Introduction to R Programming

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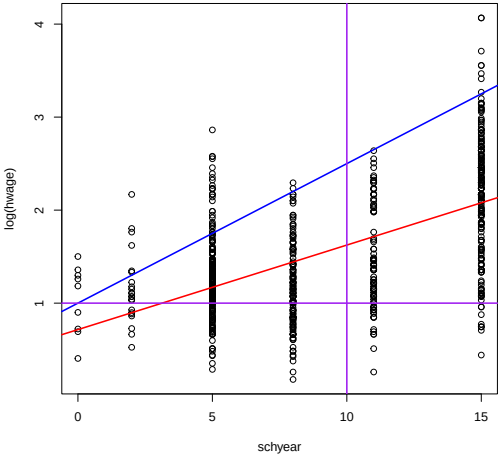
Outline

Load data I

```
f_url = "https://github.com/obakis/econ_data/raw/master/hls2011.rds"
download.file(url = f_url, destfile = "hls2011.rds", mode="wb")
hls = readRDS("hls2011.rds")
hls$educ = factor(hls$educ,labels=c("Ill","Lit","PS","MS","HS","Col"))
```

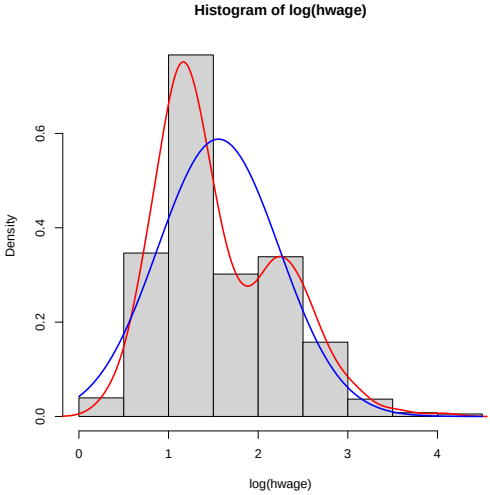
plot() I

```
plot(log(hwage)~schyear, data=hls)
abline(lm(log(hwage)~schyear,
    hls), lwd=2, col="red")
#a, b :intercept and slope
abline(a=1,b=0.15, lwd=2, col="blue")
# h:horizontal line, v:vertical line
abline(h=1,v=10,lwd=2, col="purple")
```



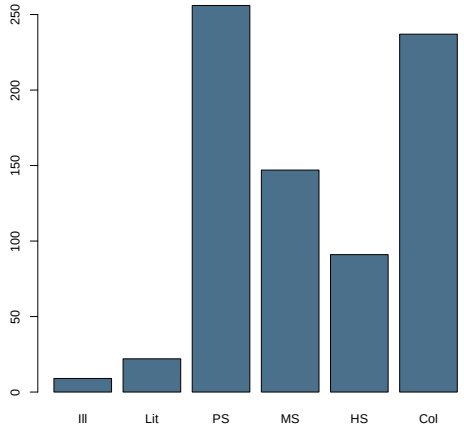
hist() I

```
with(hls, hist(log(hwage),
                    freq=FALSE))
# See also: freq=TRUE
with(hls,
     lines(density(log(hwage)),
           col = "red", lwd=2))
m=mean(log(hls$hwage))
sd = sd(log(hls$hwage))
curve(dnorm(x,m,sd),add=TRUE,
      col = "blue", lwd=2)
```



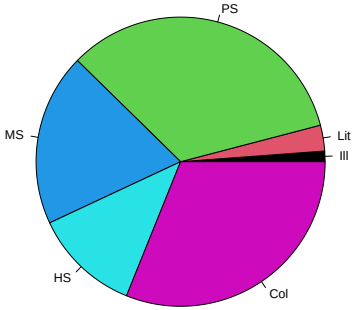
barplot() I

```
tab = table(hls$educ)
barplot(tab, col="skyblue4")
```



