Appendix F - Production Run Analysis for W241 Project

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1. Setup

```
knitr::opts_chunk$set(comment = NA)
library(data.table)
library(stargazer)
library(dplyr)
library(lmtest)
library(sandwich)
```

2. Analysis of Difference-in-Difference

```
din <- fread('./Data/Post Experiment Results.csv', header = TRUE)
head(din)
```

```
         Participant Email Study Phase Test Description Treatment
1: vinceluskinsr@gmail.com  experiment            Music         1
2:      jennel79@gmail.com  experiment           Gaming         0
3:  m.brindley79@gmail.com  experiment          Reading         2
4:       c1cs1@stjohns.edu  experiment           Gaming         0
5:     c19bb18@stjohns.edu  experiment           Gaming         0
6:     c19bb20@stjohns.edu  experiment           Gaming         0
   Pre Score Treatment Outcome (Participated = 1, DNP = 0) Post Score
1:        17                                             1         15
2:        22                                             1         38
3:        25                                             0         35
4:         9                                             0          0
5:        10                                             1          8
6:        12                                             1         13
   Total Time Spent in PreTest (seconds)
1:                                   602
2:                                   602
3:                                   602
4:                                   262
5:                                   603
6:                                   525
   Total Time Spent in Treatment (seconds)
1:                                    1802
2:                                    1828
3:                                     694
4:                                     164
```

```
5:                                    1802
6:                                    1803
   Total Time Spent in Post Test (seconds)  Time of Day Test Taken
1:                                     603 Wed 4th Dec 2019 2:18pm
2:                                     602 Thu 5th Dec 2019 5:45pm
3:                                     602 Thu 5th Dec 2019 5:52am
4:                                      79 Sat 7th Dec 2019 1:27am
5:                                     183 Sun 8th Dec 2019 7:57pm
6:                                     415 Sun 8th Dec 2019 7:57pm
               DTG       Local DTG Time of Day Cat          Location
1: 12/4/19 2:18 PM 12/4/19 2:18 PM       Afternoon                PA
2: 12/5/19 5:45 PM 12/5/19 5:45 PM         Evening                PA
3: 12/5/19 5:52 AM 12/5/19 5:52 AM         Morning                NH
4: 12/7/19 1:27 AM 12/7/19 2:57 PM       Afternoon Vijayawada, India
5: 12/8/19 7:57 PM 12/9/19 9:27 AM         Morning Vijayawada, India
6: 12/8/19 7:57 PM 12/9/19 9:27 AM         Morning Vijayawada, India
   Gender Grade (or Age) Score_diff
1:   Male             58         -2
2: Female             40         16
3: Female             39         10
4:   #N/A             NA         -9
5:   Male              9         -2
6:   Male              9          1
```

```
d <- din[which(din$`Study Phase` == 'experiment' & din$`Treatment Outcome (Participated = 1, DNP = 0)` =
d <- d[, Treated := as.numeric(`Test Description` == "Gaming")]
d <- d[, Higher_grade := as.numeric(`Grade (or Age)` == 10)]
head(d)
```

```
     Participant Email Study Phase Test Description Treatment Pre Score
1: c19bb18@stjohns.edu  experiment           Gaming         0        10
2: c19bb20@stjohns.edu  experiment           Gaming         0        12
3:  c19bb6@stjohns.edu  experiment           Gaming         0        11
4: c19bb10@stjohns.edu  experiment           Gaming         0        13
5:  c19bb4@stjohns.com  experiment           Gaming         0         8
6:  c19bb1@stjohns.edu  experiment           Gaming         0         5
   Treatment Outcome (Participated = 1, DNP = 0) Post Score
1:                                             1          8
2:                                             1         13
3:                                             1         25
4:                                             1         25
5:                                             1         17
6:                                             1         16
   Total Time Spent in PreTest (seconds)
1:                                   603
2:                                   525
3:                                   602
4:                                   602
5:                                   602
6:                                   603
   Total Time Spent in Treatment (seconds)
1:                                    1802
2:                                    1803
3:                                    1801
```

```
4:                                    1802
5:                                    1803
6:                                    1801
   Total Time Spent in Post Test (seconds)  Time of Day Test Taken
1:                                     183 Sun 8th Dec 2019 7:57pm
2:                                     415 Sun 8th Dec 2019 7:57pm
3:                                     589 Sun 8th Dec 2019 7:57pm
4:                                     603 Sun 8th Dec 2019 7:58pm
5:                                     602 Sun 8th Dec 2019 7:59pm
6:                                     587 Sun 8th Dec 2019 8:00pm
               DTG       Local DTG Time of Day Cat          Location
1: 12/8/19 7:57 PM 12/9/19 9:27 AM         Morning Vijayawada, India
2: 12/8/19 7:57 PM 12/9/19 9:27 AM         Morning Vijayawada, India
3: 12/8/19 7:57 PM 12/9/19 9:27 AM         Morning Vijayawada, India
4: 12/8/19 7:58 PM 12/9/19 9:28 AM         Morning Vijayawada, India
5: 12/8/19 7:59 PM 12/9/19 9:29 AM         Morning Vijayawada, India
6: 12/8/19 8:00 PM 12/9/19 9:30 AM         Morning Vijayawada, India
   Gender Grade (or Age) Score_diff Treated Higher_grade
1:   Male              9         -2       1            0
2:   Male              9          1       1            0
3:   Male              9         14       1            0
4:   Male              9         12       1            0
5:   Male              9          9       1            0
6:   Male              9         11       1            0
```

```r
#Stargazer model with Robust SE
sgm_rse <-function(mod_name) {
  stargazer(
  mod_name,
  type = 'text',
  se=list(sqrt(diag(vcovHC(mod_name))))
  )
}
```

