Replacing p_1 with $0.5p_1$ and p_2 with $0.5p_2$ in the equation, we get

$$x_2 = \frac{I}{0.5p_2} - \frac{0.5p_1}{0.5p_2}x_1 = \frac{2I}{p_2} - \frac{p_1}{p_2}x_1. \tag{2.1}$$

If the initial income is \$200, this implies the budget constraint when all prices fall by half is equivalent to one with the original prices and income equal to \$400. This makes intuitive sense: If all prices fall by half, then any given cash budget can buy twice as much. Thus, the simultaneous price drop is equivalent to an increase in (cash) income.

Exercise 2B.3 *Using the mathematical formulation of a budget line (equation (2.5)), illustrate how the slope and intercept terms change when p_2 instead of p_1 changes. Relate this to what your intuition would tell you in a graphical model of budget lines.*

Answer: When p_2 changes to p_2', the intercept changes from I/p_2 to I/p_2'. If $p_2' > p_2$, this implies that the intercept falls, while if $p_2' < p_2$ it implies that the intercept increases. This makes intuitive sense since an increase in the price of good 2 means that you can buy less of good 2 if that is all you spend your income on, and a decrease in the price of good 2 means that you can buy more of good 2 when that is all you spend your income on.

Looking at the slope term, an increase in p_2 causes $-p_1/p_2$ to fall in absolute value — implying a shallower budget line. Similarly, a decrease in p_2 causes $-p_1/p_2$ to rise in absolute value — implying a steeper budget. This also makes intuitive sense: When p_2 increases, the opportunity cost of x_1 falls (as illustrated by the shallower budget line), and when p_2 falls, the opportunity cost of x_1 increases (as illustrated by the steeper budget line).

Exercise 2B.4 *Convert the two equations contained in the budget set (2.7) into a format that illustrates more clearly the intercept and slope terms (as in equation (2.5)). Then, using the numbers for prices and incomes from our example, plot the two lines on a graph. Finally, erase the portions of the lines that are not relevant given that each line applies only for some values of x_1 (as indicated in (2.7)). Compare your graph to Graph 2.4a.*

Answer: The two equations can be written as

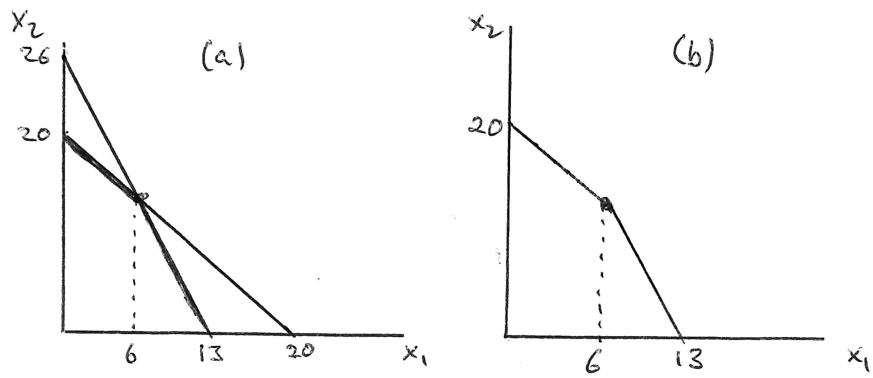
$$x_2 = \frac{I}{p_2} - \frac{p_1}{2p_2}x_1 \text{ and } x_2 = \frac{I+3p_1}{p_2} - \frac{p_1}{p_2}x_1. \tag{2.2}$$

Plugging in $I = 200$, $p_1 = 20$ and $p_2 = 10$ as in the example with pants (x_1) and shirts (x_2), this gives

$$x_2 = \frac{200}{10} - \frac{20}{2(10)}x_1 = 20 - x_1 \text{ and } x_2 = \frac{260}{10} - \frac{20}{10}x_1 = 26 - 2x_1. \tag{2.3}$$

Panel (a) in Graph 2.5 (at the top of the next page) plots these two lines, and panel (b) erases the portions that are not relevant given that the first equation applies only to values of x_1 less than or equal to 6 and the second equation applies only to values of x_1 greater than 6. The resulting graph is identical to the one we derived intuitively in the text.

