Lesson 6 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 6: Saving and Investment

Firm's Decision

Firms have to make a decision about what to use their resources for. There are two things that firms use their resources for.

1. Pay dividends to stock holders
2. Increase capacity to produce more in the future (I)

Firms will choose a level of capital (K) that maximizes profit by reaching the condition $MB = MC$

MB = Expected marginal product of capital (MPK^e)

MC = User-cost of capital (UC)

π_{max} when UC = MPK^e

User Cost

We will express user cost in number of output, which is the real cost.

Example: Michael Scott's Paper Company

- Output: Reams of Paper (Price = $10)
- Capital: Van (Price = $10,000)
- UC = 1,000 reams of paper

User Cost Factors

User Cost depends on:

- Real Price of capital (P_k)
- The depreciation rate (δ)
- The real interest rate (r)
- The business tax on revenue (τ)
- Investment Tax Credit (ITC)

Defining User Cost

Start without considering taxes or tax credits

$\frac{w}{\tau} = 0$ and $ITC = 0$

$$UC = rP_k + \delta P_k$$

$$UC = (r + \delta)P_k$$

Now lets add in τ (business tax on revenue) Firms will now be losing some % of their benefit (revenue) MPK^e

At max π:

$$UC = MPK^e - \tau MPK^e$$

$$UC = (1-\tau)MPK^e$$
$$\frac{(r+\delta)P_k}{1-\tau} = \frac{(1-\tau)MPK^e}{1-\tau}$$
$$MPK^e = \frac{(r+\delta)P_k}{1-\tau}$$
$$UC = \frac{(r+\delta)P_k}{1-\tau}$$

Now let us add in Investment Tax Credit (ITC). Assume ITC is a % of P_k (real price of capital)

$$P_k = P_k - ITC(P_k)$$
$$P_k = (1-ITC)P_k$$

Plug this into our user cost we get:

$$UC = \frac{(r+\delta)(1-ITC)P_k}{(1-\tau)}$$

Shifts in User costs

1. Increase in r is increase in UC
2. Increase in δ is increase in UC
3. Increase in ITC is decrease in UC
4. Increase in P_k is increase in UC
5. Increase in τ is increase in UC

Defining Marginal Benefit MPK^e

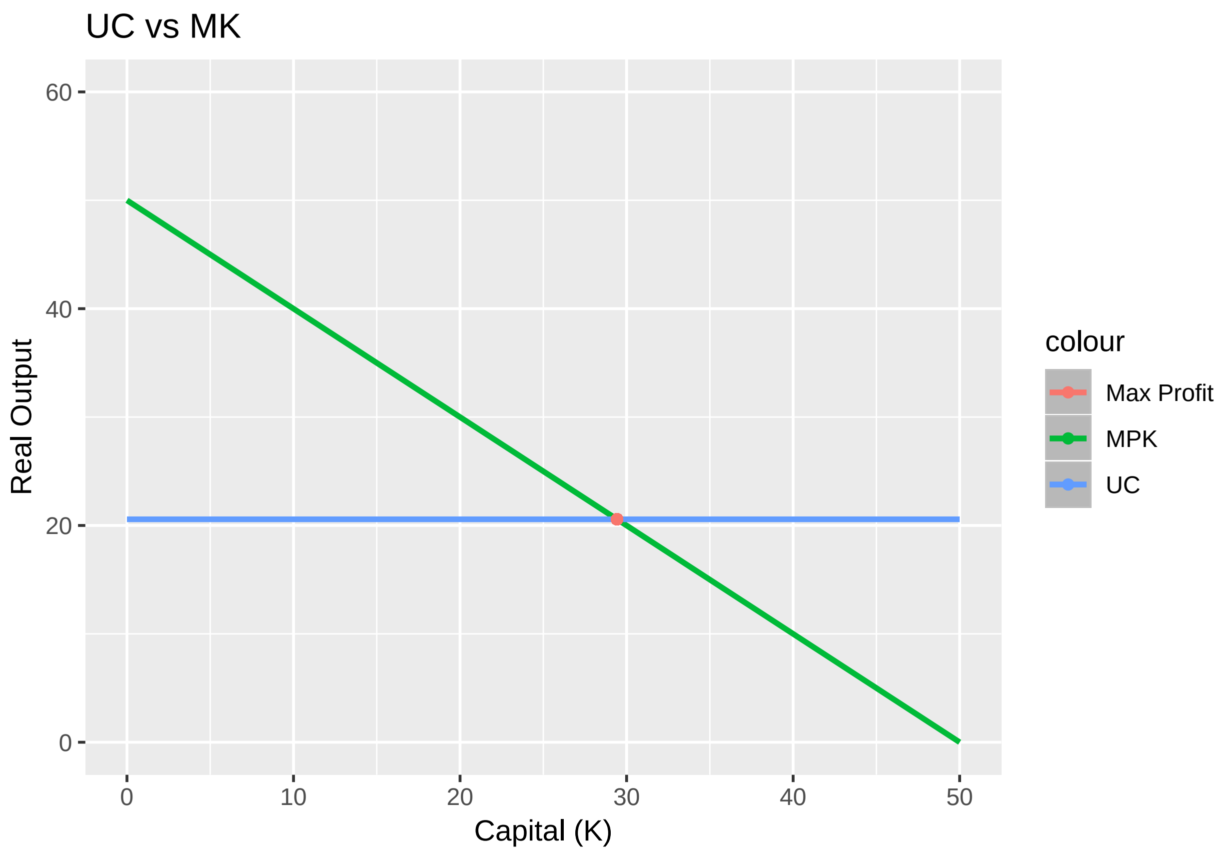
Capital has diminishing marginal returns. This means that as K increases, Y increases, but at a decreasing rate. As K goes up, MPK^e goes down.

