

question3

```
library(tidyverse)
```

```
-- Attaching core tidyverse packages ----- tidyverse 2.0.0 --
v dplyr      1.1.4      v readr      2.1.5
v forcats    1.0.0      v stringr    1.5.1
v ggplot2    3.5.1      v tibble     3.2.1
v lubridate  1.9.4      v tidyr      1.3.1
v purrr      1.0.2
-- Conflicts ----- tidyverse_conflicts() --
x dplyr::filter() masks stats::filter()
x dplyr::lag()     masks stats::lag()
i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become
```

```
library(ggplot2)
library(lme4) # For linear mixed models
```

Loading required package: Matrix

Attaching package: 'Matrix'

The following objects are masked from 'package:tidyr':

expand, pack, unpack

```
facttable<-read_csv("./facttable.csv")
```

Rows: 8778 Columns: 24

```
-- Column specification -----
Delimiter: ","
chr  (2): Country Code, Indicator
```

dbl (22): 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, ...

i Use ``spec()`` to retrieve the full column specification for this data.

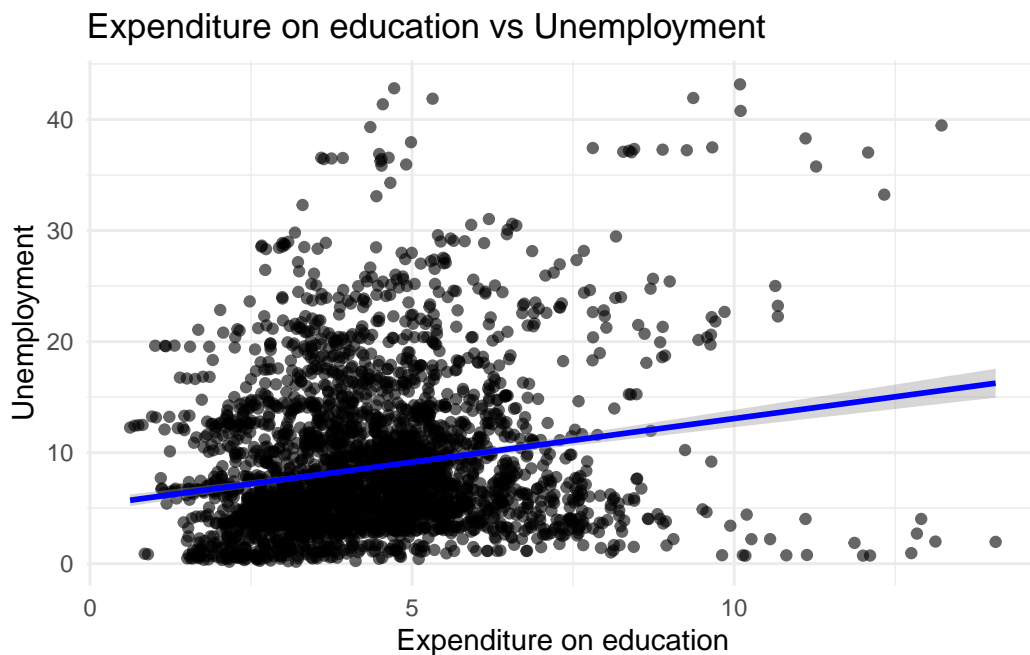
i Specify the column types or set ``show_col_types = FALSE`` to quiet this message.

```
facttable_wide <- facttable %>%  
  pivot_longer(cols = 3:24, names_to = "year", values_to = "value") %>%  
  pivot_wider(names_from = Indicator, values_from = value)
```

```
# Select relevant columns and remove missing values  
data <- facttable_wide %>%  
  select("Country Code", year, SE.XPD.TOTL.GD.ZS, SL.UEM.TOTL.FE.ZS) %>%  
  na.omit()
```

```
ggplot(data, aes(x = SE.XPD.TOTL.GD.ZS, y = SL.UEM.TOTL.FE.ZS)) +  
  geom_point(alpha = 0.6) +  
  geom_smooth(method = "lm", color = "blue") +  
  labs(title = "Expenditure on education vs Unemployment",  
       x = "Expenditure on education",  
       y = "Unemployment") +  
  theme_minimal()
```

``geom_smooth()`` using formula = 'y ~ x'



Build a linear model

```
lm_model <- lm(SL.UEM.TOTL.FE.ZS ~ SE.XPD.TOTL.GD.ZS, data = data)
summary(lm_model)
```

Call:

```
lm(formula = SL.UEM.TOTL.FE.ZS ~ SE.XPD.TOTL.GD.ZS, data = data)
```

Residuals:

Min	1Q	Median	3Q	Max
-14.293	-4.090	-1.928	2.474	33.884

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	5.22263	0.30991	16.85	<2e-16 ***
SE.XPD.TOTL.GD.ZS	0.78455	0.06723	11.67	<2e-16 ***