2.1 Simple model with treatment only

```r
dind_model_treat_only <- lm(Score_diff ~ Treated, d)
sgm_rse(dind_model_treat_only)
```

```
================================================
                        Dependent variable:
                    ---------------------------
                              Score_diff
------------------------------------------------
Treated                         -0.814
                                (0.667)

Constant                       3.625***
                                (0.361)
```

```
-----------------------------------------------
Observations                    362
R2                             0.004
Adjusted R2                    0.001
Residual Std. Error      5.763 (df = 360)
F Statistic             1.494 (df = 1; 360)
===============================================
Note:               *p<0.1; **p<0.05; ***p<0.01
```

2.2 Model with treatment and covariates

```
dind_model_with_covar <- lm(Score_diff ~ Treated + Gender + Higher_grade + `Time of Day Cat`, d)
sgm_rse(dind_model_with_covar)
```

```
=================================================
                          Dependent variable:
                      ---------------------------
                                Score_diff
-------------------------------------------------
Treated                          -1.760*
                                 (1.052)

GenderMale                       -0.213
                                 (0.628)

Higher_grade                     -0.526
                                 (0.822)

`Time of Day Cat`Evening          0.086
                                 (0.828)

`Time of Day Cat`Morning          1.236
                                 (0.789)

Constant                        3.823***
                                 (0.805)

-------------------------------------------------
Observations                       362
R2                                0.012
Adjusted R2                      -0.002
Residual Std. Error          5.773 (df = 356)
F Statistic                 0.850 (df = 5; 356)
=================================================
Note:                  *p<0.1; **p<0.05; ***p<0.01
```