UC vs MPK^e

```
k <- seq(from = 0, to = 50, by = 0.5)

r <- 0.05
delta <- 0.13
ITC <- 0.2
tau <- 0.3
P <- 100
UC <- ((r + delta) * (1 - ITC) * P)/(1 - tau)

MPK <- 50 - k

data <- data.frame(UC = UC, MPK = MPK)

data %>%
  ggplot(aes(x = k, y = MPK, color = "MPK")) +
  geom_smooth() +
  geom_smooth(aes(y = UC, color = "UC")) +
```

```
  geom_point(aes(x = 50 - UC[1], y = UC[1], color = "Max Profit")) +
  xlab("Capital (K)") +
  ylab("Real Output") +
  ggtitle("UC vs MK") +
  scale_y_continuous(limits = c(0,60))
```

```
## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
```



Shifts for UC are all the variables in the euqation of UC, which move it up or down. Shifts for MPK are A and AS. These are total factor productivty (or tech) and "Animal Spirits". Animal Spirits referrs to investor confidence.

Investment

Terminology

I_t = Gross investment in year t K_t = capital stock at beginning of year t K_{t+1} = capital stock at beginning of year t + 1

- Net investment = ΔK during year t
  - $K_{t+1} - K_t$
- Net investment = gross investment - depreciation