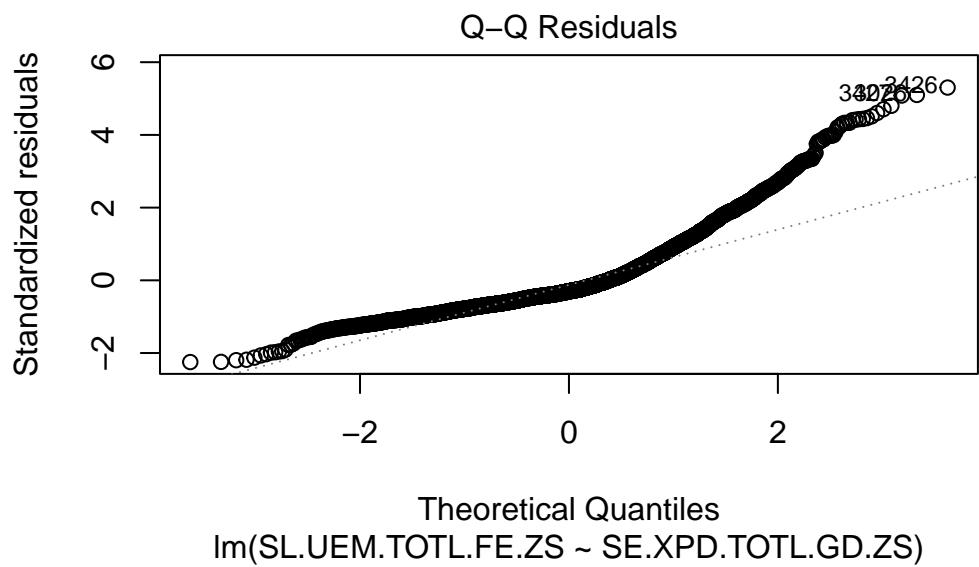
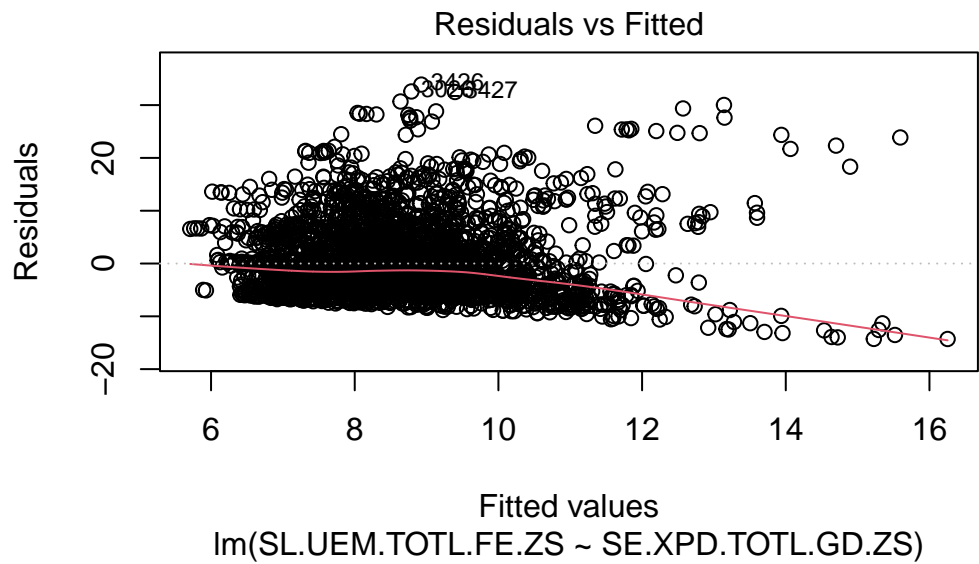
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

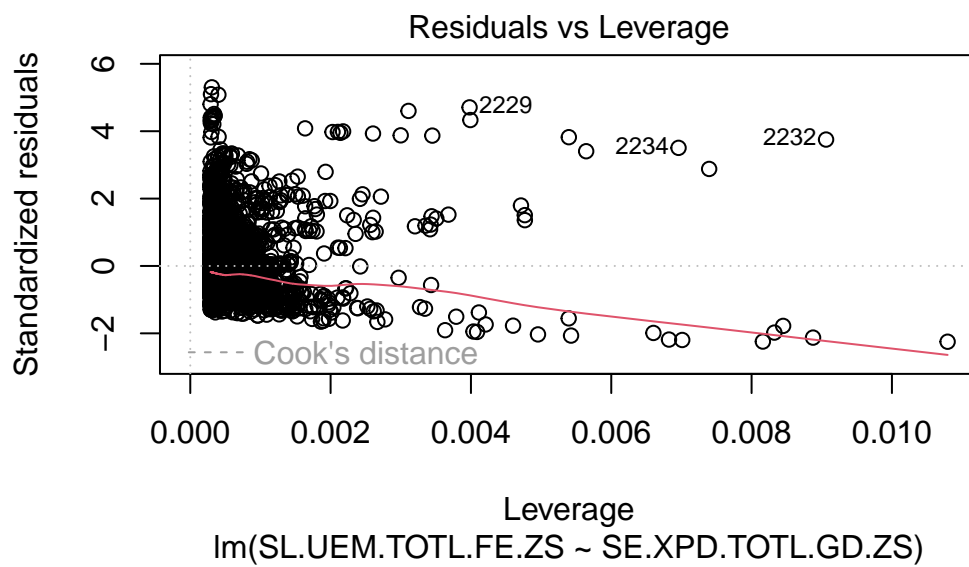
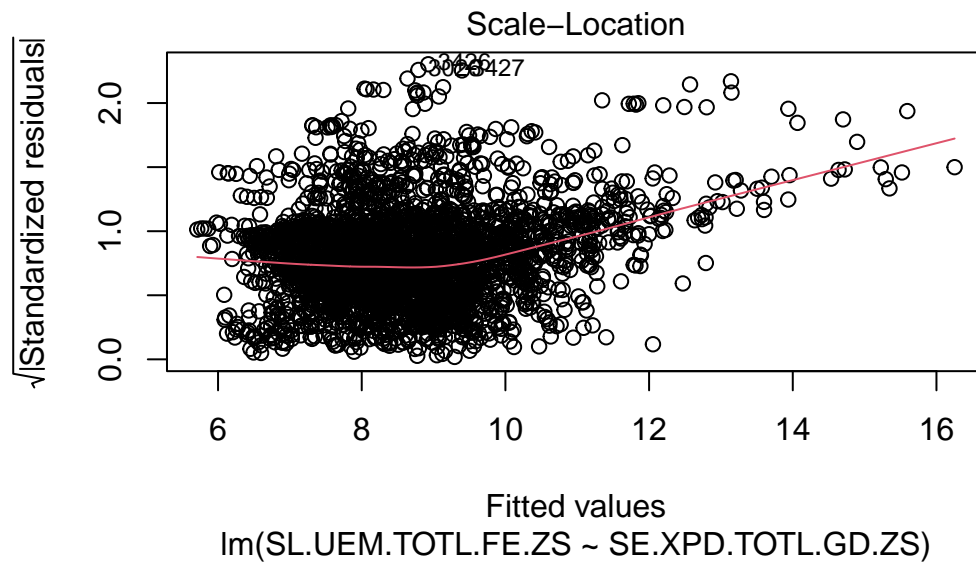
Residual standard error: 6.391 on 3453 degrees of freedom