Exercise 2B.5 *Now suppose that the 50% off coupon is applied to all pants purchased after you bought an initial 6 pants at regular price. Derive the mathematical formulation of the budget set (analogous to equation (2.7)) and then repeat the previous exercise. Compare your graph to Graph 2.4b.*



Graph 2.5: Graphs of equations in exercise 2B.4

Answer: The normal budget constraint would apply to the initial range of pants (since the coupon does not kick in until 6). After that, the price of pants (p_1) falls by half. Furthermore, since we already spent \$120 to get to 6 pair of pants, we only have \$80 left — implying that the most we could buy is 8 more pants at the reduced price for a total of 14 pants. Were we to be able to buy 14 pants at a price of \$10 (which is assumed along this line segment), our total spending would be \$140 — implying that our effective income on this line segment is \$60 less than the $I = 200$ we started with. More generally, when the price falls to $0.5p_1$ after the 6th pair, the vertical intercept of the shallower budget falls to $(I - 0.5(6p_1)) = I - 3p_1$. This gives us the following definition of the budget line:

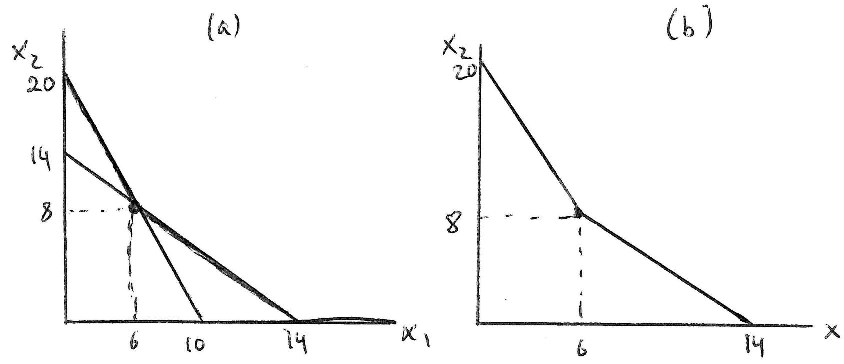
$$B(p_1, p_2, I) = \{ (x_1, x_2) \in \mathbb{R}^2_+ \mid \begin{array}{ll} p_1x_1 + p_2x_2 = I & \text{for } x_1 \leq 6 \text{ and} \\ 0.5p_1x_1 + p_2x_2 = I - 3p_1 & \text{for } x_1 > 6 \}. \end{array} \tag{2.4}$$

Taking x_2 to one side in both of these equations, and substituting in $p_1 = 20$, $p_2 = 10$ and $I = 200$, we get

$$x_2 = \frac{200}{10} - \frac{20}{10}x_1 = 20 - 2x_1 \text{ and } x_2 = \frac{200 - 60}{10} - \frac{20}{2(10)}x_1 = 14 - x_1. \tag{2.5}$$

Panel (a) of Graph 2.9 (at the top of the next page) plots these two lines, and panel (b) erases the portions that are not relevant. The resulting graph is identical to the one for this coupon in the text.

Exercise 2B.6 *Using the equation in (2.19), derive the general equation of the budget line in terms of prices and endowments. Following steps analogous to those leading to equation*



Graph 2.6: Graphs of equations in exercise 2B.5

(2.17), identify the intercept and slope terms. What would the budget line look like when my endowments are 10 shirts and 10 pants and when prices are $5 for pants and $10 for shirts? Relate this to both the equation you derived and to an intuitive derivation of the same budget line.

