Lesson 5 Guide

```
## Loading required package: dplyr

##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union

## Loading required package: lattice

## Loading required package: ggformula

## Loading required package: ggplot2

## Loading required package: ggstance

##
## Attaching package: 'ggstance'

## The following objects are masked from 'package:ggplot2':
##
##     geom_errorbarh, GeomErrorbarh

##
## New to ggformula?  Try the tutorials:
##  learnr::run_tutorial("introduction", package = "ggformula")
##  learnr::run_tutorial("refining", package = "ggformula")

## Loading required package: mosaicData

## Loading required package: Matrix

##
## The 'mosaic' package masks several functions from core packages in order to add
## additional features.  The original behavior of these functions should not be affected by this.
##
## Note: If you use the Matrix package, be sure to load it BEFORE loading mosaic.

##
## In accordance with CRAN policy, the 'mdsr' package
##           no longer attaches
## the 'tidyverse' package automatically.
## You may need to 'library(tidyverse)' in order to
##           use certain functions.
```

Lesson 5: Consumption

Consumption as part of GDP

Consumption accoutns for roughly 2/3 of GDP in the United States. This dictates that it becomes a very important aspect around policy making. From 2001-2007 consumption grew by roughly 3% per year. During the great recession however consumtion fell 0.25% in 2008 and 0.6% in 2009.

Consumption Theories

In this lesson we look at consumer choice between consumption and saving (or future consumption).

- Theory 1: Intertemporal Choice (Irving Fisher)
  - we look at this
- Theory 2: Keynesian Consumption Function (Econ 104)
- Theory 3: Permanent Income Hypothesis (Friedman)
- Theory 4: Life-Cycle Hypothesis (Modigliani)

Theory of Intertemporal Choice

3 steps to this theory

1. Define the Intertemporal Budget Constraint
2. Define the consumer preferences
3. Show the optimal consumption bundle

Assumptions

1. Individuals live in a 2 period world
   - Period 1 vs Period 2
   - Current vs Future
   - Today vs Tomorrow
2. No Income/Wealth is left over
   - anything saved in period 1, is consumed in period 2
   - anything borrowed in period 1, is paid back in period 2
3. Savings rate = borrowing rate

Terminology

$\mathrm{Y_i}$ = Income in period i ($\mathrm{Y_1}$ vs $\mathrm{Y_2}$)
$\mathrm{W_i}$ = Wealth in period i
$\mathrm{C_i}$ = Consumption in period i