Multiple R-squared: 0.03794, Adjusted R-squared: 0.03766

F-statistic: 136.2 on 1 and 3453 DF, p-value: < 2.2e-16

```
plot(lm_model)
```





```
colnames(data)[colnames(data) == "Country Code"] <- "Country"
```

Building an GLMM with Country as Random Effects

```
lmm_model <- glmer(SL.UEM.TOTL.FE.ZS ~ SE.XPD.TOTL.GD.ZS + (1 | Country), family = Gamma(link = "log"))
summary(lmm_model)
```

Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) [glmerMod]

Family: Gamma (log)

Formula: SL.UEM.TOTL.FE.ZS ~ SE.XPD.TOTL.GD.ZS + (1 | Country)

Data: data

AIC	BIC	logLik	deviance	df.resid
14152.9	14177.5	-7072.4	14144.9	3451

Scaled residuals:

Min	1Q	Median	3Q	Max
-3.0561	-0.4068	-0.0397	0.3542	6.7350

Random effects:

Groups	Name	Variance	Std.Dev.
Country	(Intercept)	0.11623	0.3409
	Residual	0.08337	0.2887

Number of obs: 3455, groups: Country, 222

Fixed effects:

	Estimate	Std. Error	t value	Pr(> z)
(Intercept)	1.960292	0.066106	29.654	<2e-16 ***
SE.XPD.TOTL.GD.ZS	-0.004539	0.005881	-0.772	0.44

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:

	(Intr)
SE.XPD.TOTL	-0.383

Compare the linear mode with the mixed model to see if indeed there is a random effect.

```
AIC(lm_model, lmm_model)
```

	df	AIC
lm_model	3	22626.07
lmm_model	4	14152.87

The comparison of Akaike Information Criterion (AIC) values between the linear model and the linear mixed model indicates that the mixed-effects model provides a better fit for the data. Since a lower AIC value suggests a more optimal model, this result implies that incorporating random effects to account for country-specific variations improves the explanation of the relationship between government R&D expenditure and high-tech exports. By considering country differences, the mixed model captures heterogeneity more effectively, making it a more suitable choice for understanding how government R&D spending influences high-tech exports across different nations.

Generalized Linear Mixed Models

Random Intercept Model

```
# Random Intercept Model
model_random_intercept <- glmer(SL.UEM.TOTL.FE.ZS ~ SE.XPD.TOTL.GD.ZS + (1 | Country),family
summary(model_random_intercept)
```

Generalized linear mixed model fit by maximum likelihood (Laplace
Approximation) [glmerMod]

Family: Gamma (log)
Formula: SL.UEM.TOTL.FE.ZS ~ SE.XPD.TOTL.GD.ZS + (1 | Country)
Data: data

AIC	BIC	logLik	deviance	df.resid
14152.9	14177.5	-7072.4	14144.9	3451

Scaled residuals:

Min	1Q	Median	3Q	Max
-3.0561	-0.4068	-0.0397	0.3542	6.7350

Random effects:

Groups	Name	Variance	Std.Dev.
Country	(Intercept)	0.11623	0.3409
	Residual	0.08337	0.2887

Number of obs: 3455, groups: Country, 222

Fixed effects:

	Estimate	Std. Error	t value	Pr(> z)
(Intercept)	1.960292	0.066106	29.654	<2e-16 ***
SE.XPD.TOTL.GD.ZS	-0.004539	0.005881	-0.772	0.44

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:

	(Intr)
SE.XPD.TOTL	-0.383

This model assumes that each country has a different baseline level of high-tech exports, but the effect of R&D expenditure is the same across all countries(same slope).

Random Intercept and Random Slope Model

```
#Random Intercept and Random Slope Model
```

```
model_random_slope <- glmer(SL.UEM.TOTL.FE.ZS ~ SE.XPD.TOTL.GD.ZS + (SE.XPD.TOTL.GD.ZS | Country)
summary(model_random_slope)
```

Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) [glmerMod]

Family: Gamma (log)

Formula: SL.UEM.TOTL.FE.ZS ~ SE.XPD.TOTL.GD.ZS + (SE.XPD.TOTL.GD.ZS | Country)

Data: data

AIC	BIC	logLik	deviance	df.resid
13623.8	13660.7	-6805.9	13611.8	3449

Scaled residuals:

Min	1Q	Median	3Q	Max
-3.5258	-0.3837	-0.0354	0.3647	7.5228

Random effects:

Groups	Name	Variance	Std.Dev.	Corr
Country	(Intercept)	0.62344	0.7896	
	SE.XPD.TOTL.GD.ZS	0.02997	0.1731	-0.89
Residual		0.06237	0.2497	

Number of obs: 3455, groups: Country, 222

Fixed effects:

	Estimate	Std. Error	t value	Pr(> z)
(Intercept)	1.85762	0.12145	15.296	<2e-16 ***
SE.XPD.TOTL.GD.ZS	0.01966	0.02526	0.779	0.436