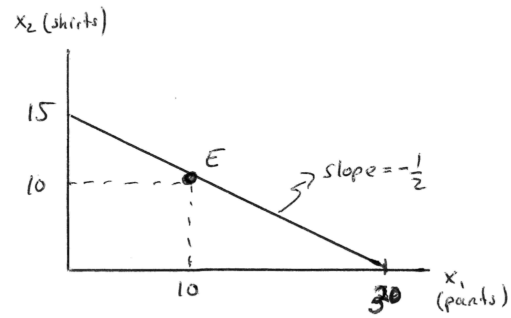
Answer: Changing the inequality to an equality and solving the equation for x_2, we get

$$x_2 = \frac{p_1 e_1 + p_2 e_2}{p_2} - \frac{p_1}{p_2} x_1. \tag{2.6}$$

The slope is therefore $-p_1/p_2$ as it always is. The x_2 intercept is $(p_1 e_1 + p_2 e_2)/p_2$ — which is just the value of my endowment divided by price. When endowments are 10 shirts and 10 pants and when prices are $p_1 = 5$ and $p_2 = 10$, the equation becomes

$$x_2 = \frac{5(10) + 10(10)}{10} - \frac{5}{10} x_1 = 15 - \frac{1}{2} x_1. \tag{2.7}$$

We would intuitively derive this as follows: We would begin at the endowment point (10,10). Given the prices of pants and shirts, I could sell my 10 pants for $50 and with that I could buy 5 more shirts. Thus, the most shirts I could buy if I only bought shirts is 15 — the x_2 intercept. Since pants cost half what shirts cost, I could buy 30 pants. The resulting budget line, which is equivalent to the one derived mathematically above, is depicted in Graph 2.7 (at the top of the next page).



Graph 2.7: Graph of equation in exercise 2B.6

End of Chapter Exercises

Exercise 2.2

Suppose the only two goods in the world are peanut butter and jelly.

A: *You have no exogenous income but you do own 6 jars of peanut butter and 2 jars of jelly. The price of peanut butter is $4 per jar, and the price of jelly is $6 per jar.*

(a) *On a graph with jars of peanut butter on the horizontal and jars of jelly on the vertical axis, illustrate your budget constraint.*

Answer: This is depicted in panel (a) of Graph 2.8 (at the top of the next page). The point E is the endowment point of 2 jars of jelly and 6 jars of peanut butter (PB). If you sold your 2 jars of jelly (at a price of $6 per jar), you could make $12, and with that you could buy an additional 3 jars of PB (at the price of $4 per jar). Thus, the most PB you could have is 9, the intercept on the horizontal axis. Similarly, you could sell your 6 jars of PB for $24, and with that you could buy 4 additional jars of jelly to get you to a maximum total of 6 jars of jelly – the intercept on the vertical axis. The resulting budget line has slope $-2/3$, which makes sense since the price of PB ($4) divided by the price of jelly ($6) is in fact $2/3$.

(b) *How does your constraint change when the price of peanut butter increases to $6? How does this change your opportunity cost of jelly?*

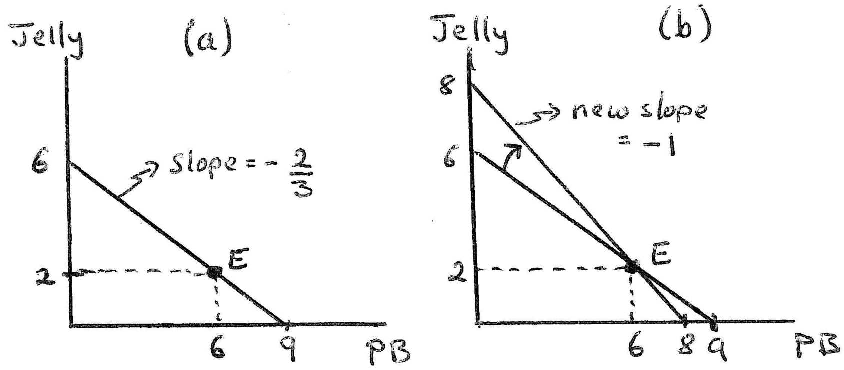
Answer: The change is illustrated in panel (b) of Graph 2.8. Since you can always still consume your endowment E, the new budget must contain E. But the opportunity costs have now changed, with the ratio of the two prices now equal to 1. Thus, the new budget constraint has slope -1 and runs through E. The opportunity cost of jelly has now fallen from $3/2$ to 1. This should make sense: Before, PB was cheaper than jelly and so, for every jar of jelly you had to give up more than a jar of peanut butter. Now that they are the same price, you only have to give up one jar of PB to get 1 jar of jelly.