$$K_{t+1} - K_t = I_t - \delta K_t$$

$$I_t = K_{t+1} - K_t + \delta K_t$$

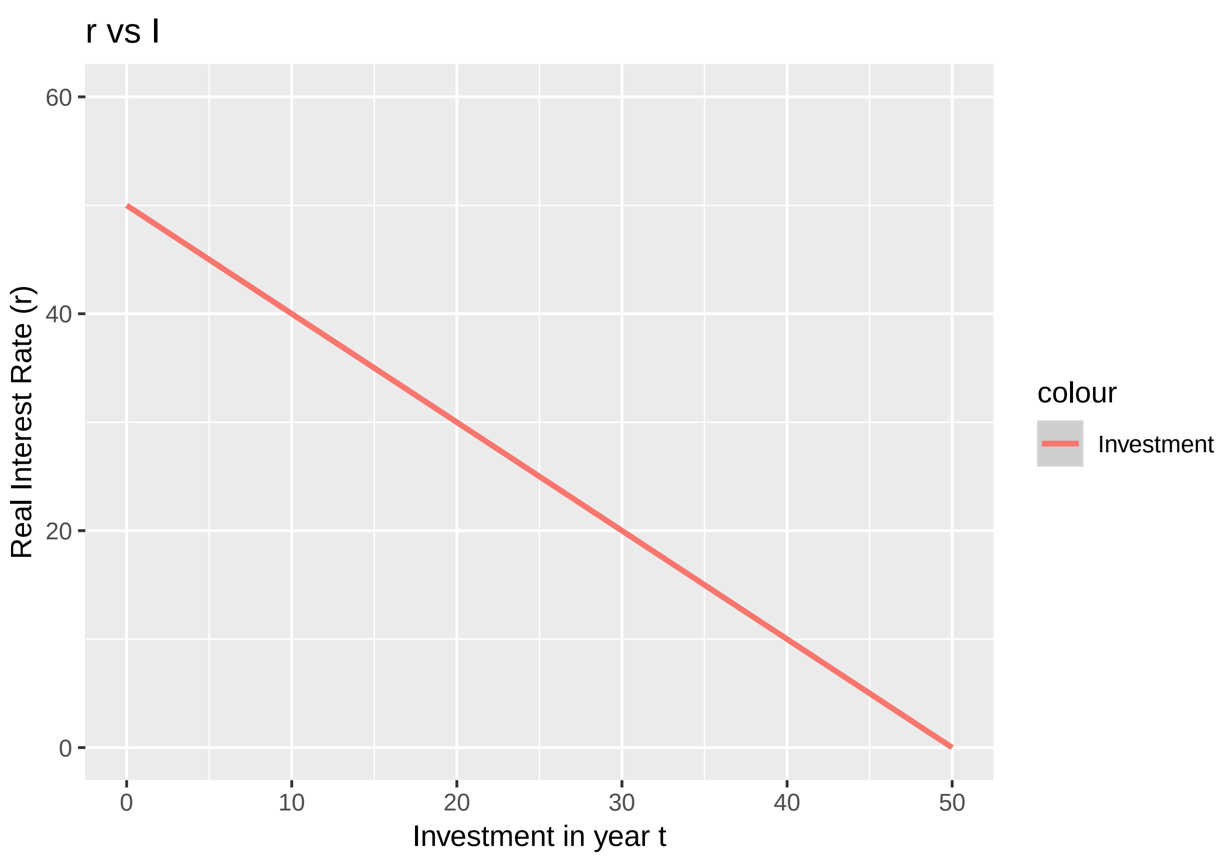
If we assume that firms are trying to maximize profit π then $I_t = K^* - K_t + \delta K_t$ where K^* is the value of $\mathrm{k_{t+1}}$ that fulfills the condition UC = $\mathrm{MPK^e}$

From this we can see that if r (real interest rate) increases, then User Cost increases, which means $\mathrm{MPK^e}$ must increase, which means K^* must increase, so $\mathrm{I_t}$ decreases.

- r increases, $\mathrm{I_t}$ decreases

```r
data %>%
  ggplot(aes(x = k, y = MPK, color = "Investment")) +
  geom_smooth() +
  ylab("Real Interest Rate (r)") +
  xlab("Investment in year t") +
  ggtitle("r vs I") +
  scale_y_continuous(limits = c(0,60))
```

```
## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
```



The Goods Market Equlibrium

- We are in a closed economy so NX = 0
- Savings = Investment

We can go back to our GDP function

$$Y = C + I + G$$

Then rewrite it with investment as our response:

$$I = Y - C - G$$

We know for savings

$$S = S_{pvt} + S_{pub}$$

$$S = ((Y + TR + INT) - (C + T)) + (T - (G + TR + INT))$$

$$S = Y - C - G$$

Therefore savings is equal to investment ($S = I$) when in equilibrium.

Recall in Lesson 5 we learned that when r increases, consumption decreases, so savings must increase. And in this lesson we determined that when r increases, I decreases.