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:

(Intr)
SE.XPD.TOTL -0.828

This model assumes that both:

- Each country has a different baseline level of high-tech exports (random intercept).
- The effect of R&D expenditure on high-tech exports varies by country (random slope).

```
# Compare the 2 models;  
anova(model_random_intercept, model_random_slope)
```

Data: data

Models:

model_random_intercept: SL.UEM.TOTL.FE.ZS ~ SE.XPD.TOTL.GD.ZS + (1 | Country)

model_random_slope: SL.UEM.TOTL.FE.ZS ~ SE.XPD.TOTL.GD.ZS + (SE.XPD.TOTL.GD.ZS | Country)

	npar	AIC	BIC	logLik	deviance	Chisq	Df	Pr(>Chisq)
model_random_intercept	4	14153	14178	-7072.4	14145			
model_random_slope	6	13624	13661	-6805.9	13612	533.1	2	< 2.2e-16

model_random_intercept

model_random_slope ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

The comparison between the random intercept and random slope models shows that the random slope model provides a better fit for the data. The lower AIC (16029 vs. 16051) and BIC (16061 vs. 16072), along with a higher log-likelihood (-8008.6 vs. -8021.4), indicate an improvement in model performance when allowing for random slopes. Additionally, the Chi-square test statistic (25.624, $df = 2$, $p\text{-value} = 2.728e-06$) confirms that including random slopes significantly enhances the model fit. The highly significant $p\text{-value}$ ($2.728e-06$) suggests that the relationship between government R&D expenditure and high-tech exports varies across countries. Some nations experience a strong positive effect, while others may see weaker or differing impacts. Given this variation, the random slope model is preferred as it captures country-specific differences in how R&D investment translates into high-tech exports. This finding highlights the need to investigate which factors contribute to the differences in slopes among countries, as understanding these variations can provide valuable insights into the conditions under which government R&D spending leads to higher high-tech exports.

```
facttable_wide
```

```
# A tibble: 5,852 x 35
  `Country Code` year IC.BUS.DISC.XQ IC.CRD.INFO.XQ FS.AST.PRVT.GD.ZS
  <chr>          <chr>      <dbl>          <dbl>          <dbl>
1 AFE            2000         NA              NA             75.0
2 AFE            2001         NA              NA             77.0
3 AFE            2002         NA              NA             62.4
4 AFE            2003         NA              NA             71.3
5 AFE            2004         NA              NA             80.3
6 AFE            2005         3.73           NA             85.8
7 AFE            2006         3.73           NA             95.0
8 AFE            2007         3.73           NA             94.0
9 AFE            2008         3.69           NA             78.9
10 AFE           2009         3.88           NA             79.3
# i 5,842 more rows
# i 30 more variables: EG.USE.ELEC.KH.PC <dbl>, EG.IMP.CON.S.ZS <dbl>,
# GC.XPN.TOTL.GD.ZS <dbl>, IT.NET.BBND.P2 <dbl>, IT.MLT.MAIN.P2 <dbl>,
# NY.GDP.MKTP.KD.ZG <dbl>, SI.POV.GINI <dbl>, SE.XPD.TOTL.GD.ZS <dbl>,
# TX.VAL.TECH.MF.ZS <dbl>, FP.CPI.TOTL.ZG <dbl>, FR.INR.LNDP <dbl>,
# SL.TLF.CACT.FE.ZS <dbl>, SL.TLF.CACT.MA.ZS <dbl>, LP.LPI.OVRL.XQ <dbl>,
# CM.MKT.LCAP.GD.ZS <dbl>, MS.MIL.XPND.GD.ZS <dbl>, IT.CEL.SETS.P2 <dbl>, ...
```

```
colnames(facttable_wide)[colnames(facttable_wide) == "Country Code"] <- "Country"
```

```
lmm_extended <- lmer(SL.UEM.TOTL.FE.ZS ~
  SE.XPD.TOTL.GD.ZS * (NY.GDP.MKTP.KD.ZG + GC.TAX.TOTL.GD.ZS +
    IT.NET.BBND.P2 + SL.TLF.CACT.FE.ZS +
    FP.CPI.TOTL.ZG) +
  (SE.XPD.TOTL.GD.ZS | Country),
  data = facttable_wide, REML = FALSE)
summary(lmm_extended)
```

Linear mixed model fit by maximum likelihood ['lmerMod']

Formula: SL.UEM.TOTL.FE.ZS ~ SE.XPD.TOTL.GD.ZS * (NY.GDP.MKTP.KD.ZG +
GC.TAX.TOTL.GD.ZS + IT.NET.BBND.P2 + SL.TLF.CACT.FE.ZS +
FP.CPI.TOTL.ZG) + (SE.XPD.TOTL.GD.ZS | Country)

Data: facttable_wide

AIC	BIC	logLik	deviance	df.resid
9233.6	9323.7	-4600.8	9201.6	2049

Scaled residuals:

Min	1Q	Median	3Q	Max
-5.6702	-0.3455	-0.0189	0.3334	5.4404

Random effects:

Groups	Name	Variance	Std.Dev.	Corr
Country	(Intercept)	91.041	9.542	
	SE.XPD.TOTL.GD.ZS	2.827	1.681	-0.83
Residual		3.173	1.781	