($\mathrm{Y_i}$ + $\mathrm{W_i}$) = i-Period's resources

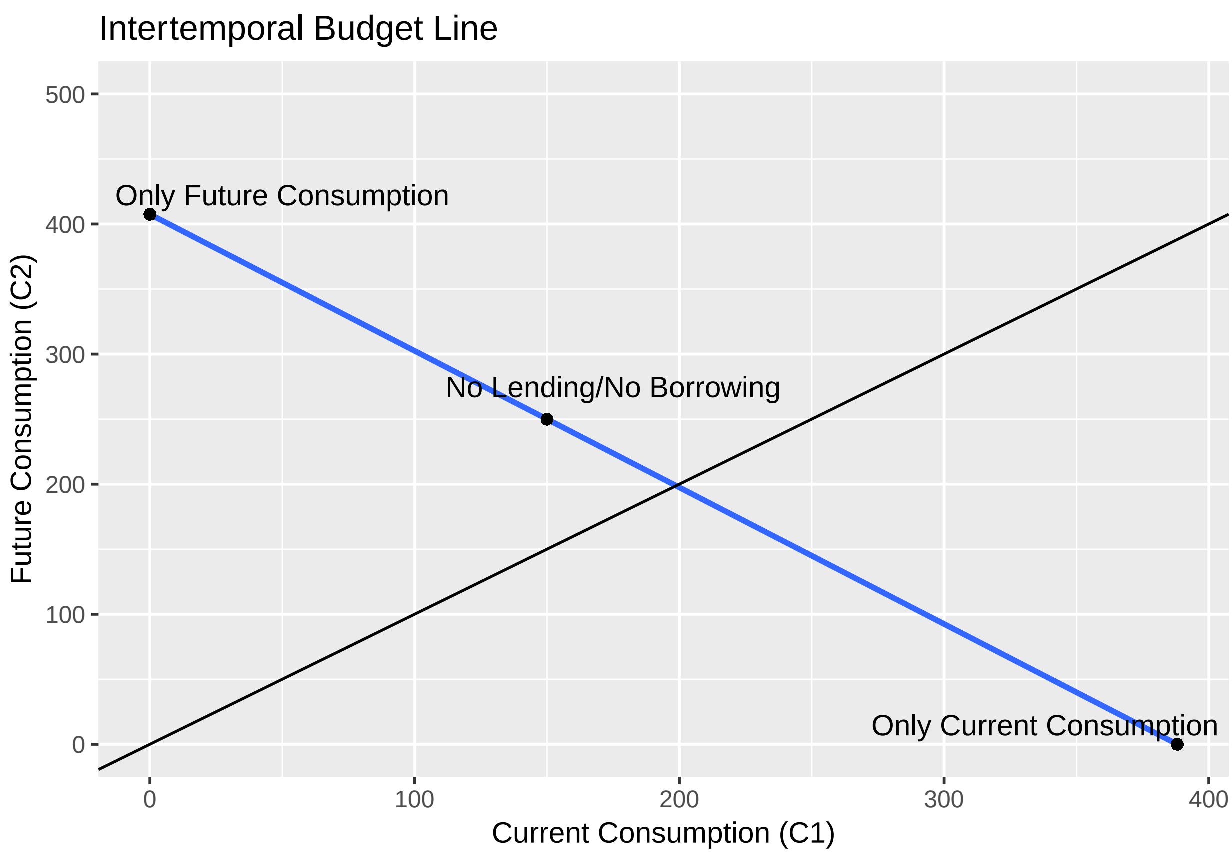
With 2 time periods:

- ($\mathrm{Y_1}$ + $\mathrm{W_1}$) = current resources
- ($\mathrm{Y_2}$ + $\mathrm{W_2}$) = future resources
  - Combined they are lifetime resources

Intertemporal Budget Line

```
y1 <- 100
w1 <- 50
y2 <- 50
w2 <- 200
r <- 0.05

c1 <- seq(from = 0, to = 500, by = 0.5)
c2 <- ((y1 + w1) * (1 + r) + (y2 + w2)) - (1 + r) * c1
IBL <- data.frame(c1 = c1, c2 = c2)

nlnbc1 <- y1 + w1
nlnbc2 <- y2 + w2

yintercept <- (1 + r) * (y1 + w1) + (y2 + w2)
xintercept <- (y1 + w1) + (y2 + w2) / (1 + r)

IBL %>%
  ggplot(aes(x = c1, y = c2)) +
  geom_smooth() +
  geom_point(aes(x = xintercept, y = 0)) +
  geom_point(aes(x = 0, y = yintercept)) +
  geom_point(aes(x = nlnbc1, y = nlnbc2)) +
  xlab("Current Consumption (C1)") +
  ylab("Future Consumption (C2)") +
  ggtitle("Intertemporal Budget Line") +
  scale_y_continuous(limits = c(0,500)) +
  geom_abline(slope = 1, intercept = 0) +
  annotate(geom = "text", x = xintercept - 50, y = 15,
           label = "Only Current Consumption") +
  annotate(geom = "text", x = 50, y = yintercept + 15,
           label = "Only Future Consumption") +
  annotate(geom = "text", x = nlnbc1 + 25, y = nlnbc2 + 25,
           label = "No Lending/No Borrowing")
```

```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'

## Warning: Removed 224 rows containing non-finite values (stat_smooth).
```



Points to observe

- Y-intercept = Only Future consumption (C_2)
- X-intercept = Only Current consumption (C_1)
- intserction of IBL and y = x is $C_1 = C_2$ (Consumption Smoothing)
- No-Lending/No-Borrowing Point
  - $C_1 = Y_1 + W_1$
  - $C_2 = Y_2 + W_2$
- Slope = -(1 + r)
  - r = real interest rate