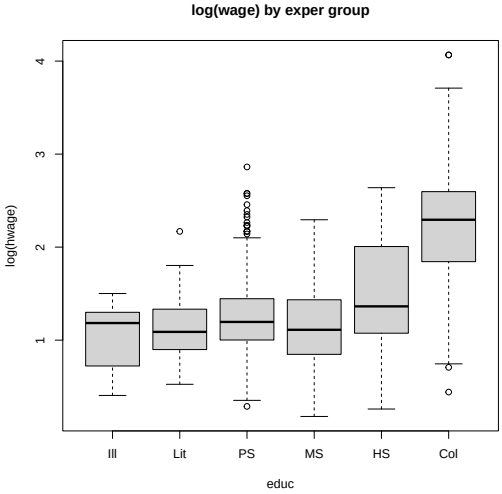
pie() I

```r
pie(tab, col=1:6)
```



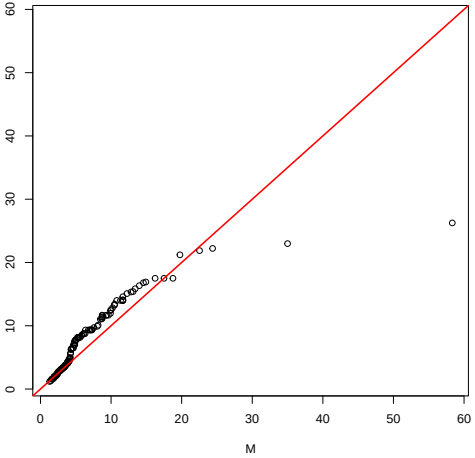
boxplot() I

```
boxplot(log(hwage) ~ educ,
        data=hls,
    main="log(wage) by exper group")
```



qqplot() I

```
mwage = subset(hls,
               female==0)$hwage
fwage = subset(hls,
               female==1)$hwage
w_range = range(hls$hwage)
qqplot(mwage,fwage, xlim=w_range,
       ylim=w_range, xlab="M", ylab="F")
abline(a=0,b=1,lwd=2,col="red")
```



Graphical parameters I

Modifications: `plot()` has many arguments, including

- `type`: modify plot type, e.g., points (`type = "p"`, default), lines (`type = "l"`), both (`type = "b"`), stair steps (`type = "s"`).
- `main`, `xlab`, `ylab`: modify title and axis labels.
- Further graphical parameters (see `?par`) can be passed to `plot()` or set separately via `par()`.
- `col`: set color(s).
- `xlim`, `ylim`: adjust plotting ranges.
- `pch`: modify the plotting character for points.
- `cex`: corresponding character extension.

Graphical parameters II

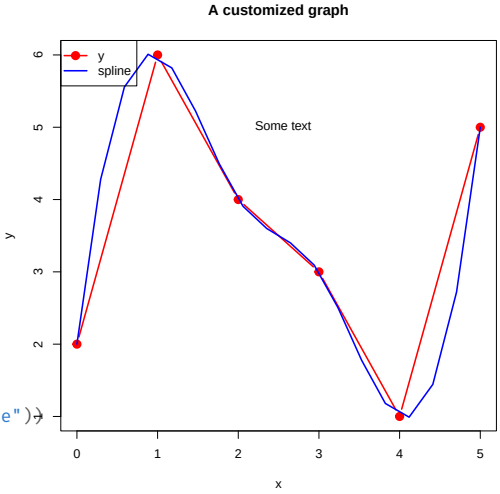
- `lty`, `lwd`: line type and width.
- `cex.lab`, `cex.axis`, `cex.`*foo*: size of labels, axis ticks, etc.