2.3 Comparison of the base model for D-in-D with covariates

```r
stargazer(
  list(dind_model_treat_only, dind_model_with_covar),
  type = 'text',
  se=list(sqrt(diag(vcovHC(dind_model_treat_only))), sqrt(diag(vcovHC(dind_model_with_covar))))
  )
```

```
===============================================================
                                Dependent variable:
                            ---------------------------------
                                        Score_diff
                                  (1)                 (2)
---------------------------------------------------------------
Treated                         -0.814              -1.760*
                                (0.667)             (1.052)

GenderMale                                          -0.213
                                                    (0.628)

Higher_grade                                        -0.526
                                                    (0.822)

`Time of Day Cat`Evening                             0.086
                                                    (0.828)

`Time of Day Cat`Morning                             1.236
                                                    (0.789)

Constant                       3.625***            3.823***
                                (0.361)             (0.805)

---------------------------------------------------------------
Observations                      362                 362
R2                                0.004               0.012
Adjusted R2                       0.001               -0.002
Residual Std. Error         5.763 (df = 360)    5.773 (df = 356)
F Statistic                1.494 (df = 1; 360) 0.850 (df = 5; 356)
===============================================================
Note:                                 *p<0.1; **p<0.05; ***p<0.01
```

2.4 Simple model with Test Description

```r
dind_model_exp <- lm(Score_diff ~ `Test Description`, d)
sgm_rse(dind_model_exp)
```

```
=====================================================
                            Dependent variable:
                        ---------------------------
                                   Score_diff
```

```
-------------------------------------------------
`Test Description`Music              1.009
                                    (0.750)

`Test Description`Reading            0.689
                                    (0.753)

Constant                           2.811***
                                    (0.561)

-------------------------------------------------
Observations                          362
R2                                    0.005
Adjusted R2                          -0.001
Residual Std. Error            5.769 (df = 359)
F Statistic                   0.839 (df = 2; 359)
=================================================
Note:                    *p<0.1; **p<0.05; ***p<0.01
```

2.5 With covariates

```
dind_model_exp_with_covar <- lm(Score_diff ~ `Test Description` + Gender + Higher_grade + `Time of Day C
sgm_rse(dind_model_exp_with_covar)
```

```
=================================================
                           Dependent variable:
                       ---------------------------
                                Score_diff
-------------------------------------------------
`Test Description`Music            1.813*
                                   (1.043)

`Test Description`Reading          1.577
                                   (1.320)

GenderMale                        -0.199
                                   (0.619)

Higher_grade                      -0.423
                                   (0.967)

`Time of Day Cat`Evening           0.149
                                   (0.823)

`Time of Day Cat`Morning           1.236
                                   (0.791)

Constant                          2.055**
                                   (0.883)

-------------------------------------------------
```

```
Observations                          362
R2                                  0.012
Adjusted R2                        -0.005
Residual Std. Error           5.780 (df = 355)
F Statistic                  0.720 (df = 6; 355)
=================================================
Note:                   *p<0.1; **p<0.05; ***p<0.01
```

2.6 Comparison of the base model for D-in-D with covariates

```
stargazer(
  list(dind_model_exp, dind_model_exp_with_covar),
  type = 'text',
  se=list(sqrt(diag(vcovHC(dind_model_exp))), sqrt(diag(vcovHC(dind_model_exp_with_covar))))
  )
```

```
=============================================================
                              Dependent variable:
                          -------------------------------
                                     Score_diff
                                (1)                (2)
-------------------------------------------------------------
`Test Description`Music        1.009              1.813*
                              (0.750)            (1.043)

`Test Description`Reading      0.689              1.577
                              (0.753)            (1.320)

GenderMale                                       -0.199
                                                 (0.619)

Higher_grade                                     -0.423
                                                 (0.967)

`Time of Day Cat`Evening                         0.149
                                                 (0.823)

`Time of Day Cat`Morning                         1.236
                                                 (0.791)

Constant                      2.811***           2.055**
                              (0.561)            (0.883)

-------------------------------------------------------------
Observations                    362                362
R2                             0.005              0.012
Adjusted R2                   -0.001             -0.005
Residual Std. Error     5.769 (df = 359)   5.780 (df = 355)
F Statistic           0.839 (df = 2; 359) 0.720 (df = 6; 355)
=============================================================
Note:                           *p<0.1; **p<0.05; ***p<0.01
```