Math of IBL

Assumption 2: PVLC = PVLR

Present Value Lifetime Consumption (PVLC)

$$C_1 + \frac{C_2}{(1+r)} + \frac{C_3}{(1+r)^2} + \frac{C_4}{(1+r)^3} + ... + \frac{C_n}{(1+r)^{n-1}}$$

Present Value Lifetime Resources (PVLR)

$$(Y_1 + W_1) + \frac{(Y_2 + W_2)}{(1+r)} + \frac{(Y_3 + W_3)}{(1+r)^2} + \frac{(Y_4 + W_4)}{(1+r)^3} + ... + \frac{(Y_n + W_n)}{(1+r)^{n-1}}$$

When n = 2 you get our IBL:

$$C_1 + \frac{C_2}{(1+r)} = (Y_1 + W_1) + \frac{(Y_2 + W_2)}{(1+r)}$$

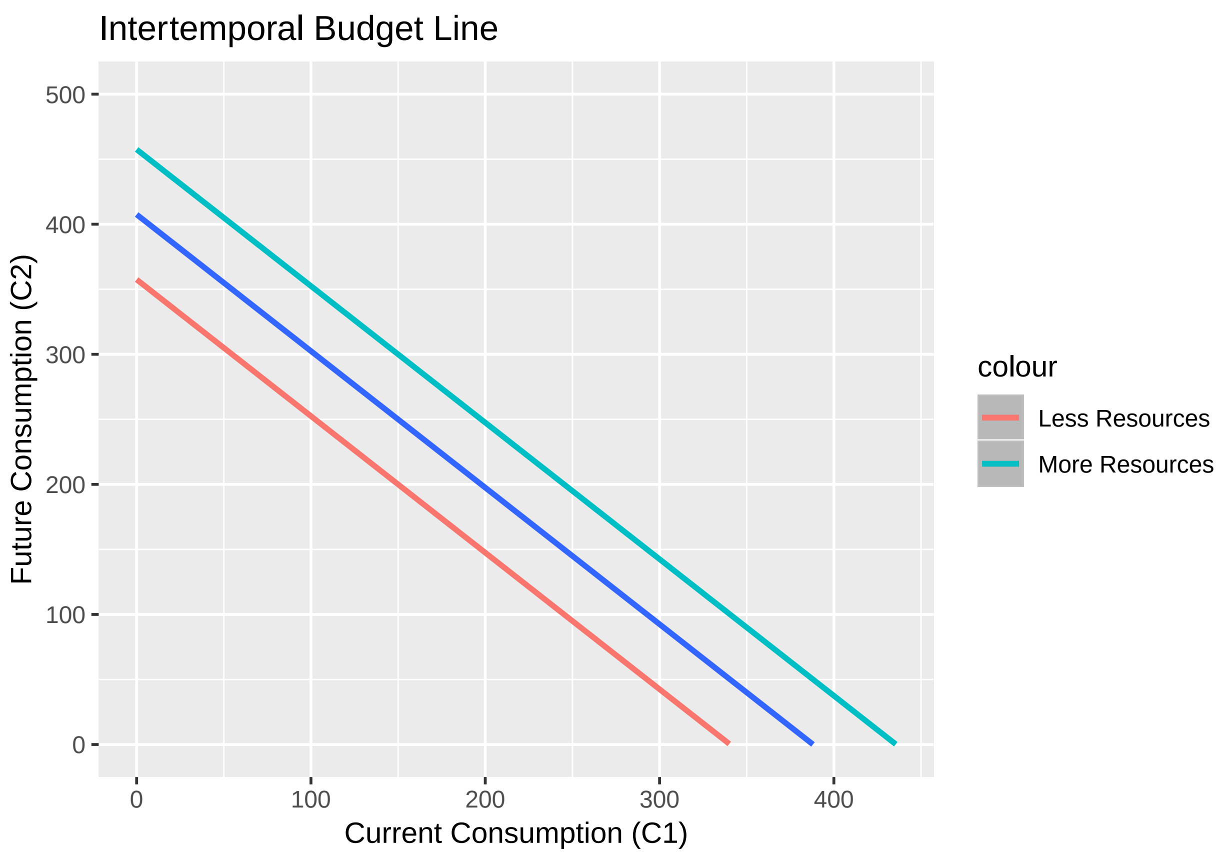
Put it into `y = mx + b` form:

