Econometrics

Do innovation and technology drive economic growth?

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Agenda

I Introduction

II Data Collection and Variables Selection

III Descriptive Analysis

IV Econometrics Models and Results

V Conclusion

VI Q & A

I Introduction

"What is new is that more countries than ever are competing for global leadership, and they know the value of innovation."

- Bill Gates. "America's Secret Weapons"

II Data Collection and Variable Selection

- **Data Collection**
  - World bank
  - 4 different data sets

- **Variable Selection**
  - GDP per capita (US$)
  - Patent Applications (Residents)
  - Patent Applications (Non-Residents)
  - Fixed Broadband Subscriptions (per 100)

II Data Collection and Variable Selection

	country.code	country.name	year	patent.res	GDP	patent.non	fixed.broadband	income.group
1	ARG	Argentina	2007	937	7193.6176	4806	6.50484221	Upper middle income
2	ARG	Argentina	2008	801	8953.3593	4781	7.71311722	Upper middle income
3	ARG	Argentina	2009	640	8161.3070	4336	8.60558096	Upper middle income
4	ARG	Argentina	2010	552	10276.2605	4165	9.77161082	Upper middle income
5	ARG	Argentina	2011	688	12726.9084	4133	10.97543337	Upper middle income
6	ARG	Argentina	2012	735	12969.7071	4078	12.23036065	Upper middle income
7	ARG	Argentina	2013	643	12976.6364	4129	14.69447819	Upper middle income
8	ARG	Argentina	2014	509	12245.2565	4173	15.16805073	Upper middle income
9	ARG	Argentina	2015	546	13467.1024	3579	15.79039594	Upper middle income
10	ARG	Argentina	2016	884	12440.3210	2925	16.49367591	Upper middle income

Table 1: Sample panel data

III Descriptive Analysis

```
> summary(data.final)
 country.code       country.name            year        patent.res            GDP
 Length:840         Length:840         Min.   :2007   Min.   :     1.0   Min.   :   377.9
 Class :character   Class :character   1st Qu.:2009   1st Qu.:   105.8   1st Qu.:  3876.7
 Mode  :character   Mode  :character   Median :2012   Median :   504.0   Median : 11772.5
                                       Mean   :2012   Mean   : 18132.7   Mean   : 21780.8
                                       3rd Qu.:2014   3rd Qu.:  1757.5   3rd Qu.: 38464.3
                                       Max.   :2016   Max.   :1204981.0   Max.   :119225.4
                                                      NA's   :58
   patent.non      fixed.broadband                 income.group
 Min.   :     1   Min.   : 0.00838   High income        :400
 1st Qu.:    53   1st Qu.: 4.02110   Low income         : 30
 Median :   267   Median :15.29842   Lower middle income:190
 Mean   :  9220   Mean   :16.48734   Upper middle income:220
 3rd Qu.:  4169   3rd Qu.:27.45871
 Max.   :310244   Max.   :45.13470
 NA's   :61       NA's   :4
>
```