Number of obs: 2065, groups: Country, 166

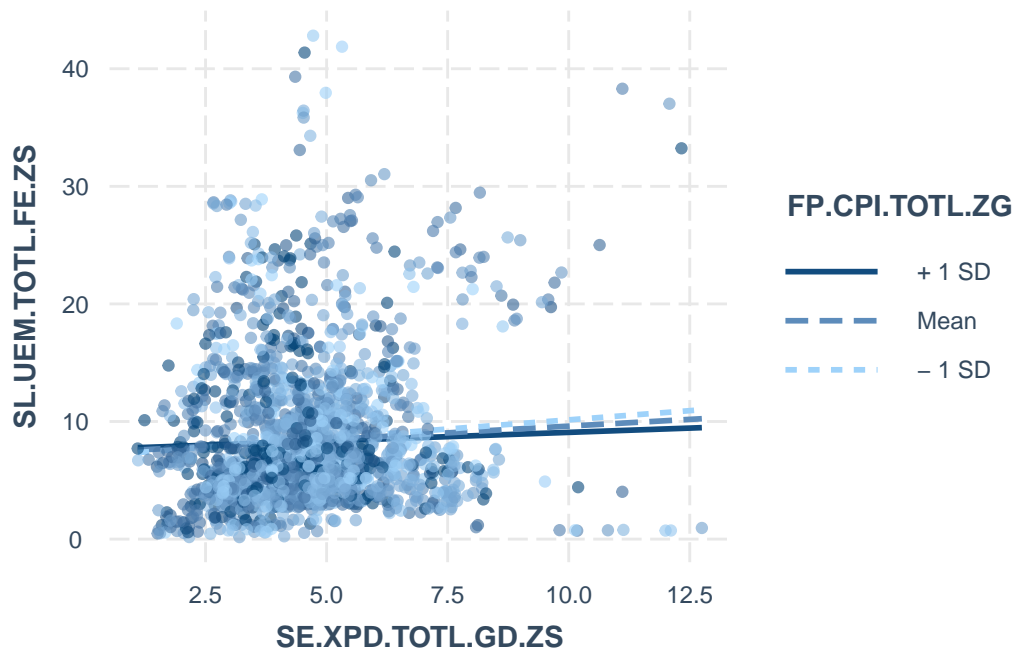
Fixed effects:

	Estimate	Std. Error	t value
(Intercept)	15.521796	2.560609	6.062
SE.XPD.TOTL.GD.ZS	-0.173632	0.531620	-0.327
NY.GDP.MKTP.KD.ZG	-0.074994	0.036103	-2.077
GC.TAX.TOTL.GD.ZS	0.001999	0.037852	0.053
IT.NET.BBND.P2	-0.105793	0.024976	-4.236
SL.TLF.CACT.FE.ZS	-0.134742	0.045894	-2.936
FP.CPI.TOTL.ZG	0.066051	0.043791	1.508
SE.XPD.TOTL.GD.ZS:NY.GDP.MKTP.KD.ZG	0.001565	0.007388	0.212
SE.XPD.TOTL.GD.ZS:GC.TAX.TOTL.GD.ZS	-0.002328	0.005359	-0.434
SE.XPD.TOTL.GD.ZS:IT.NET.BBND.P2	0.018512	0.004769	3.882
SE.XPD.TOTL.GD.ZS:SL.TLF.CACT.FE.ZS	0.005873	0.009570	0.614
SE.XPD.TOTL.GD.ZS:FP.CPI.TOTL.ZG	-0.018367	0.009300	-1.975

Correlation of Fixed Effects:

	(Intr)	SE.XPD.TOTL.GD.ZS	NY.GDP	GC.TAX	IT.NET	SL.TLF	FP.CPI
SE.XPD.TOTL.GD.ZS	-0.912						
NY.GDP.MKTP	-0.032	0.043					
GC.TAX.TOTL	-0.109	0.031	-0.064				
IT.NET.BBND	0.038	0.012	0.229	-0.159			
SL.TLF.CACT	-0.903	0.845	-0.037	-0.111	-0.126		
FP.CPI.TOTL	-0.018	0.026	0.037	-0.111	0.212	-0.059	
SE.XPD.TOTL.GD.ZS:N	0.021	-0.024	-0.934	0.049	-0.182	0.033	-0.021
SE.XPD.TOTL.GD.ZS:G	0.108	-0.049	0.081	-0.957	0.152	0.100	0.167
SE.XPD.TOTL.GD.ZS:I	-0.033	-0.001	-0.215	0.163	-0.967	0.113	-0.200
SE.XPD.TOTL.GD.ZS:S	0.835	-0.928	0.021	0.104	0.071	-0.915	0.043
SE.XPD.TOTL.GD.ZS:F	0.010	-0.015	-0.029	0.116	-0.176	0.054	-0.954
	SE.XPD.TOTL.GD.ZS:N	SE.XPD.TOTL.GD.ZS:G	SE.XPD.TOTL.GD.ZS:I				
SE.XPD.TOTL.GD.ZS							
NY.GDP.MKTP							
GC.TAX.TOTL							
IT.NET.BBND							
SL.TLF.CACT							
FP.CPI.TOTL							
SE.XPD.TOTL.GD.ZS:N							
SE.XPD.TOTL.GD.ZS:G	-0.075						
SE.XPD.TOTL.GD.ZS:I	0.189	-0.157					
SE.XPD.TOTL.GD.ZS:S	-0.031	-0.091	-0.084				
SE.XPD.TOTL.GD.ZS:F	0.018	-0.185	0.179				
	SE.XPD.TOTL.GD.ZS:S						
SE.XPD.TOTL.GD.ZS							
NY.GDP.MKTP							
GC.TAX.TOTL							
IT.NET.BBND							
SL.TLF.CACT							
FP.CPI.TOTL							
SE.XPD.TOTL.GD.ZS:N							
SE.XPD.TOTL.GD.ZS:G							
SE.XPD.TOTL.GD.ZS:I							
SE.XPD.TOTL.GD.ZS:S							
SE.XPD.TOTL.GD.ZS:F	-0.048						

```
library(interactions)
interact_plot(lmm_extended, pred = "SE.XPD.TOTL.GD.ZS", modx = "FP.CPI.TOTL.ZG", plot.points
```



```
lmm_extended <- lmer(SL.UEM.TOTL.FE.ZS ~
  SE.XPD.TOTL.GD.ZS * (GC.TAX.TOTL.GD.ZS +
    IT.NET.BBND.P2 + SL.TLF.CACT.FE.ZS +
    FP.CPI.TOTL.ZG + CM.MKT.LCAP.GD.ZS + EN.URB.LCTY.UR.ZS
    (SE.XPD.TOTL.GD.ZS | Country),
  data = facttable_wide, REML = FALSE)
vcov(summary(lmm_extended))
```