$$C_2 = -(1+r) * C_1 + ((Y_1 + W_1)(1+r) + (Y_2 + W_2))$$

Shifts of the IBL

```
IBL$c2up <- IBL$c2 + 50
IBL$c2down <- IBL$c2 - 50

IBL %>%
  ggplot(aes(x = c1, y = c2)) +
  geom_smooth() +
  geom_smooth(aes(y = c2up, color = "More Resources")) +
  geom_smooth(aes(y = c2down, color= "Less Resources")) +
  xlab("Current Consumption (C1)") +
  ylab("Future Consumption (C2)") +
  ggtitle("Intertemporal Budget Line") +
  scale_y_continuous(limits = c(0,500))
```

```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'

## Warning: Removed 224 rows containing non-finite values (stat_smooth).

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'

## Warning: Removed 129 rows containing non-finite values (stat_smooth).

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'

## Warning: Removed 320 rows containing non-finite values (stat_smooth).
```



Green (Shifts up/right): * Increase in Y_1, Y_2, W_1, W_2

Red (Shifts down/left): * Decrease in Y_1, Y_2, W_1, W_2

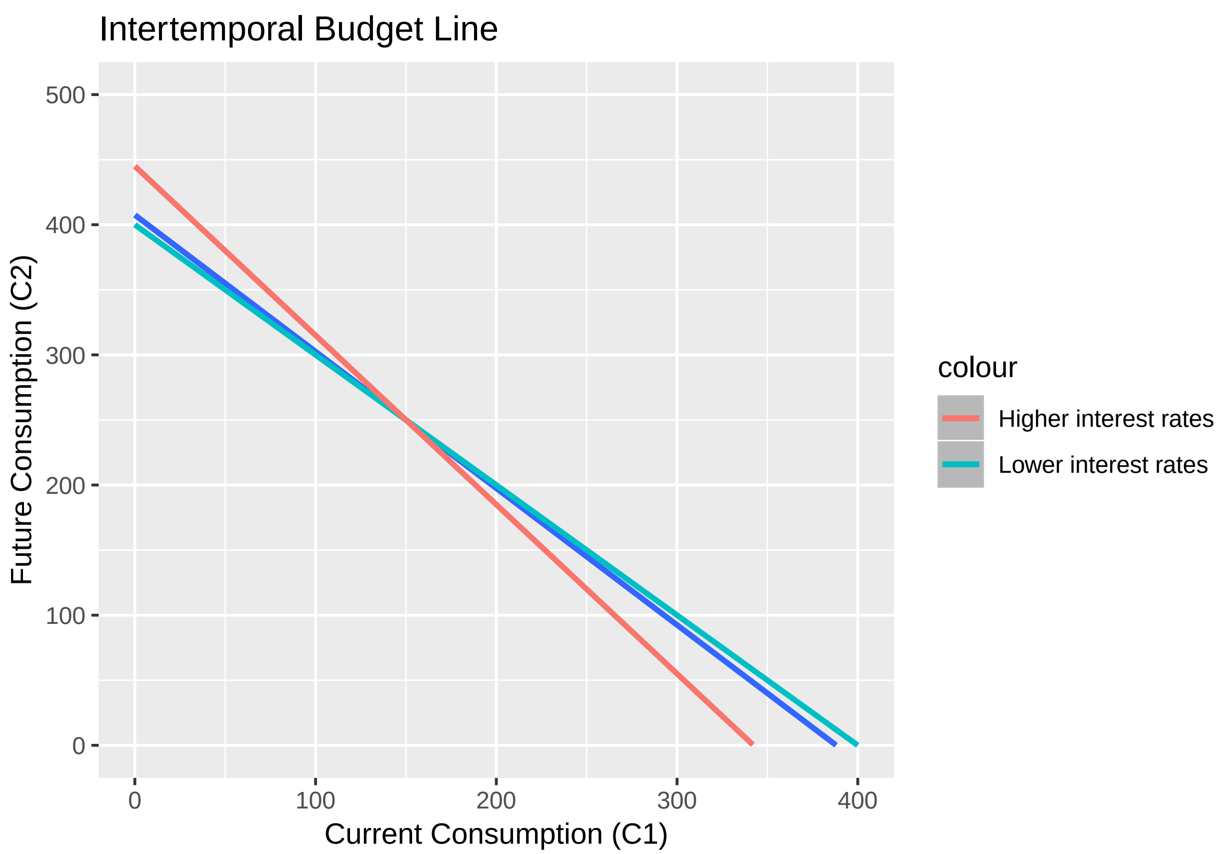
Rotation of the IBL

```
r <- 0
IBL$c2slow <- ((y1 + w1) * (1 + r) + (y2 + w2)) - (1 + r) * IBL$c1
r <- 0.3
IBL$c2steep <- ((y1 + w1) * (1 + r) + (y2 + w2)) - (1 + r) * IBL$c1

IBL %>%
  ggplot(aes(x = c1, y = c2)) +
  geom_smooth() +
  geom_smooth(aes(y = c2slow, color = "Lower interest rates")) +
  geom_smooth(aes(y = c2steep, color= "Higher interest rates")) +
  xlab("Current Consumption (C1)") +
  ylab("Future Consumption (C2)") +
  ggtitle("Intertemporal Budget Line") +
  scale_y_continuous(limits = c(0,500))
```

```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```