Graphical parameters I

Argument	Description
`axes`	should axes be drawn?
`bg`	background color
`cex`	size of a point or symbol
`col`	color
`las`	orientation of axis labels
`lty, lwd`	line type and line width
`main, sub`	title and subtitle
`mar`	size of margins
`mfcol, mfrow`	array defining layout for several graphs on a plot
`pch`	plotting symbol
`type`	types (see text)
`xlab, ylab`	axis labels
`xlim, ylim`	axis ranges
`xlog, ylog, log`	logarithmic scales

text() and lines() I

```
set.seed(12)
x=0:5; y=sample(6)
plot(y~x, type="b",col="red",
     lwd=2, pch=20,cex=2,
  main = "A customized graph")
text(3.0, 5.0, "Some text",
     pos = 2)
lines(spline(x,y), col="blue",
      lwd=2)
legend("topleft", col=c("red","blue"),
       lty=1,lwd=2,pt.cex=c(2,NA),
       pch=c(20,NA),legend=c("y","spline"))
```



Mathematical annotation of plots I

Overview: `?plotmath` and `demo("plotmath")`.

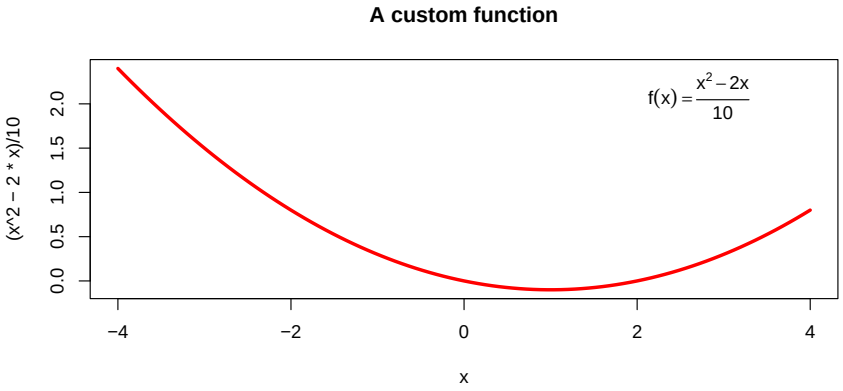
Syntax: Somewhat similar to LaTeX.

Illustration: Let us plot the following function for $-4 \leqslant x \leqslant 4$.

$$f(x) = \frac{x^2 - 2x}{10}$$

```
curve((x^2-2*x)/10, from = -4, to = 4, col = "red", lwd = 3,
  main = "A custom function")
text(2.0, 2.0, expression(f(x) == frac(x^2-2*x, 10)), pos = 4)
# pos: 1(below),2(left),3(above) and 4(right), of the specified coord.
```

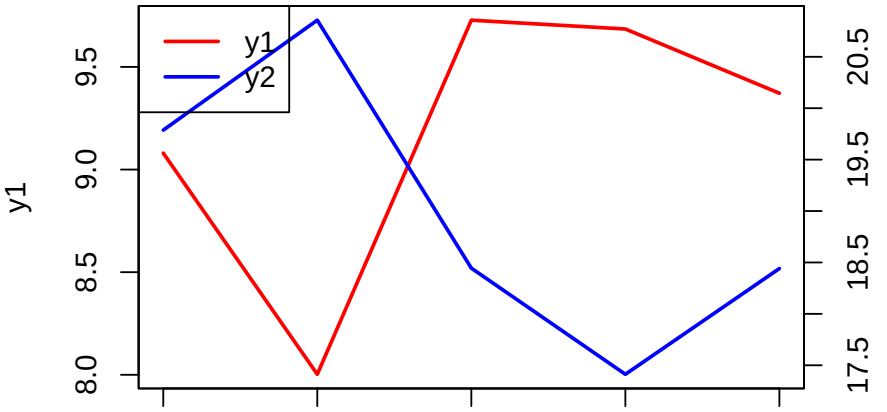
Mathematical annotation of plots I



Double Y axes I

```
## See also,
## stackoverflow.com/questions/6142944/how-can-i-plot-with-2-different-y-axes
x <- 2001:2005
y1 <- rnorm(5,10,1)
y2 <- rnorm(5,20,2)
plot(x,y1,type="l",col="red",lwd=2)
par(new=TRUE)
plot(x, y2,type="l",col="blue",lwd=2,
     xaxt="n",yaxt="n",xlab="",ylab="")
axis(4)
mtext("y2",side=4,line=3)
legend("topleft",col=c("red","blue"),
       lty=1,lwd=2,legend=c("y1","y2"))
```