3. Analysis of post-test results only

3.1 Treatment only

```
post_model_treat_only <- lm(`Post Score` ~ Treated, d)
sgm_rse(post_model_treat_only)
```

```
================================================
                        Dependent variable:
                    ---------------------------
                           `Post Score`
------------------------------------------------
Treated                      -0.500
                             (0.556)

Constant                    15.680***
                             (0.296)

------------------------------------------------
Observations                   362
R2                            0.002
Adjusted R2                   -0.0005
Residual Std. Error      4.754 (df = 360)
F Statistic             0.831 (df = 1; 360)
================================================
Note:                *p<0.1; **p<0.05; ***p<0.01
```

3.2 Treatment with covariates

```
post_model_with_covar <- lm(`Post Score` ~ Treated + Gender + Higher_grade + `Time of Day Cat`, d)
sgm_rse(post_model_with_covar)
```

```
=================================================
                            Dependent variable:
                        ---------------------------
                               `Post Score`
-------------------------------------------------
Treated                          -0.629
                                 (0.842)

GenderMale                       0.876*
                                 (0.507)

Higher_grade                     -0.605
                                 (0.679)

`Time of Day Cat`Evening          0.625
```

```
                                  (0.685)

`Time of Day Cat`Morning          -0.160
                                  (0.625)

Constant                         15.465***
                                  (0.676)

--------------------------------------------------
Observations                        362
R2                                 0.018
Adjusted R2                        0.004
Residual Std. Error          4.742 (df = 356)
F Statistic                1.323 (df = 5; 356)
==================================================
Note:                  *p<0.1; **p<0.05; ***p<0.01
```

3.2 Treatment with Reading and Music

```r
post_model_exp <- lm(`Post Score` ~ `Test Description`, d)
sgm_rse(post_model_exp)
```

```
==================================================
                           Dependent variable:
                       -------------------------
                              `Post Score`
--------------------------------------------------
`Test Description`Music          -0.509
                                 (0.611)

`Test Description`Reading        1.148*
                                 (0.625)

Constant                        15.179***
                                 (0.471)

--------------------------------------------------
Observations                       362
R2                                0.023
Adjusted R2                       0.017
Residual Std. Error         4.711 (df = 359)
F Statistic               4.192** (df = 2; 359)
==================================================
Note:                  *p<0.1; **p<0.05; ***p<0.01
```

```r
post_model_exp_with_covar <- lm(`Post Score` ~ `Test Description` + Gender + Higher_grade + `Time of Da
sgm_rse(post_model_exp_with_covar)
```

```
==================================================
```

```
                              Dependent variable:
                          ---------------------------
                                  `Post Score`
-------------------------------------------------------
`Test Description`Music                0.145
                                      (0.831)

`Test Description`Reading             2.300**
                                      (1.009)

GenderMale                             0.755
                                      (0.498)

Higher_grade                          -1.538**
                                      (0.722)

`Time of Day Cat`Evening               0.048
                                      (0.683)

`Time of Day Cat`Morning              -0.154
                                      (0.627)

Constant                              14.909***
                                      (0.712)

-------------------------------------------------------
Observations                             362
R2                                       0.047
Adjusted R2                              0.031
Residual Std. Error                4.679 (df = 355)
F Statistic                   2.902*** (df = 6; 355)
=======================================================
Note:                       *p<0.1; **p<0.05; ***p<0.01
```

```r
pre_model_exp <- lm(`Pre Score` ~ `Test Description`, d)
sgm_rse(pre_model_exp)
```

```
=======================================================
                              Dependent variable:
                          ---------------------------
                                  `Pre Score`
-------------------------------------------------------
`Test Description`Music               -1.518**
                                      (0.694)

`Test Description`Reading              0.459
                                      (0.654)

Constant                              12.368***
                                      (0.474)

-------------------------------------------------------
Observations                             362
```

```
R2                                0.024
Adjusted R2                       0.019
Residual Std. Error           5.244 (df = 359)
F Statistic                 4.464** (df = 2; 359)
=================================================
Note:                   *p<0.1; **p<0.05; ***p<0.01
```

```
pre_model_exp_with_covar <- lm(`Pre Score` ~ `Test Description` + Gender + Higher_grade + `Time of Day C
sgm_rse(pre_model_exp_with_covar)
```

```
=================================================
                          Dependent variable:
                      ---------------------------
                                `Pre Score`
-------------------------------------------------
`Test Description`Music            -1.668*
                                   (0.955)

`Test Description`Reading           0.723
                                   (1.104)

GenderMale                         0.954*
                                   (0.556)

Higher_grade                       -1.115
                                   (0.814)

`Time of Day Cat`Evening           -0.101
                                   (0.787)

`Time of Day Cat`Morning          -1.390**
                                   (0.682)

Constant                          12.854***
                                   (0.723)

-------------------------------------------------
Observations                         362
R2                                  0.055
Adjusted R2                         0.039
Residual Std. Error           5.189 (df = 355)
F Statistic                 3.463*** (df = 6; 355)
=================================================
Note:                   *p<0.1; **p<0.05; ***p<0.01
```

