Open book exam.
Problem I has 60 % weight and Problem II has 40 % weight.

**Problem I**

The output on Page 1 shows Stata results of regression analyses of a production function. The variables are defined as follows: **lnva**= log(Value added), **lnl**= log(employment) and **lnk**=log(capital). The observation units are cross-section observations of Norwegian manufacturing firms in one year.

1.
Compare the two regressions on Page 1. Give an interpretation of the coefficient for employment in both models. Why did the estimated coefficient change between the two specifications? What can you say about the sign of the correlation between **lnl** and **lnk** on the basis of the displayed results?

2.
In the first model of Page 2, the variable **edu** is introduced into the regression. **edu** measures the average number of years of education among the employees in the firm. Give an interpretation of the coefficient for **edu**, and construct a 95 percent confidence interval for it. In the second model **edu** is replaced by the log of **edu** (**lnedu**). Give an interpretation of the coefficient for the log of **edu** and calculate the marginal effect of one more year of education on log(Value added) for a firm with average level of education (the mean of **edu** is given on Page 1). Which of the two models on Page 2 do you prefer, and why?

3.
The estimated residuals from these regressions may be interpreted as measures of firm specific productivity differences. Give an estimate of the dispersion in these productivity differences across firms in that case, based on the output from your preferred model.

From production theory we know, among other things, that more productive firms will choose higher levels of employment. Explain why our OLS-estimator for employment may be biased in this case. (Assume for simplicity that capital and the level of education are exogenous variables.)

Suppose that the firms are observed in different locations. Discuss if the local unemployment rate and the local share of public sector employment in the region where the firm is based, may be valid instruments for employment in this case. Focus on the requirements for internal validity of the instruments.

Problem II

On Page 3 you will find some output from an analysis of the data from project STAR. Project STAR is a class size reduction experiment which allocates both students and teachers randomly to classes of different sizes. The point is to estimate the causal effect on class size on various outcomes like test-scores. The analysis in this problem includes the following variables:

**readscore**, the score on a reading skills test
**smallclass**, a dummy variable taking the value of 1 if the student was allocated to a small class
**experience**, teacher's years of teaching experience
**smallexp,** an interaction term between smallclass and experience (Smallclass *x* Experience)
**schoolid,** an indicator variable for each of 80 schools.

1.
The first section of Page 3 gives summary statistics. How many students were allocated to small classes in this experiment? The next section reports the results from an OLS regression. Is there a significant effect of class size on the student's score on the reading skills test?

The last section on Page 3 reports the results from a fixed school effect regression, including an indicator for each school. The response variable is **readscore**. To save space, the coefficients for each school indicator are not shown in the output. Only the F-value for the joint test of all the school indicators is reported. The F-value reported for the schoolid variable (testing the null hypothesis of no difference between shools) is 17.982. The adjusted R-square increases from 0.02 to 0.20 between the two models. What do these two statistics (the F-value and change in adj. R-square) tell you about the scores on the reading skills test?

2.
Even if the F-value of the fixed effects is highly significant, the change in the estimated effect of class size from the OLS-specification to the fixed effects specification is rather small. What does this tell you about the experimental design? Explain.

It appears that teacher's experience has a positive effect on test scores. On Page 4, we report a regression including the interaction term between teacher's experience and the small class indicator as well. Based on this analysis, what is the estimated effect of one more year of teacher's experience on test scores in large classes? And what is the estimated effect of one more year of teacher's experience on test scores in small classes? What is the estimated effect of being in a small class if your teacher has one year of experience, and what is the estimated effect of being in a small class if your teacher has 10 years of experience?