Double Y axes II



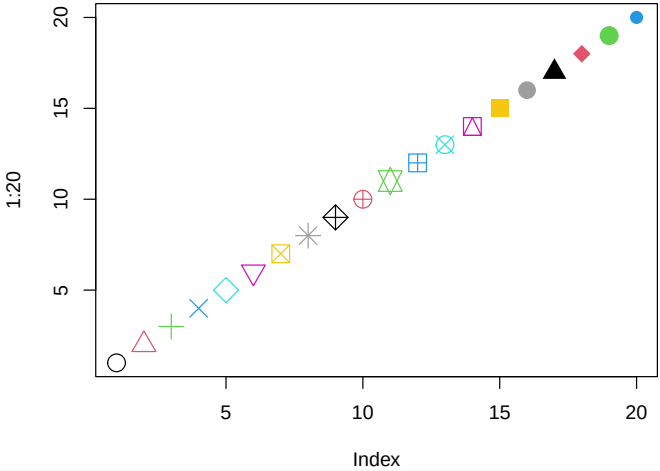
Exporting graphics I

We can save graphics in various formats including `PDF,PS,EPS,PNG,JPG,BMP,WMF,SVG`. In R language it is known as *starting a device driver*. For instance a `PDF` graphic may be created by

```
pdf("myfile.pdf", height = 5, width = 6)
plot(1:20, pch = 1:20, col = 1:20, cex = 2)
dev.off()
```

After graphic is done we should terminate the device driver by issuing the command `dev.off()`.

Exporting graphics II



Outline

ggplot2 I

- The main function is `ggplot()`. The key components of this function are data and aesthetics (`aes`). The aesthetics specify the variables to be plotted and the optional arguments regarding plotting size, shape color, etc.
- To below command specifies the data and the variables to be plotted.
  `ggplot(data = my_df, aes(x = my_x, y = my_y))`
- However we may have many "geom"s at te same time (points, line,bars etc.) The most widely used ones are
  ⇒ `geom_point` used for scatter plots and dot plots.
  ⇒ `geom_line` for lines.
- For adding geoms to a plot we need to use `+` operator.

ggplot2 II

- In examples below, we use the gapminder data. There are six variables: country, continent, year, lifeExp (life expectancy at birth), pop (total population), gdpPercap (per-capita GDP).
- The per-capita GDP is in units of 2005 international dollars.

ggplot2 III

```
#install.packages("gapminder")
library(gapminder)

## Registered S3 methods overwritten by 'tibble':
##  method    from
##  format.tbl pillar
##  print.tbl  pillar

library(ggplot2)
library(dplyr)

##
## Attaching package:  'dplyr'
## The following objects are masked from 'package:stats':
##
##    filter, lag
## The following objects are masked from 'package:base':
```

ggplot2 IV

```
##
##     intersect, setdiff, setequal, union
```

```
library("gridExtra")
```

```
##
## Attaching package:  'gridExtra'
## The following object is masked from 'package:dplyr':
##
##     combine
```