20 x 20 Matrix of class "dpoMatrix"

	(Intercept)	SE.XPD.TOTL.GD.ZS
(Intercept)	29.0456513083	-5.663393e+00
SE.XPD.TOTL.GD.ZS	-5.6633929623	1.361430e+00
GC.TAX.TOTL.GD.ZS	-0.4300525985	7.236583e-02
IT.NET.BBND.P2	-0.0099989125	5.284903e-05
SL.TLF.CACT.FE.ZS	-0.3168998432	6.470781e-02
FP.CPI.TOTL.ZG	-0.0318093390	8.623082e-03
CM.MKT.LCAP.GD.ZS	-0.0082385916	2.123997e-03
EN.URB.LCTY.UR.ZS	-0.1156278306	2.617550e-02
FR.INR.LNDP	-0.1014401840	1.735712e-02
FS.AST.PRVT.GD.ZS	-0.0212938185	3.681170e-03
TX.VAL.TECH.MF.ZS	0.0013710979	-4.261075e-04
SE.XPD.TOTL.GD.ZS:GC.TAX.TOTL.GD.ZS	0.0909001044	-1.697409e-02

SE.XPD.TOTL.GD.ZS:IT.NET.BBND.P2	-0.0002656525	8.782054e-04
SE.XPD.TOTL.GD.ZS:SL.TLF.CACT.FE.ZS	0.0610888519	-1.539886e-02
SE.XPD.TOTL.GD.ZS:FP.CPI.TOTL.ZG	0.0046606367	-1.373043e-03
SE.XPD.TOTL.GD.ZS:CM.MKT.LCAP.GD.ZS	0.0018727654	-5.121141e-04
SE.XPD.TOTL.GD.ZS:EN.URB.LCTY.UR.ZS	0.0190738294	-6.566941e-03
SE.XPD.TOTL.GD.ZS:FR.INR.LNDP	0.0182572415	-3.770824e-03
SE.XPD.TOTL.GD.ZS:FS.AST.PRVT.GD.ZS	0.0043950367	-1.031353e-03
SE.XPD.TOTL.GD.ZS:TX.VAL.TECH.MF.ZS	-0.0004649832	1.466696e-04
GC.TAX.TOTL.GD.ZS	IT.NET.BBND.P2	
(Intercept)	-4.300526e-01	-9.998912e-03
SE.XPD.TOTL.GD.ZS	7.236583e-02	5.284903e-05
GC.TAX.TOTL.GD.ZS	4.659433e-02	1.208687e-03
IT.NET.BBND.P2	1.208687e-03	1.010349e-02
SL.TLF.CACT.FE.ZS	-2.156038e-03	-6.345402e-04
FP.CPI.TOTL.ZG	-3.614979e-03	1.442971e-03
CM.MKT.LCAP.GD.ZS	-3.412959e-04	4.518147e-04
EN.URB.LCTY.UR.ZS	-5.223386e-03	5.957238e-04
FR.INR.LNDP	4.548109e-04	6.462954e-04
FS.AST.PRVT.GD.ZS	2.013607e-05	-1.961975e-03
TX.VAL.TECH.MF.ZS	4.270031e-04	2.955938e-04
SE.XPD.TOTL.GD.ZS:GC.TAX.TOTL.GD.ZS	-9.263138e-03	-1.699131e-04
SE.XPD.TOTL.GD.ZS:IT.NET.BBND.P2	-2.420291e-04	-2.211741e-03
SE.XPD.TOTL.GD.ZS:SL.TLF.CACT.FE.ZS	5.138887e-04	2.447609e-04
SE.XPD.TOTL.GD.ZS:FP.CPI.TOTL.ZG	7.335390e-04	-2.371714e-04
SE.XPD.TOTL.GD.ZS:CM.MKT.LCAP.GD.ZS	7.705506e-05	-9.737425e-05
SE.XPD.TOTL.GD.ZS:EN.URB.LCTY.UR.ZS	1.486640e-03	-2.086599e-04
SE.XPD.TOTL.GD.ZS:FR.INR.LNDP	-1.191406e-05	-1.629705e-04
SE.XPD.TOTL.GD.ZS:FS.AST.PRVT.GD.ZS	2.539795e-05	4.081160e-04
SE.XPD.TOTL.GD.ZS:TX.VAL.TECH.MF.ZS	-1.472019e-04	-1.031269e-04
SL.TLF.CACT.FE.ZS	FP.CPI.TOTL.ZG	
(Intercept)	-3.168998e-01	-3.180934e-02
SE.XPD.TOTL.GD.ZS	6.470781e-02	8.623082e-03
GC.TAX.TOTL.GD.ZS	-2.156038e-03	-3.614979e-03
IT.NET.BBND.P2	-6.345402e-04	1.442971e-03
SL.TLF.CACT.FE.ZS	8.503927e-03	6.074316e-04
FP.CPI.TOTL.ZG	6.074316e-04	9.077201e-03
CM.MKT.LCAP.GD.ZS	2.964555e-06	1.867468e-04
EN.URB.LCTY.UR.ZS	-5.491358e-05	9.550447e-04
FR.INR.LNDP	-3.236148e-03	-5.619412e-03
FS.AST.PRVT.GD.ZS	-4.358620e-04	-4.325959e-05
TX.VAL.TECH.MF.ZS	-1.606067e-04	-2.183757e-04
SE.XPD.TOTL.GD.ZS:GC.TAX.TOTL.GD.ZS	2.685663e-04	6.538665e-04
SE.XPD.TOTL.GD.ZS:IT.NET.BBND.P2	1.670399e-04	-2.759712e-04