B: *Consider the same economic circumstances described in 2.2A and use x_1 to represent jars of peanut butter and x_2 to represent jars of jelly.*

(a) *Write down the equation representing the budget line and relate key components to your graph from 2.2A(a).*

Answer: The budget line has to equate your wealth to the cost of your consumption. Your wealth is equal to the value of your endowment, which is $p_1e_1 + p_2e_2$ (where e_1 is your endowment of PB and e_2 is your endowment of jelly). The cost of your consumption is just your spending on the two goods — i.e. $p_1x_1 + p_2x_2$. The resulting equation is

$$p_1e_1 + p_2e_2 = p_1x_1 + p_2x_2. \tag{2.8}$$



Graph 2.8: (a) Answer to (a); (b) Answer to (b)

When the values given in the problem are plugged in, the left hand side becomes $4(6)+6(2) = 36$ and the right hand side becomes $4x_1 + 6x_2$ — resulting in the equation $36 = 4x_1 + 6x_2$. Taking x_2 to one side, we then get

$$x_2 = 6 - \frac{2}{3}x_1, \tag{2.9}$$

which is exactly what we graphed in panel (a) of Graph 2.8 — a line with vertical intercept of 6 and slope of $-2/3$.

(b) *Change your equation for your budget line to reflect the change in economic circumstances described in 2.2A(b) and show how this new equation relates to your graph in 2.2A(b).*

Answer: Now the left hand side of equation (2.8) is $6(6)+6(2) = 48$ while the right hand side is $6x_1 + 6x_2$. The equation thus becomes $48 = 6x_1 + 6x_2$ or, when x_2 is taken to one side,

$$x_2 = 8 - x_1. \tag{2.10}$$

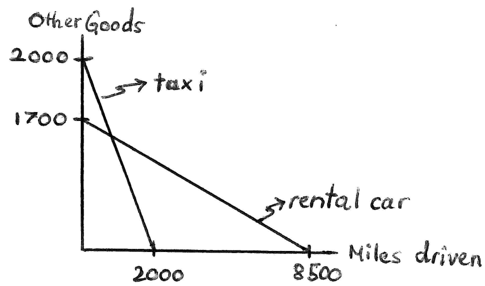
This is an equation of a line with vertical intercept of 8 and slope of -1 — exactly what we graphed in panel (b) of Graph 2.8.

Exercise 2.6: *Renting a Car versus Taking Taxis*

Everyday Application: *Renting a Car versus Taking Taxis*: *Suppose my brother and I both go on a week-long vacation in Cayman and, when we arrive at the airport on the island, we have to choose between either renting a car or taking a taxi to our hotel. Renting a car involves a fixed fee of \$300 for the week, with each mile driven afterwards just costing 20 cents — the price of gasoline per mile. Taking a taxi involves no fixed fees, but each mile driven on the island during the week now costs \$1 per mile.*

A: *Suppose both my brother and I have brought \$2,000 on our trip to spend on "miles driven on the island" and "other goods". On a graph with miles driven on the horizontal and other consumption on the vertical axis, illustrate my budget constraint assuming I chose to rent a car and my brother's budget constraint assuming he chose to take taxis.*

Answer: The two budget lines are drawn in Graph 2.9 (on the next page). My brother could spend as much as \$2,000 on other goods if he stays at the airport and does not rent any taxis, but for every mile he takes a taxi, he gives up \$1 in other good consumption. The most he can drive on the island is 2,000 miles. As soon as I pay the \$300 rental fee, I can at most consume \$1,700 in other goods, but each mile costs me only 20 cents. Thus, I can drive as much as 1700/0.2=8,500 miles.