First few observations:

```
gm = gapminder
head(gm,4)
```

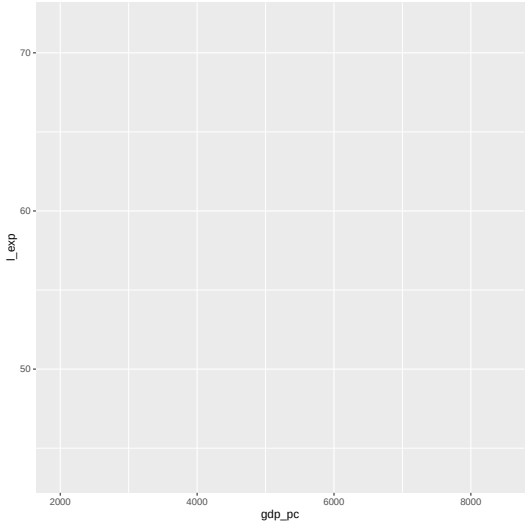
ggplot2 V

```
## # A tibble: 4 x 6
##   country     continent  year lifeExp      pop gdpPercap
##   <fct>       <fct>     <int>   <dbl>    <int>     <dbl>
## 1 Afghanistan Asia       1952    28.8  8425333      779.
## 2 Afghanistan Asia       1957    30.3  9240934      821.
## 3 Afghanistan Asia       1962    32.0 10267083      853.
## 4 Afghanistan Asia       1967    34.0 11537966      836.
```

```
colnames(gm)=c("ctry","contin","yr","l_exp","pop","gdp_pc")
```

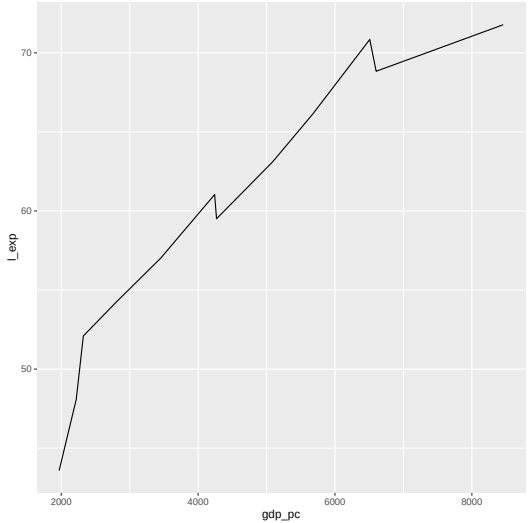
ggplot2 VI

```
gm_t = filter(gm, ctry=="Turkey")

g1 = ggplot(gm_t,
            aes(x=gdp_pc, y=l_exp))
print(g1)
```



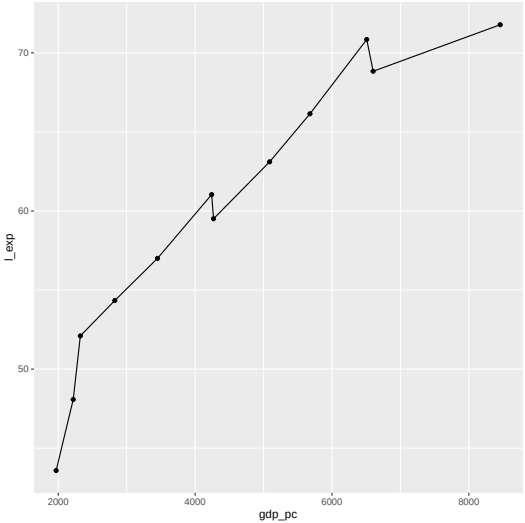
ggplot2 VII

```
g2 = g1 + geom_line()
print(g2)
```



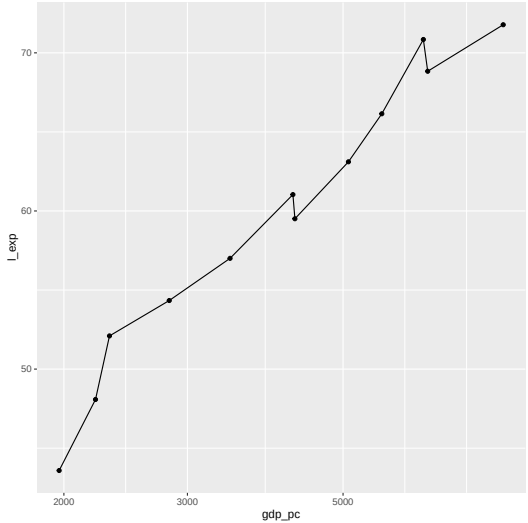
ggplot2 VIII

```
g3 = g1 + geom_line() + geom_point()
print(g3)
```