SE.XPD.TOTL.GD.ZS:SL.TLF.CACT.FE.ZS	-1.726558e-03	-9.810351e-05
SE.XPD.TOTL.GD.ZS:FP.CPI.TOTL.ZG	-1.045652e-04	-1.776453e-03
SE.XPD.TOTL.GD.ZS:CM.MKT.LCAP.GD.ZS	-7.595806e-06	-3.539300e-05
SE.XPD.TOTL.GD.ZS:EN.URB.LCTY.UR.ZS	2.433367e-05	-2.949710e-04
SE.XPD.TOTL.GD.ZS:FR.INR.LNDP	5.561852e-04	9.093525e-04
SE.XPD.TOTL.GD.ZS:FS.AST.PRVT.GD.ZS	1.157399e-04	7.131008e-06
SE.XPD.TOTL.GD.ZS:TX.VAL.TECH.MF.ZS	5.544561e-05	7.543408e-05
	CM.MKT.LCAP.GD.ZS	EN.URB.LCTY.UR.ZS
(Intercept)	-8.238592e-03	-1.156278e-01
SE.XPD.TOTL.GD.ZS	2.123997e-03	2.617550e-02
GC.TAX.TOTL.GD.ZS	-3.412959e-04	-5.223386e-03
IT.NET.BBND.P2	4.518147e-04	5.957238e-04
SL.TLF.CACT.FE.ZS	2.964555e-06	-5.491358e-05
FP.CPI.TOTL.ZG	1.867468e-04	9.550447e-04
CM.MKT.LCAP.GD.ZS	2.169823e-04	1.650950e-04
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FS.AST.PRVT.GD.ZS	-1.493061e-04	-4.354599e-05
TX.VAL.TECH.MF.ZS	-6.447449e-06	-1.341548e-04
SE.XPD.TOTL.GD.ZS:GC.TAX.TOTL.GD.ZS	8.263375e-05	1.074286e-03
SE.XPD.TOTL.GD.ZS:IT.NET.BBND.P2	-9.225914e-05	-8.660392e-05
SE.XPD.TOTL.GD.ZS:SL.TLF.CACT.FE.ZS	1.100979e-06	-2.151812e-05
SE.XPD.TOTL.GD.ZS:FP.CPI.TOTL.ZG	-3.317171e-05	-1.577820e-04
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SE.XPD.TOTL.GD.ZS:FR.INR.LNDP	-2.237493e-05	-6.517266e-06
SE.XPD.TOTL.GD.ZS:FS.AST.PRVT.GD.ZS	3.150264e-05	-1.125534e-05
SE.XPD.TOTL.GD.ZS:TX.VAL.TECH.MF.ZS	2.211641e-06	4.600948e-05
	FR.INR.LNDP	FS.AST.PRVT.GD.ZS
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GC.TAX.TOTL.GD.ZS	4.548109e-04	2.013607e-05
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SE.XPD.TOTL.GD.ZS:GC.TAX.TOTL.GD.ZS	-8.656346e-06	9.549397e-06
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SE.XPD.TOTL.GD.ZS:SL.TLF.CACT.FE.ZS	6.062875e-04	1.038448e-04

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	TX.VAL.TECH.MF.ZS	
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GC.TAX.TOTL.GD.ZS	4.270031e-04	
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SL.TLF.CACT.FE.ZS	-1.606067e-04	
FP.CPI.TOTL.ZG	-2.183757e-04	
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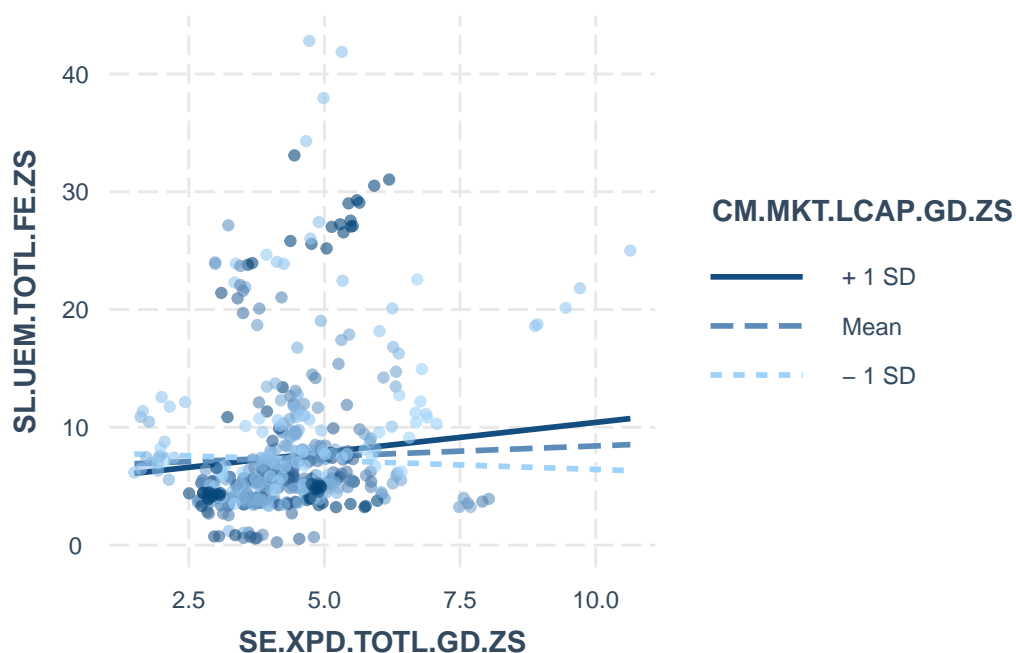
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SE.XPD.TOTL.GD.ZS:CM.MKT.LCAP.GD.ZS	-5.616679e-07
SE.XPD.TOTL.GD.ZS:EN.URB.LCTY.UR.ZS	-1.586987e-05
SE.XPD.TOTL.GD.ZS:FR.INR.LNDP	-1.044186e-05
SE.XPD.TOTL.GD.ZS:FS.AST.PRVT.GD.ZS	-8.548778e-06