4. Analysis of pre-test results only

4.1 Treatment only

```r
pre_model_treat_only <- lm(`Pre Score` ~ Treated, d)
sgm_rse(pre_model_treat_only)
```

```
================================================
                        Dependent variable:
                    ---------------------------
                            `Pre Score`
------------------------------------------------
Treated                       0.313
                             (0.585)

Constant                     12.055***
                             (0.343)

------------------------------------------------
Observations                   362
R2                            0.001
Adjusted R2                  -0.002
Residual Std. Error      5.299 (df = 360)
F Statistic             0.262 (df = 1; 360)
================================================
Note:               *p<0.1; **p<0.05; ***p<0.01
```

4.2 Treatment with covariates

```r
pre_model_with_covar <- lm(`Pre Score` ~ Treated + Gender + Higher_grade + `Time of Day Cat`, d)
sgm_rse(pre_model_with_covar)
```

```
=================================================
                          Dependent variable:
                      ---------------------------
                              `Pre Score`
-------------------------------------------------
Treated                         1.131
                               (0.946)

GenderMale                     1.089*
                               (0.566)

Higher_grade                   -0.080
                               (0.779)

`Time of Day Cat`Evening        0.539
                               (0.770)

`Time of Day Cat`Morning       -1.396**
                               (0.684)
```

```
Constant                               11.642***
                                        (0.806)

----------------------------------------------------
Observations                             362
R2                                      0.027
Adjusted R2                             0.013
Residual Std. Error                5.259 (df = 356)
F Statistic                      1.976* (df = 5; 356)
====================================================
Note:                        *p<0.1; **p<0.05; ***p<0.01
```

5 Summary of pre and post models

```r
stargazer(
  list(pre_model_treat_only, pre_model_with_covar, post_model_treat_only, post_model_with_covar),
  type='text',
  se=list(sqrt(diag(vcovHC(pre_model_treat_only))), sqrt(diag(vcovHC(pre_model_with_covar))),
          sqrt(diag(vcovHC(post_model_treat_only))), sqrt(diag(vcovHC(post_model_with_covar)))
          )
  )
```

```
==========================================================================================================
                                                    Dependent variable:
                         ---------------------------------------------------------------------------------
                                     `Pre Score`                               `Post Score`
                                (1)                  (2)                  (3)                  (4)
----------------------------------------------------------------------------------------------------------
Treated                        0.313                1.131               -0.500               -0.629
                              (0.585)              (0.946)              (0.556)              (0.842)

GenderMale                                          1.089*                                    0.876*
                                                   (0.566)                                   (0.507)

Higher_grade                                        -0.080                                   -0.605
                                                   (0.779)                                   (0.679)

`Time of Day Cat`Evening                            0.539                                     0.625
                                                   (0.770)                                   (0.685)

`Time of Day Cat`Morning                           -1.396**                                  -0.160
                                                   (0.684)                                   (0.625)

Constant                     12.055***            11.642***            15.680***            15.465***
                              (0.343)              (0.806)              (0.296)              (0.676)

----------------------------------------------------------------------------------------------------------
Observations                    362                  362                  362                  362
R2                             0.001                0.027                0.002                0.018
Adjusted R2                   -0.002                0.013               -0.0005               0.004
Residual Std. Error      5.299 (df = 360)     5.259 (df = 356)     4.754 (df = 360)     4.742 (df = 356)
```

```
F Statistic              0.262 (df = 1; 360) 1.976* (df = 5; 356) 0.831 (df = 1; 360) 1.323 (df = 5; 35
=============================================================================================================
Note:                                                                                 *p<0.1; **p<0.05; ***p<0.
```

