Tutorial 7: Dummy Variables and Interactions (II)

Jan Vogler (jan.vogler@duke.edu)

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Today's Agenda

1. Interaction terms with two interval-level variables
2. Graphical representation of interactions
3. Analysis of Variance (ANOVA)
4. Expectations for research proposal

1. Interaction terms with two interval-level variables

In today's session we will build upon the last lab and continue to work on interaction effects.

Last time we looked at interactions between a continuous and a binary variable. This time both our variables will be continuous.

For this purpose we will again refer to the dataset by Milner and Kubota.

Let us try to test a hypothesis that combines claims from modernization theory and the literature on FDI.

Modernization theory claims that as countries develop economically, societies become more complex and people more educated which leads to a process of democratization. The literature on FDI claims that FDI is one of the key drivers of economic development and can speed up this process by allowing for technology transfers from other countries. Therefore, one might think that there is a positive interaction of GDP and FDI inflows.

Let us test this hypothesis through an regression model with an interaction term.

```
# First: load the data
setwd('C:/Users/Jan/OneDrive/Documents/GitHub/ps630_lab/W7')
library(foreign)
LDC=read.dta("LDC_IO_replication.dta")
summary(LDC)
```

```
##     country       ctylabel             date        gatt_wto_new
##  Min.   :186.0   Length:5370       Min.   :1970   Min.   :0.0000
##  1st Qu.:423.0   Class :character  1st Qu.:1977   1st Qu.:0.0000
##  Median :628.0   Mode  :character  Median :1984   Median :0.0000
##  Mean   :605.9                     Mean   :1984   Mean   :0.4747
##  3rd Qu.:816.0                     3rd Qu.:1992   3rd Qu.:1.0000
##  Max.   :968.0                     Max.   :1999   Max.   :1.0000
##                                                   NA's   :698
##     aclpn            bpc1         dopen_wacz2        ecris2
##  Min.   :0.0000   Min.   :0.000   Min.   :0.0000   Min.   :0.0000
##  1st Qu.:0.0000   1st Qu.:0.000   1st Qu.:0.0000   1st Qu.:0.0000
##  Median :0.0000   Median :1.000   Median :0.0000   Median :0.0000
##  Mean   :0.3002   Mean   :0.591   Mean   :0.3097   Mean   :0.0641
##  3rd Qu.:1.0000   3rd Qu.:1.000   3rd Qu.:1.0000   3rd Qu.:0.0000
```

```
## Max.   :1.0000   Max.   :1.000   Max.   :1.0000   Max.   :1.0000
## NA's   :1183     NA's   :2734    NA's   :2580     NA's   :1967
##     fdignp           gdp_pc_95d        l1aclpn          l1bpc1
## Min.   :-27.2356  Min.   :    0.0  Min.   :0.0000   Min.   :0.0000
## 1st Qu.:  0.0361  1st Qu.:  442.9  1st Qu.:0.0000   1st Qu.:0.0000
## Median :  0.6644  Median : 1266.5  Median :0.0000   Median :1.0000
## Mean   :  1.8962  Mean   : 2885.5  Mean   :0.2924   Mean   :0.5909
## 3rd Qu.:  2.0829  3rd Qu.: 3002.4  3rd Qu.:1.0000   3rd Qu.:1.0000
## Max.   :184.5647  Max.   :44164.5  Max.   :1.0000   Max.   :1.0000
## NA's   :2294      NA's   :1679     NA's   :1341     NA's   :2735
##    l1ecris2          newtar        polityiv_update2    signed
## Min.   :0.0000   Min.   :  0.00   Min.   :-10.000   Min.   :0.0000
## 1st Qu.:0.0000   1st Qu.: 10.95   1st Qu.: -7.000   1st Qu.:0.0000
## Median :0.0000   Median : 17.00   Median : -6.000   Median :0.0000
## Mean   :0.0641   Mean   : 20.54   Mean   : -2.074   Mean   :0.1465
## 3rd Qu.:0.0000   3rd Qu.: 27.00   3rd Qu.:  6.000   3rd Qu.:0.0000
## Max.   :1.0000   Max.   :102.20   Max.   : 10.000   Max.   :1.0000
## NA's   :1967     NA's   :4463     NA's   :2003      NA's   :1362
##    yrsoffic          usheg           l1usheg          l1fiveop
## Min.   : 0.000   Min.   :0.2434   Min.   :0.2434   Min.   :10.20
## 1st Qu.: 2.000   1st Qu.:0.2574   1st Qu.:0.2574   1st Qu.:10.90
## Median : 5.000   Median :0.2663   Median :0.2655   Median :12.35
## Mean   : 8.431   Mean   :0.2696   Mean   :0.2683   Mean   :12.03
## 3rd Qu.:12.000   3rd Qu.:0.2785   3rd Qu.:0.2784   3rd Qu.:12.72
## Max.   :44.000   Max.   :0.3083   Max.   :0.2988   Max.   :13.20
## NA's   :2361                      NA's   :179      NA's   :358
##    l1gdp_pc          avsw           avnewtar          l1avsw
## Min.   :    0   Min.   :0.1398   Min.   : 0.00    Min.   :0.1398
## 1st Qu.:  442   1st Qu.:0.1505   1st Qu.: 0.00    1st Qu.:0.1505
## Median : 1266   Median :0.1720   Median :17.43    Median :0.1613
## Mean   : 2888   Mean   :0.3097   Mean   :14.91    Mean   :0.2974
## 3rd Qu.: 2999   3rd Qu.:0.5269   3rd Qu.:24.37    3rd Qu.:0.5054
## Max.   :44165   Max.   :0.6667   Max.   :30.52    Max.   :0.6559
## NA's   :1823                                      NA's   :179
##   l1avnewtar         lnpop           l1lnpop          l1office
## Min.   : 0.00    Min.   :10.57    Min.   :10.62    Min.   : 0.000
## 1st Qu.: 0.00    1st Qu.:13.86    1st Qu.:13.86    1st Qu.: 2.000
## Median :18.73    Median :15.32    Median :15.31    Median : 5.000
## Mean   :15.01    Mean   :15.11    Mean   :15.10    Mean   : 8.431
## 3rd Qu.:24.37    3rd Qu.:16.40    3rd Qu.:16.39    3rd Qu.:12.000
## Max.   :30.52    Max.   :20.95    Max.   :20.94    Max.   :44.000
## NA's   :179      NA's   :490      NA's   :661      NA's   :2361
## l1partyage2000       l1fdi          l1polity         l2polity
## Min.   :  0.00   Min.   :-27.2356  Min.   :-10.000  Min.   :-10.00
## 1st Qu.: 10.00   1st Qu.:  0.0269  1st Qu.: -7.000  1st Qu.: -7.00
## Median : 19.50   Median :  0.6382  Median : -6.000  Median : -7.00
## Mean   : 24.18   Mean   :  1.7931  Mean   : -2.215  Mean   : -2.36
## 3rd Qu.: 32.00   3rd Qu.:  1.9904  3rd Qu.:  6.000  3rd Qu.:  5.00
## Max.   :183.00   Max.   :184.5647  Max.   : 10.000  Max.   : 10.00
## NA's   :3284     NA's   :2423      NA's   :2124     NA's   :2246
##    l3polity         l1signed         milit2            sp2
## Min.   :-10.000  Min.   :0.0000   Min.   :0.0000   Min.   :0.0000
## 1st Qu.: -7.000  1st Qu.:0.0000   1st Qu.:0.0000   1st Qu.:0.0000
## Median : -7.000  Median :0.0000   Median :0.0000   Median :0.0000
```