# PAGE 1

```
. summarize lnva lnl lnk edu lnedu

    Variable |       Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
        lnva |       333    10.52615    1.237322   7.664347   14.11676
         lnl |       333    4.611243    1.072925   2.302585   7.204893
         lnk |       333    11.51218    1.573342   6.946014   15.66018
         edu |       333    11.11878     .712528   9.814516   14.39001
       lnedu |       333    2.406695    .0616282   2.283863   2.666534


. regress lnva lnl

      Source |       SS       df       MS              Number of obs =     333
-------------+------------------------------           F(  1,   331) = 1334.06
       Model |  407.239078     1  407.239078           Prob > F      =  0.0000
    Residual |  101.041936   331  .305262646           R-squared     =  0.8012
-------------+------------------------------           Adj R-squared =  0.8006
       Total |  508.281014   332  1.53096691           Root MSE      =  .55251

------------------------------------------------------------------------------
        lnva |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         lnl |   1.032253   .0282617    36.52   0.000     .9766578    1.087848
       _cons |   5.766178   .1337924    43.10   0.000     5.502987    6.029369
------------------------------------------------------------------------------

. regress lnva lnl lnk

      Source |       SS       df       MS              Number of obs =     333
-------------+------------------------------           F(  2,   330) =  727.50
       Model |  414.313208     2  207.156604           Prob > F      =  0.0000
    Residual |  93.9678061   330  .284750927           R-squared     =  0.8151
-------------+------------------------------           Adj R-squared =  0.8140
       Total |  508.281014   332  1.53096691           Root MSE      =  .53362

------------------------------------------------------------------------------
        lnva |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         lnl |     .86178   .0437588    19.69   0.000     .7756986    .9478614
         lnk |   .1487359   .0298409     4.98   0.000     .0900335    .2074383
       _cons |   4.839997   .2263329    21.38   0.000      4.39476    5.285234
------------------------------------------------------------------------------
```

```
. regress lnva lnl lnk edu

      Source |       SS       df       MS              Number of obs =     333
-------------+------------------------------           F(  3,   329) =  532.82
       Model |  421.522129     3  140.507376            Prob > F      =  0.0000
    Residual |  86.7588854   329  .263704819           R-squared     =  0.8293
-------------+------------------------------           Adj R-squared =  0.8278
       Total |  508.281014   332  1.53096691           Root MSE      =  .51352

------------------------------------------------------------------------------
        lnva |      Coef.   Std. Err.      t    P>|t|
-------------+----------------------------------------------------------------
         lnl |   .8092067   .0432945    18.69   0.000
         lnk |   .1639823   .0288646     5.68   0.000
         edu |   .2144836   .0410221     5.23   0.000
       _cons |    2.52211   .4939353     5.11   0.000
------------------------------------------------------------------------------

. regress lnva lnl lnk lnedu

      Source |       SS       df       MS              Number of obs =     333
-------------+------------------------------           F(  3,   329) =  533.72
       Model |  421.643808     3  140.547936            Prob > F      =  0.0000
    Residual |  86.6372064   329  .263334974           R-squared     =  0.8295
-------------+------------------------------           Adj R-squared =  0.8280
       Total |  508.281014   332  1.53096691           Root MSE      =  .51316

------------------------------------------------------------------------------
        lnva |      Coef.   Std. Err.      t    P>|t
-------------+----------------------------------------------------------------
         lnl |   .8084192   .0432794    18.68   0.000
         lnk |   .1635854   .0288345     5.67   0.000
       lnedu |   2.503951    .474581     5.28   0.000
       _cons |   -1.11114   1.148744    -0.97   0.334
------------------------------------------------------------------------------
```

## PAGE 3

```
. summarize smallclass readscore schoolid experience smallexp

    Variable |       Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
  smallclass |      6325    .3003953    .4584661         0          1
   readscore |      5789    436.7253    31.70626       315        627
    schoolid |      6325    39.88933    22.70935         1         80
  experience |      6304    9.258249    5.808783         0         27
    smallexp |      6304    2.688293    5.189821         0         27

. regress readscore smallclass experience

      Source |       SS       df       MS              Number of obs =    5769
-------------+------------------------------           F(  2,  5766) =   57.43
       Model |  113499.359     2  56749.6796           Prob > F      =  0.0000
    Residual |  5697205.19  5766  988.068884           R-squared     =  0.0195
-------------+------------------------------           Adj R-squared =  0.0192
       Total |  5810704.55  5768   1007.4037           Root MSE      =  31.434

------------------------------------------------------------------------------
   readscore |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  smallclass |   5.722971   .9024363     6.34   0.000     3.953857    7.492085
  experience |   .6363361   .0718185     8.86   0.000     .4955448    .7771274
       _cons |   429.1004   .8396752   511.03   0.000     427.4543    430.7465
------------------------------------------------------------------------------

:Fixed school effects model (Coefficients etc. for school indicator not shown):

                                                Number of obs =    5769
                                                R-squared     =  0.2135
                                                Adj R-squared =  0.2024
                                                Root MSE      =  28.346

------------------------------------------------------------------------------
   readscore |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  smallclass |   6.141785   .8243809     7.45   0.000     4.525684    7.757886
  experience |   .3217389   .0729901     4.41   0.000     .1786505    .4648273
       _cons |   431.9023   .8216885   525.63   0.000     430.2915    433.5131
-------------+----------------------------------------------------------------
    schoolid |       F(78, 5688) =     17.982   0.000          (79 categories)
```

## PAGE 4

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:Fixed school effects model (Coefficients etc. for school indicator not shown):

                                                Number of obs =    5769
                                                R-squared     =  0.2145
                                                Adj R-squared =  0.2033
                                                Root MSE      =   28.33

------------------------------------------------------------------------------
   readscore |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  smallclass |   10.07196   1.664397     6.05   0.000     6.809109    13.33481
  experience |   .4564966   .0882062     5.18   0.000     .2835788    .6294144
    smallexp |  -.4314103    .158743    -2.72   0.007     -.742607   -.1202136
       _cons |   430.6331   .9447321   455.83   0.000     428.7811    432.4851
-------------+----------------------------------------------------------------
    schoolid |       F(78, 5687) =     17.926   0.000          (79 categories)
```