Graph 2.9: Graphs of equations in exercise 2

(a) *What is the opportunity cost for each mile driven that I faced?*

Answer: I am renting a car – which means I give up 20 cents in other consumption per mile driven. Thus, my opportunity cost is 20 cents. My opportunity cost does not include the rental fee since I paid that before even getting into the car.

(b) *What is the opportunity cost for each mile driven that my brother faced?*

Answer: My brother is taking taxis – so he has to give up \$1 in other consumption for every mile driven. His opportunity cost is therefore \$1 per mile.

B: *Derive the mathematical equations for my budget constraint and my brother's budget constraint, and relate elements of these equations to your graphs in part A. Use x_1 to denote miles driven and x_2 to denote other consumption.*

Answer: My budget constraint, once I pay the rental fee, is $0.2x_1 + x_2 = 1700$ while my brother's budget constraint is $x_1 + x_2 = 2000$. These can be rewritten with x_2 on the left hand side as

$$x_2 = 1700 - 0.2x_1 \text{ for me, and} \tag{2.11}$$

$$x_2 = 2000 - x_1 \text{ for my brother.} \tag{2.12}$$

The intercept terms (1700 for me and 2000 for my brother) as well as the slopes (-0.2 for me and -1 for my brother) are as in Graph 2.9.

(a) *Where in your budget equation for me can you locate the opportunity cost of a mile driven?*

Answer: My opportunity cost of miles driven is simply the slope term in my budget equation — i.e. 0.2. I give up \$0.20 in other consumption for every mile driven.

(b) *Where in your budget equation for my brother can you locate the opportunity cost of a mile driven?*

Answer: My brother's opportunity cost of miles driven is the slope term in his budget equation — i.e. 1; he gives up \$1 in other consumption for every mile driven.

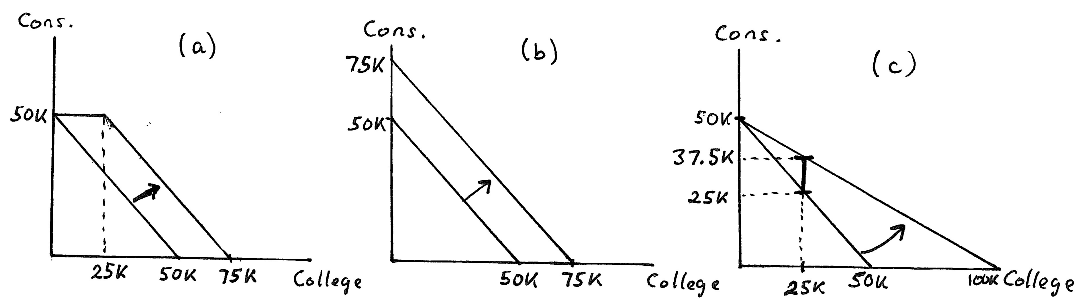
Exercise 2.8: *Setting up a College Trust Fund*

Everyday Application: *Setting up a College Trust Fund*: *Suppose that you, after studying economics in college, quickly became rich – so rich that you have nothing better to do than worry about your 16-year old niece who can't seem to focus on her future. Your niece currently already has a trust fund that will pay her a nice yearly income of \$50,000 starting when she is 18, and she has no other means of support.*

A: *You are concerned that your niece will not see the wisdom of spending a good portion of her trust fund on a college education, and you would therefore like to use $100,000 of your wealth to change her choice set in ways that will give her greater incentives to go to college.*

(a) *One option is for you to place $100,000 in a second trust fund but to restrict your niece to be able to draw on this trust fund only for college expenses of up to $25,000 per year for four years. On a graph with "yearly dollars spent on college education" on the horizontal axis and "yearly dollars spent on other consumption" on the vertical, illustrate how this affects her choice set.*

Answer: Panel (a) of Graph 2.10 illustrates the change in the budget constraint for this type of trust fund. The original budget shifts out by $25,000 (denoted $25K), except that the first $25,000 can only be used for college. Thus, the maximum amount of other consumption remains $50,000 because of the stipulation that she cannot use the trust fund for non-college expenses.