This brings us to our model of Savings vs Investment

```r
data$savings <- k
data %>%
  ggplot(aes(x = k, y = MPK, color = "Investment")) +
  geom_smooth() +
  geom_smooth(aes(y = savings, color = "Savings")) +
  geom_point(aes(x = 25, y = 25, color = "equilibrium")) +
  ylab("Real Interest Rate (r)") +
  xlab("Investment in year t") +
  ggtitle("r vs I") +
  scale_y_continuous(limits = c(0,60))
```

```
## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
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```

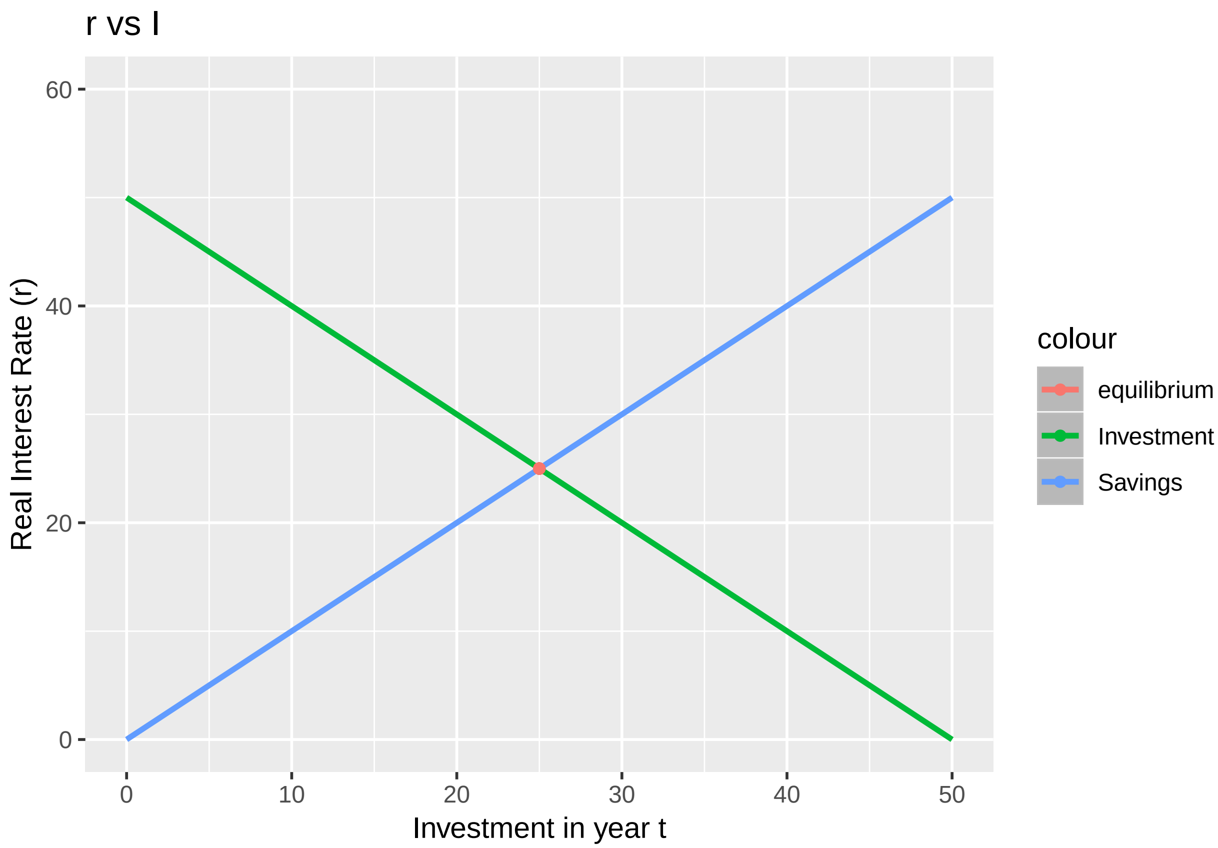

At the equilibrum point above Savings is equal to investment for the given level of r (real interest rate).

Shifts

The following states how an increase in each factor changes the resposne variable.

Savings Function

$$S = Y - C - G$$

- Y +
- Y_2 -
- W_1 -
- W_2 -
- T +
- Autonomous Consumption -
- Consumer confidence -
- G -

Investment Function

$$I = K^* - K_t + \delta K_t$$

- A +

- AS +
- τ -
- δ -
- P_k -
- ITC +