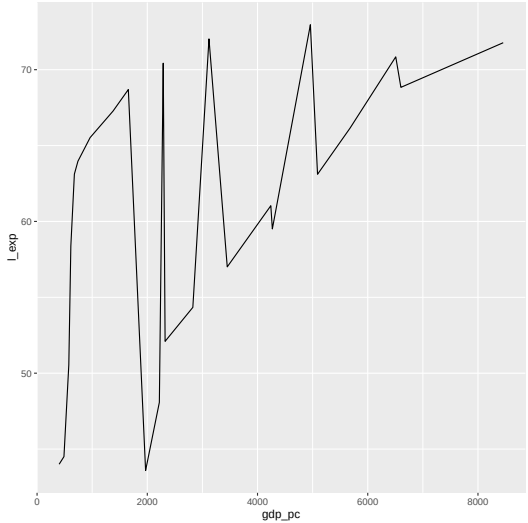
ggplot2 IX

```
g4 = g1 + geom_line() +
  geom_point() + scale_x_log10()
print(g4)
```



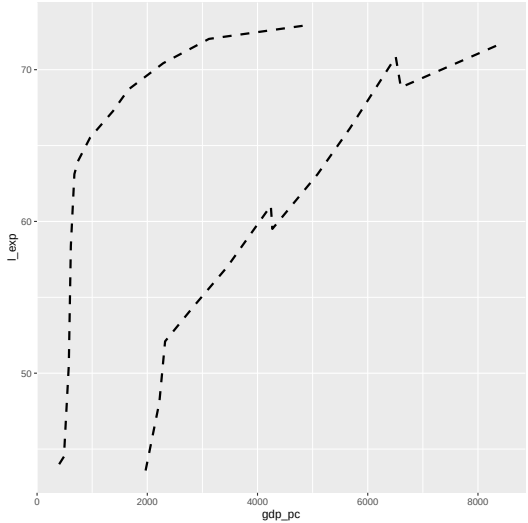
ggplot2 X

```
gm_ct = filter(gm,
  ctry=="China" | ctry=="Turkey")

p_ct = ggplot(gm_ct,
          aes(x=gdp_pc, y=l_exp))
g5 = p_ct + geom_line()
print(g5)
```



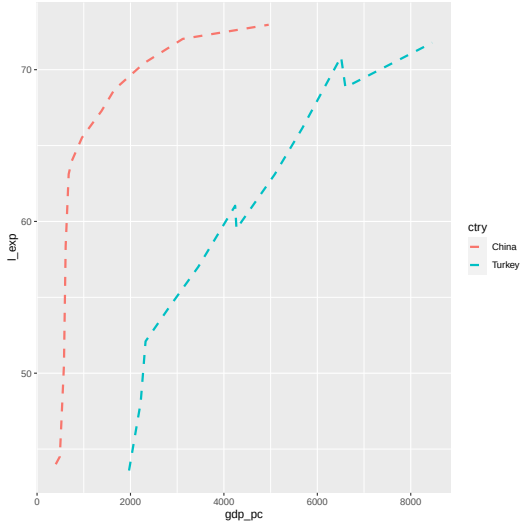
ggplot2 XI

```
## ctry is defined as group now
p2_ct=ggplot(gm_ct,
        aes(x=gdp_pc, y=l_exp,
            group=ctry))
#lty=line type, lwd=line width
g6 = p2_ct +
  geom_line(lty=2, lwd=1)
print(g6)
```