SE.XPD.TOTL.GD.ZS:TX.VAL.TECH.MF.ZS

5.741865e-05

```
library(interactions)
interact_plot(lmm_extended, pred = "SE.XPD.TOTL.GD.ZS", modx = "CM.MKT.LCAP.GD.ZS", plot.pois
```



```
anova(lmm_extended)
```

Analysis of Variance Table

	npars	Sum Sq	Mean Sq	F value
SE.XPD.TOTL.GD.ZS	1	4.044	4.044	2.0081
GC.TAX.TOTL.GD.ZS	1	17.095	17.095	8.4883
IT.NET.BBND.P2	1	2.134	2.134	1.0595
SL.TLF.CACT.FE.ZS	1	85.366	85.366	42.3860
FP.CPI.TOTL.ZG	1	5.655	5.655	2.8077
CM.MKT.LCAP.GD.ZS	1	2.266	2.266	1.1250
EN.URB.LCTY.UR.ZS	1	0.639	0.639	0.3174
FR.INR.LNDP	1	1.152	1.152	0.5720
FS.AST.PRVT.GD.ZS	1	0.852	0.852	0.4231
TX.VAL.TECH.MF.ZS	1	0.760	0.760	0.3774
SE.XPD.TOTL.GD.ZS:GC.TAX.TOTL.GD.ZS	1	12.664	12.664	6.2878
SE.XPD.TOTL.GD.ZS:IT.NET.BBND.P2	1	28.567	28.567	14.1843
SE.XPD.TOTL.GD.ZS:SL.TLF.CACT.FE.ZS	1	0.273	0.273	0.1355

SE.XPD.TOTL.GD.ZS:FP.CPI.TOTL.ZG	1	0.238	0.238	0.1179
SE.XPD.TOTL.GD.ZS:CM.MKT.LCAP.GD.ZS	1	4.321	4.321	2.1455
SE.XPD.TOTL.GD.ZS:EN.URB.LCTY.UR.ZS	1	0.273	0.273	0.1355
SE.XPD.TOTL.GD.ZS:FR.INR.LNDP	1	0.257	0.257	0.1278
SE.XPD.TOTL.GD.ZS:FS.AST.PRVT.GD.ZS	1	3.040	3.040	1.5093
SE.XPD.TOTL.GD.ZS:TX.VAL.TECH.MF.ZS	1	3.924	3.924	1.9481

```
library(car)
```

Loading required package: carData

Attaching package: 'car'

The following object is masked from 'package:dplyr':

recode

The following object is masked from 'package:purrr':

some

```
Anova(lmm_extended, type = "III")
```

Analysis of Deviance Table (Type III Wald chisquare tests)

Response: SL.UEM.TOTL.FE.ZS

	Chisq	Df	Pr(>Chisq)
(Intercept)	20.3530	1	6.439e-06 ***
SE.XPD.TOTL.GD.ZS	3.2420	1	0.0717709 .
GC.TAX.TOTL.GD.ZS	1.0094	1	0.3150499
IT.NET.BBND.P2	12.6478	1	0.0003760 ***
SL.TLF.CACT.FE.ZS	7.1157	1	0.0076411 **
FP.CPI.TOTL.ZG	1.2559	1	0.2624320
CM.MKT.LCAP.GD.ZS	2.8586	1	0.0908838 .
EN.URB.LCTY.UR.ZS	0.0030	1	0.9560429
FR.INR.LNDP	0.0527	1	0.8184300
FS.AST.PRVT.GD.ZS	1.7866	1	0.1813419
TX.VAL.TECH.MF.ZS	2.0156	1	0.1556859
SE.XPD.TOTL.GD.ZS:GC.TAX.TOTL.GD.ZS	4.6107	1	0.0317727 *

SE.XPD.TOTL.GD.ZS:IT.NET.BBND.P2	12.8833	1	0.0003315	***
SE.XPD.TOTL.GD.ZS:SL.TLF.CACT.FE.ZS	0.0051	1	0.9432279	
SE.XPD.TOTL.GD.ZS:FP.CPI.TOTL.ZG	0.3684	1	0.5438640	
SE.XPD.TOTL.GD.ZS:CM.MKT.LCAP.GD.ZS	3.5822	1	0.0584008	.
SE.XPD.TOTL.GD.ZS:EN.URB.LCTY.UR.ZS	0.2407	1	0.6237260	
SE.XPD.TOTL.GD.ZS:FR.INR.LNDP	0.0570	1	0.8112273	
SE.XPD.TOTL.GD.ZS:FS.AST.PRVT.GD.ZS	0.9818	1	0.3217470	
SE.XPD.TOTL.GD.ZS:TX.VAL.TECH.MF.ZS	1.9481	1	0.1627887	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1