2

```
##   Mean   : -2.512   Mean   :0.1511   Mean   :0.1119   Mean   :0.1959
##   3rd Qu.:  5.000   3rd Qu.:0.0000   3rd Qu.:0.0000   3rd Qu.:0.0000
##   Max.   : 10.000   Max.   :1.0000   Max.   :1.0000   Max.   :1.0000
##   NA's   :2371      NA's   :1517
##      pers2           l1milit2          l1sp2           dictator1
##   Min.   :0.0000   Min.   :0.0000   Min.   :0.0000   Min.   :1.000
##   1st Qu.:0.0000   1st Qu.:0.0000   1st Qu.:0.0000   1st Qu.:2.000
##   Median :0.0000   Median :0.0000   Median :0.0000   Median :5.000
##   Mean   :0.1665   Mean   :0.1135   Mean   :0.1986   Mean   :4.737
##   3rd Qu.:0.0000   3rd Qu.:0.0000   3rd Qu.:0.0000   3rd Qu.:8.000
##   Max.   :1.0000   Max.   :1.0000   Max.   :1.0000   Max.   :8.000
##                    NA's   :179      NA's   :179      NA's   :1157
##   l1dictator1         yr70             yr80            l1ssch
##   Min.   :1.000   Min.   :0.0000   Min.   :0.0000   Min.   :0.0140
##   1st Qu.:2.000   1st Qu.:0.0000   1st Qu.:0.0000   1st Qu.:0.4562
##   Median :5.000   Median :0.0000   Median :0.0000   Median :0.8519
##   Mean   :4.708   Mean   :0.3333   Mean   :0.3333   Mean   :1.0411
##   3rd Qu.:8.000   3rd Qu.:1.0000   3rd Qu.:1.0000   3rd Qu.:1.4652
##   Max.   :8.000   Max.   :1.0000   Max.   :1.0000   Max.   :4.4422
##   NA's   :1315                                      NA's   :3140
##     closedyr          _spline1         _spline2          _spline3
##   Min.   : 0.000   Min.   :-24389   Min.   :-7854.0   Min.   :-9030.0
##   1st Qu.: 0.000   1st Qu.: -3375   1st Qu.:-2048.3   1st Qu.:-1629.3
##   Median : 7.000   Median :  -343   Median : -260.2   Median : -165.6
##   Mean   : 8.691   Mean   : -3075   Mean   :-1388.8   Mean   :-1340.9
##   3rd Qu.:15.000   3rd Qu.:     0   3rd Qu.:    0.0   3rd Qu.:    0.0
##   Max.   :29.000   Max.   :     0   Max.   :    0.0   Max.   :    0.0
##   NA's   :2580     NA's   :2580     NA's   :2580      NA's   :2580
##   l1gatt_wto_new
##   Min.   :0.000
##   1st Qu.:0.000
##   Median :0.000
##   Mean   :0.468
##   3rd Qu.:1.000
##   Max.   :1.000
##   NA's   :868
```

```r
# Second: estimate the model
intmodel=lm(polityiv_update2~l1gdp_pc+l1fdi+l1gdp_pc*l1fdi, data=LDC)
summary(intmodel)
```

```
##
## Call:
## lm(formula = polityiv_update2 ~ l1gdp_pc + l1fdi + l1gdp_pc *
##     l1fdi, data = LDC)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -21.687  -4.959  -2.689   7.206  12.278
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)  -2.724e+00  1.951e-01 -13.957  < 2e-16 ***
## l1gdp_pc      1.006e-03  1.042e-04   9.653  < 2e-16 ***
```

```
## l1fdi           -5.063e-02  3.696e-02  -1.370    0.171
## l1gdp_pc:l1fdi  1.726e-04  3.475e-05   4.967 7.28e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 6.755 on 2372 degrees of freedom
##   (2994 observations deleted due to missingness)
## Multiple R-squared:  0.08849,    Adjusted R-squared:  0.08734
## F-statistic: 76.76 on 3 and 2372 DF,  p-value: < 2.2e-16
```

2. Graphical representation of interactions

In-class exercise: interaction terms with two interval-level variables

Assume that you have the following linear model

$Y = 10 + 5 * X1 + (2) * X2 + (1) * X1 * X2 + \text{epsilon}$

1. Calculate the derivative of Y with respect to X1 and X2.
2. Use R to plot the marginal effect of X1 at different levels of X2. Assume that X2 is an integer that varies between -10 and 10.

Hint: To plot this in R you need to create a vector with values for X2 for your x-axis and a vector with the respective marginal effect of X1 on your y-axis.

3. Analysis of Variance (ANOVA)

4. Expectations for research proposal

1. What is your area of interest?
2. What is your theory?
3. How can you turn this theory into a testable hypothesis?
4. Which data is out there that would allow you to test your hypothesis?

Have a great fall break!