5.2 Average of pre, post and d-in-d scores

```
nrow(d[d$`Test Description` == "Gaming"])
```

```
[1] 106
```

```
nrow(d[d$`Test Description` == "Reading"])
```

```
[1] 156
```

```
nrow(d[d$`Test Description` == "Music"])
```

```
[1] 100
```

```
mean(d[`Test Description` == "Gaming",as.numeric(`Pre Score`)])
```

```
[1] 12.36792
```

```
mean(d[`Test Description` == "Gaming",as.numeric(`Post Score`)])
```

```
[1] 15.17925
```

6. Comparison against Music only and Reading only

```
#Gaming and Music only
d_gm = d[d$`Test Description` == "Gaming" | d$`Test Description` == "Music"]
nrow(d_gm)
```

```
[1] 206
```

```
#Gaming and Reading only
d_gr = d[d$`Test Description` == "Gaming" | d$`Test Description` == "Reading"]
nrow(d_gr)
```

```
[1] 262
```

```
#Music and Reading only
d_mr = d[d$`Test Description` == "Music" | d$`Test Description` == "Reading"]
nrow(d_mr)
```

```
[1] 256
```

```r
dind_model_gaming_music <- lm(Score_diff ~ `Test Description` + Gender + Higher_grade + `Time of Day Ca
dind_model_gaming_reading <- lm(Score_diff ~ `Test Description` + Gender + Higher_grade + `Time of Day
dind_model_music_reading <- lm(Score_diff ~ `Test Description` + Gender + Higher_grade + `Time of Day Ca
stargazer(
  list(dind_model_gaming_music, dind_model_gaming_reading, dind_model_music_reading),
  type = 'text',
  se=list(sqrt(diag(vcovHC(dind_model_gaming_music))), sqrt(diag(vcovHC(dind_model_gaming_reading))), s
  )
```

```
================================================================================================
                                                Dependent variable:
                                    ------------------------------------------------------------
                                                        Score_diff
                                          (1)                  (2)                  (3)
------------------------------------------------------------------------------------------------
`Test Description`Music                  1.580
                                        (1.174)

`Test Description`Reading                                    2.396                -0.163
                                                            (1.951)              (0.839)

GenderMale                              1.539**              -0.656               -1.136
                                        (0.747)              (0.767)              (0.736)

Higher_grade                             -0.445              -1.186               -0.656
                                        (1.018)              (1.795)              (0.987)

`Time of Day Cat`Evening                 2.208*              -1.315                0.057
                                        (1.147)              (1.077)              (0.857)

`Time of Day Cat`Morning                 1.732*               0.492               1.713*
                                        (1.025)              (0.919)              (0.983)

Constant                                 0.787              2.832***             4.398***
                                        (0.981)              (0.973)              (0.871)

------------------------------------------------------------------------------------------------
Observations                              206                  262                  256
R2                                        0.052                0.012                0.021
Adjusted R2                               0.028               -0.007                0.002
Residual Std. Error                5.309 (df = 200)     6.073 (df = 256)     5.763 (df = 250)
F Statistic                2.200* (df = 5; 200) 0.627 (df = 5; 256) 1.081 (df = 5; 250)
================================================================================================
Note:                                                              *p<0.1; **p<0.05; ***p<0.01
```