```
## Warning: Removed 224 rows containing non-finite values (stat_smooth).
```

```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'

## Warning: Removed 200 rows containing non-finite values (stat_smooth).

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'

## Warning: Removed 316 rows containing non-finite values (stat_smooth).
```



An increase in r (real interest rate) correponds to a steeper slope and a decrease in r corresponds to a shallower slope. This makes sense since the slope is -(1 + r)

Preferences

The question: what combination of C_1 and C_2 would make an individual equally happy?

Use an indifference curve.

```
util <- 200
IBL$indiff <- (util / c1 ^ 0.5) ^ 2
IBL$indiffDouble <- (util * 2 / c1 ^ 0.5) ^ 2

IBL %>%
  ggplot(aes(x = c1, y = c2)) +
  geom_smooth() +
  geom_smooth(aes(c = c1, y = indiff, color = "IC")) +
```

```
  geom_smooth(aes(c = c1, y = indiffDouble, color = "IC * 2")) +
  geom_point(aes(x = xintercept, y = 0)) +
  geom_point(aes(x = 0, y = yintercept)) +
  geom_point(aes(x = nlnbc1, y = nlnbc2)) +
  xlab("Current Consumption (C1)") +
  ylab("Future Consumption (C2)") +
  ggtitle("Intertemporal Budget Line vs Indifference Curve (IC)") +
  scale_y_continuous(limits = c(0,500))
```

```
## Warning: Ignoring unknown aesthetics: c

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## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'

## Warning: Removed 224 rows containing non-finite values (stat_smooth).

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'

## Warning: Removed 160 rows containing non-finite values (stat_smooth).

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'