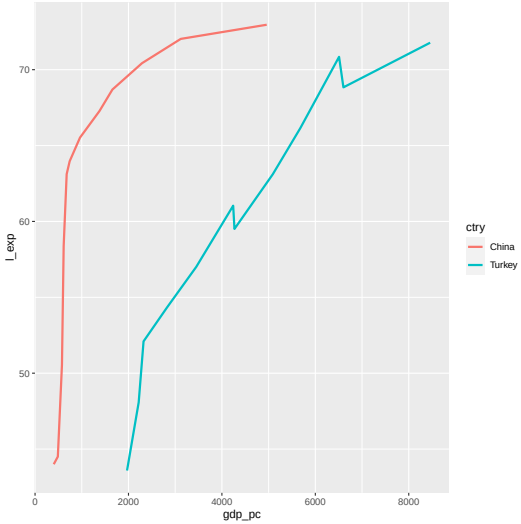
ggplot2 XII

```
#color is conditioned on country
g7=p2_ct +
  geom_line(
    aes(color=ctry),lty=2, lwd=1
    )
print(g7)
```



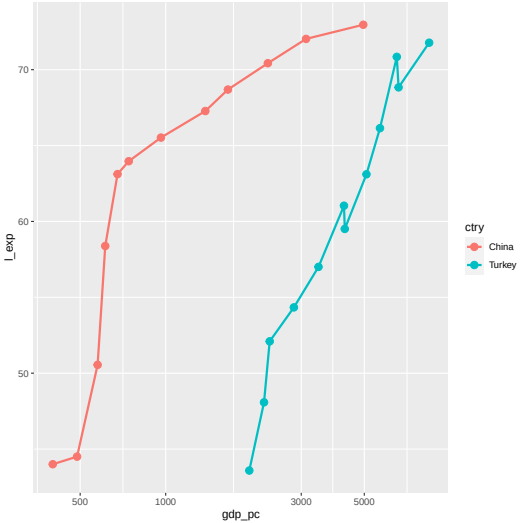
ggplot2 XIII

```
#color and group are condi-
tioned on country
p3_ct=ggplot(gm_ct,
        aes(x=gdp_pc, y=l_exp,
            group=ctry, color=ctry))
#lty=line type, lwd=line width
g8 = p3_ct +
  geom_line(lwd=1)
print(g8)
```



ggplot2 XIV

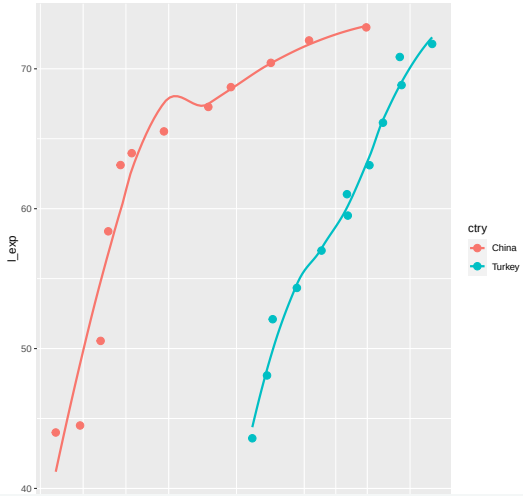
```
g12 = p3_ct +
  geom_line(lwd=1) + geom_point(size=3)
print(g12)
```



ggplot2 XV

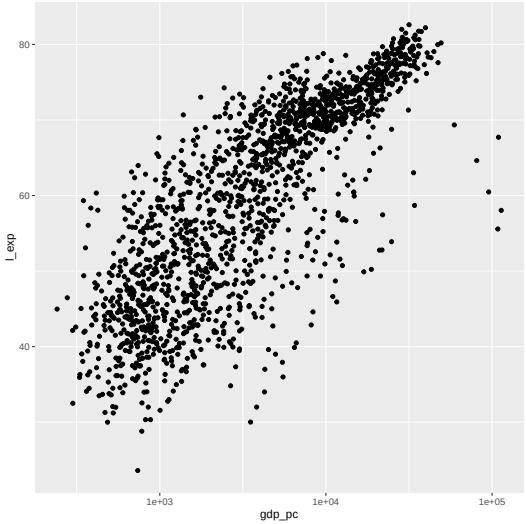
```
g13=p3_ct + geom_point(size=3) +
  geom_smooth(lwd = 1, se = FALSE)
print(g13)
```