Graph 2.10: (a) Restricted Trust Fund; (b) Unrestricted; (c) Matching Trust Fund

(b) *A second option is for you to simply tell your niece that you will give her $25,000 per year for 4 years and you will trust her to "do what's right". How does this impact her choice set?*

Answer: This is depicted in panel (b) of Graph 2.10 — it is a pure income shift of $25,000 since there are no restrictions on how the money can be used.

(c) *Suppose you are wrong about your niece's short-sightedness and she was planning on spending more than $25,000 per year from her other trust fund on college education. Do you think she will care whether you do as described in part (a) or as described in part (b)?*

Answer: If she was planning to spend more than $25K on college anyhow, then the additional bundles made possible by the trust fund in (b) are not valued by her. She would therefore not care whether you set up the trust fund as in (a) or (b).

(d) *Suppose you were right about her: she never was going to spend very much on college. Will she care now?*

Answer: Now she will care — because she would actually choose one of the bundles made available in (b) that is not available in (a) and would therefore prefer (b) over (a).

(e) *A friend of yours gives you some advice: be careful — your niece will not value her education if she does not have to put up some of her own money for it. Sobered by this advice, you decide to set up a different trust fund that will release 50 cents to your niece (to be spent on whatever she wants) for every dollar that she spends on college expenses. How will this affect her choice set?*

Answer: This is depicted in panel (c) of Graph 2.10. If your niece now spends $1 on education, she gets 50 cents for anything she would like to spend it on — so, in effect, the opportunity cost of getting $1 of additional education is just 50 cents. This "matching" trust fund therefore reduces the opportunity cost of education whereas the previous ones did not.

(f) *If your niece spends $25,000 per year on college under the trust fund in part (e), can you identify a vertical distance that represents how much you paid to achieve this outcome?*

Answer: If your niece spends $25,000 on her education under the "matching" trust fund, she will get half of that amount from your trust fund — or $12,500. This can be seen as the vertical distance between the before and after budget constraints (in panel (c) of the graph) at $25,000 of education spending.

B: *How would you write the budget equation for each of the three alternatives discussed above?*

Answer: The initial budget is $x_1 + x_2 = 50,000$. The first trust fund in (a) expands this to a budget of

$$x_2 = 50,000 \text{ for } x_1 \leq 25,000 \text{ and } x_1 + x_2 = 75,000 \text{ for } x_1 > 25,000, \tag{2.13}$$

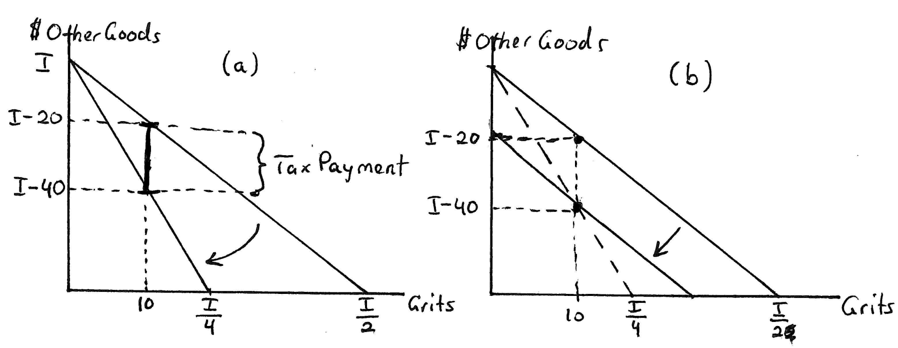
while the second trust fund in (b) expands it to $x_1 + x_2 = 75,000$. Finally, the last "matching" trust fund in (e) (depicted in panel (c)) is $0.5x_1 + x_2 = 50,000$.