## Warning: Removed 640 rows containing non-finite values (stat_smooth).
```

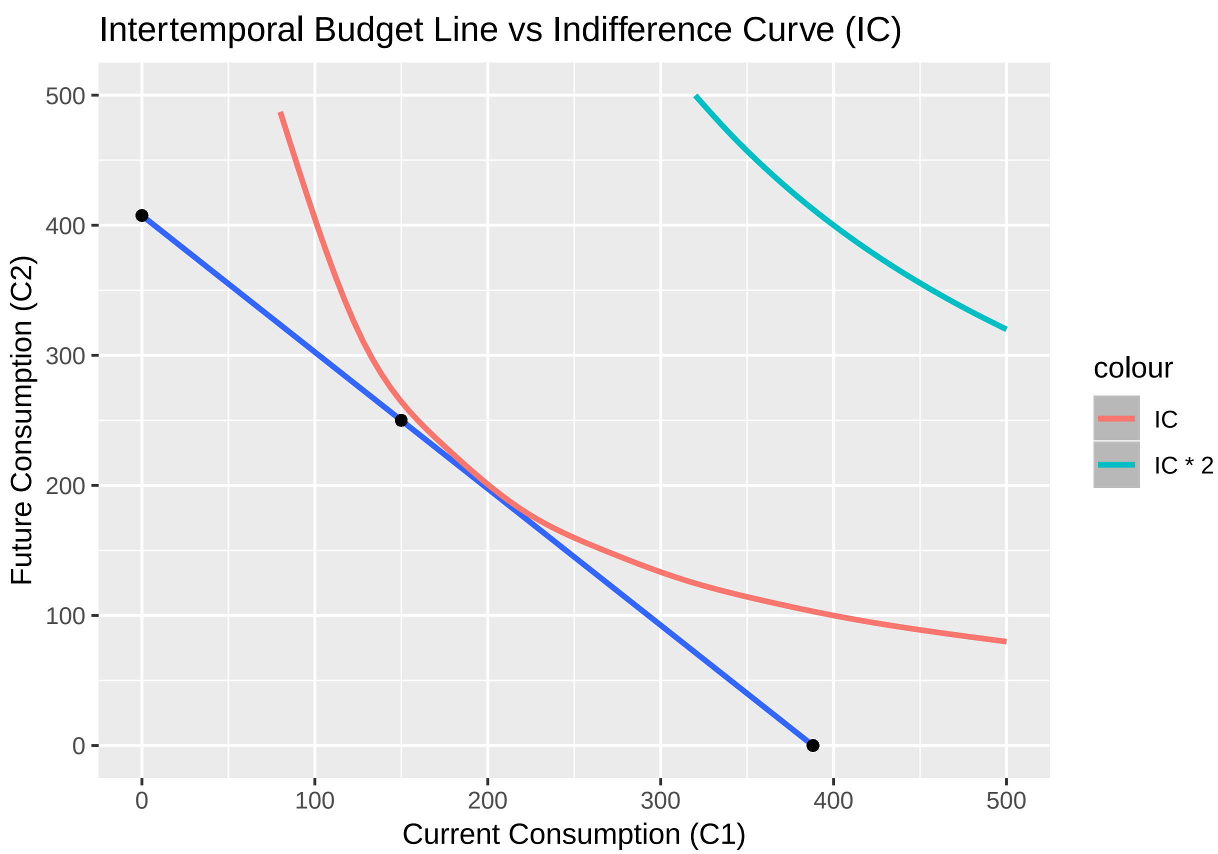

The indifference curve used in the example is at a utility of 200 for a cobb douglas utility function of $U = C_1^{0.5} * C_2^{0.5}$

If "Marissa" always consumptions smooths, then you want to find the point on the graph where $C_1 = C_2$

To find C*:

1. Preference ($C_1 = C_2$)
2. IBL (PVLR = PVLC)

$$C_1 + \frac{C_2}{(1+r)} = (Y_1 + W_1) + \frac{(Y_2 + W_2)}{(1+r)}$$

Replace C_2 with C_1, since they are equal when smoothing

$$C_1 + \frac{C_1}{(1+r)} = (Y_1 + W_1) + \frac{(Y_2 + W_2)}{(1+r)}$$

$$(1+r) * C_1 + C_1 = (1+r)(Y_1 + W_1) + (Y_2 + W_2)$$

$$C^* = \frac{(1+r)(Y_1 + W_1) + (Y_2 + W_2)}{(2+r)}$$

What if "Sam" prefers to consume twice as much in the future period?

1. $C_1 = 0.5 * C_2$
2. IBL

$$C_1^* = \frac{(1+r)(Y_1 + W_1) + (Y_2 + W_2)}{(3+r)}$$

How does changes in r (real interest rate) affect consumption?

Substitution Effect

If r increases, then C_1 is more expensive for both borrowers and savers.

Therefore, C_1 goes down and C_2 goes up, for both types.

- Sub into "cheaper" good

Income Effect

If r increases

- Borrower has less real income, so all consumption goes down
- Saver has more real income, so all consumption goes up

When looking at data, when the real interest rate increases, C_1 decreases, so the substitution effect is stronger than the income effect.