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



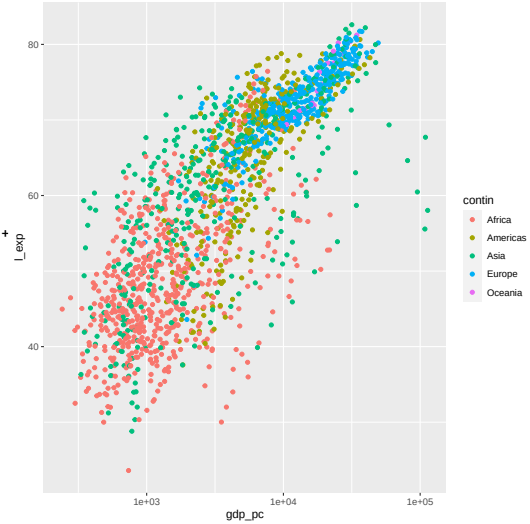
ggplot2 XVI

```
## all countries
p1 = ggplot(gm,
            aes(x=gdp_pc, y=l_exp))
g14 = p1 +
  geom_point() + scale_x_log10()

print(g14)
```



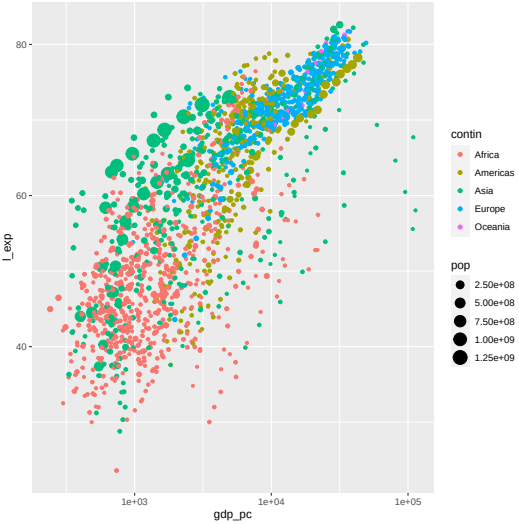
ggplot2 XVII

```
p3 = ggplot(gm,
 aes(x=gdp_pc, y=l_exp, color=contin))+
 scale_x_log10()

g15 = p3 + geom_point()
print(g15)
```



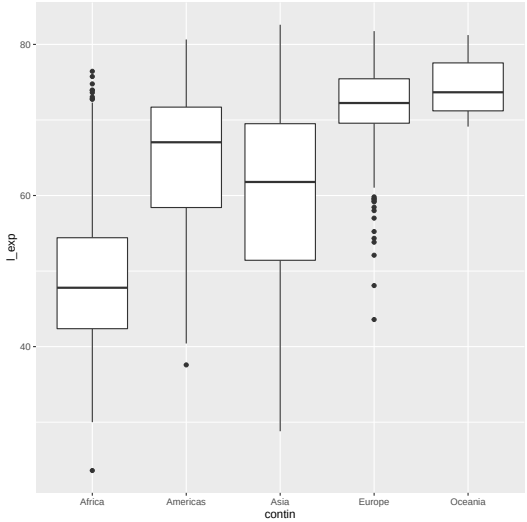
ggplot2 XVIII

```
g16 = p3 + geom_point(aes(size=pop))
print(g16)
```



ggplot2 XIX

```
g17 = ggplot(gm,
  aes(x=contin, y=l_exp)) +
  geom_boxplot()

print(g17)
```



ggplot2 XX

```
g18 = ggplot(gm,
  aes(x=contin, y=l_exp, fill=contin))
  geom_boxplot()
print(g18)
```