Exercise 2.15: *Taxing Goods versus Lump Sum Taxes*

Policy Application: *Taxing Goods* versus *Lump Sum Taxes*: *I have finally convinced my local congressman that my wife's taste for grits are nuts and that the world should be protected from too much grits consumption. As a result, my congressman has agreed to sponsor new legislation to tax grits consumption which will raise the price of grits from $2 per box to $4 per box. We carefully observe my wife's shopping behavior and notice with pleasure that she now purchases 10 boxes of grits per month rather than her previous 15 boxes.*

A: *Putting "boxes of grits per month" on the horizontal and "dollars of other consumption" on the vertical, illustrate my wife's budget line before and after the tax is imposed. (You can simply denote income by I.)*

Answer: The tax raises the price, thus resulting in a rotation of the budget line as illustrated in panel (a) of Graph 2.11 (on the next page). Since no indication of an income level was given in the problem, income is simply denoted *I*.



Graph 2.11: (a) Tax on Grits; (b) Lump Sum Rebate

(a) *How much tax revenue is the government collecting per month from my wife? Illustrate this as a vertical distance on your graph.* (Hint*: If you know how much she is consuming after the tax and how much in other consumption this leaves her with, and if you know how much in other consumption she would have had if she consumed that same quantity before the* *imposition of the tax, then the difference between these two "other consumption" quantities must be equal to how much she paid in tax.)*

Answer: When she consumes 10 boxes of grits after the tax, she pays $40 for grits. This leaves her with $(I-40)$ to spend on other goods. Had she bought 10 boxes of grits prior to the tax, she would have paid $20, leaving her with $(I-20)$. The difference between $(I-40)$ and $(I-20)$ is $20 — which is equal to the vertical distance in panel (a). You can verify that this is exactly how much she indeed must have paid — the tax is $2 per box and she bought 10 boxes, implying that she paid $2 times 10 or $20 in grits taxes.

(b) *Given that I live in the South, the grits tax turned out to be unpopular in my congressional district and has led to the defeat of my congressman. His replacement won on a pro-grits platform and has vowed to repeal the grits tax. However, new budget rules require him to include a new way to raise the same tax revenue that was yielded by the grits tax. He proposes to simply ask each grits consumer to pay exactly the amount he or she paid in grits taxes as a monthly lump sum payment. Ignoring for the moment the difficulty of gathering the necessary information for implementing this proposal, how would this change my wife's budget constraint?*

Answer: In panel (b) of Graph 2.11, the previous budget under the grits tax is illustrated as a dashed line. The grits tax changed the opportunity cost of grits — and thus the slope of the budget (as illustrated in panel (a)). The lump sum tax, on the other hand, does not alter opportunity costs but simply reduces income by $20, the amount of grits taxes my wife paid under the grits tax. This change is illustrated in panel (b).

B: *State the equations for the budget constraints you derived in A(a) and A(b), letting grits be denoted by x_1 and other consumption by x_2.*

Answer: The initial (before-tax) budget was $x_2 = I - 2x_1$ and becomes $x_2 = I - 4x_1$ after the imposition of the grits tax. The lump sum tax budget constraint is $x_2 = I - 20 - 2x_1$.

Conclusion: Potentially Helpful Reminders

1. When income I is exogenous, the intercepts of the budget line are I/p_1 (on the horizontal) and I/p_2 (on the vertical).

2. When income is endogenously derived from the sale of an endowment, you can calculate the person's cash budget I by simply multiplying each good's quantity in the endowment bundle by its price and adding up. (That's the value of the endowment bundle in the market). The vertical and horizontal intercepts of the budget line are then calculated just as in point 1 above.

3. The slope of budget lines — whether they emerge from exogenous incomes or endowments — is always $-p_1/p_2$, NOT $-p_2/p_1$. If good 2 is a composite good, the slope is just $-p_1$.

4. Remember that changes in the income or the endowment bundle cause parallel shifts; changes in prices cause rotations. And — if the income is exogenous, the rotation is through the intercept on the axis whose price has not changed; but if the income is endogenously derived from an endowment, the rotation is through the endowment bundle.

5. Be sure to do end-of-chapter exercises 2.6 and 2.15. Exercise 2.6 forms the basis for material introduced in Chapters 7, and Exercise 2.15 introduces a technique used repeatedly in Chapters 8 through 10.