Table 2: Summary of the data set

III Descriptive Analysis

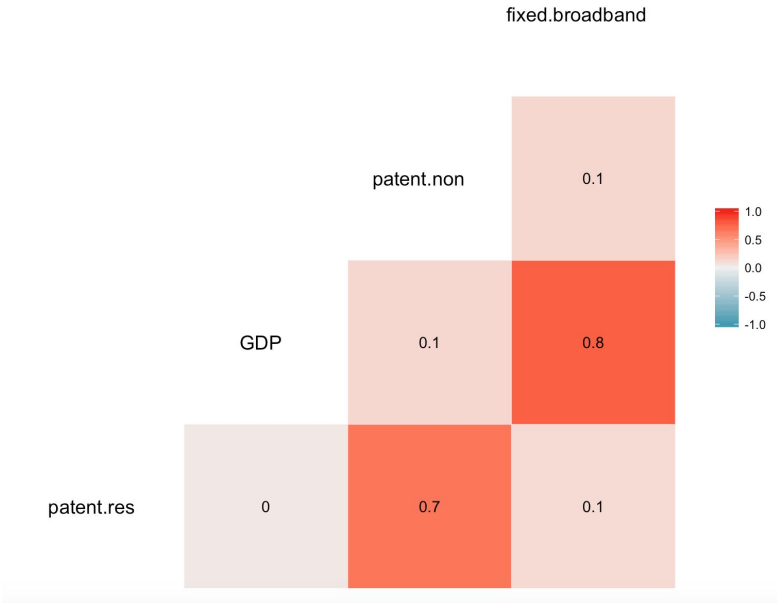


Figure 1: Correlation plot on raw data

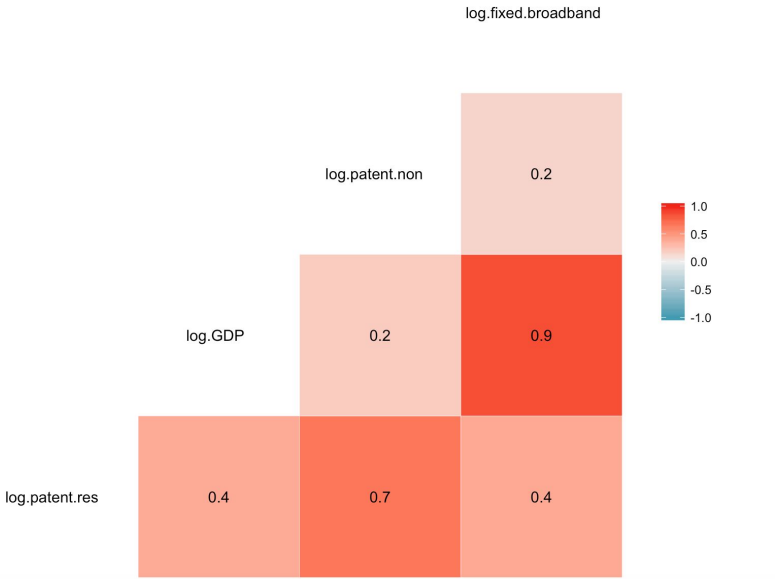
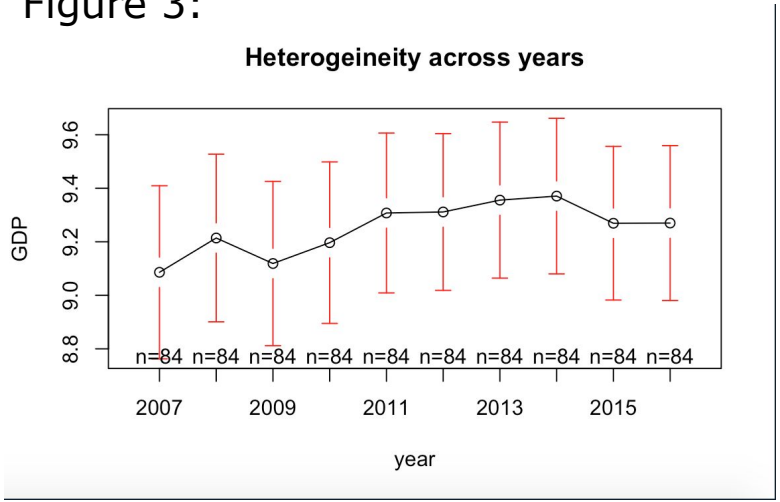


Figure 2: Correlation plot with log transformation

IV Econometrics Models and Results

1. **OLS** $\log(\text{PC. GDP})_{it} = \beta_0 + \beta_1 * \log(\text{patent. res})_{it} + \beta_2 * \log(\text{patent. non})_{it} + \beta_3 * \log(\text{fixed. broadband})_{it} + \mu_{it}$

Figure 3:



How about heterogeneity across countries or time?

```
> summary(OLS1)

Call:
lm(formula = GDP ~ patent.res + patent.non + fixed.broadband,
    data = data.final1)

Residuals:
     Min       1Q   Median       3Q      Max
-1.99860 -0.40511 -0.04475  0.49880  2.44990

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)     7.5661599  0.0686332 110.241  < 2e-16 ***
patent.res     -0.0009808  0.0139315  -0.070  0.94389
patent.non      0.0354537  0.0123885   2.862  0.00433 **
fixed.broadband 0.7006473  0.0167998  41.706  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.7004 on 771 degrees of freedom
  (65 observations deleted due to missingness)
Multiple R-squared:  0.7394,    Adjusted R-squared:  0.7384
F-statistic: 729.2 on 3 and 771 DF,  p-value: < 2.2e-16
```

Table 3: OLS summary

IV Econometrics Models and Results

2. OLS Dummy

```
Residuals:
     Min       1Q   Median       3Q      Max
-0.55419 -0.07649  0.00666  0.08007  0.45283

Coefficients:
                                    Estimate Std. Error t value Pr(>|t|)
patent.res                          0.065793   0.014989   4.389 1.32e-05 ***
patent.non                          0.015055   0.011651   1.292    0.197
fixed.broadband                     0.144988   0.009144  15.856  < 2e-16 ***
factor(country.name)Argentina       8.391422   0.136259  61.584  < 2e-16 ***
factor(country.name)Armenia         7.664746   0.084609  90.590  < 2e-16 ***
factor(country.name)Australia       9.793956   0.163182  60.019  < 2e-16 ***
factor(country.name)Austria         9.731701   0.134457  72.378  < 2e-16 ***
factor(country.name)Azerbaijan      8.022746   0.098647  81.327  < 2e-16 ***
factor(country.name)Bahamas, The    9.723445   0.082885 117.313  < 2e-16 ***
factor(country.name)Bahrain         9.462814   0.086736 109.100  < 2e-16 ***
```

Table 4: OLS Dummy summary

```
factor(country.name)United Kingdom      9.396152   0.173809  54.
factor(country.name)United States       9.352235   0.225857  41.
factor(country.name)Uzbekistan          6.910753   0.106986  64.
factor(country.name)Vietnam             6.608755   0.127739  51.
factor(country.name)Zambia              7.479869   0.068600 109.
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.1332 on 688 degrees of freedom
  (65 observations deleted due to missingness)
Multiple R-squared:  0.9998,    Adjusted R-squared:  0.9998
F-statistic: 4.424e+04 on 87 and 688 DF,  p-value: < 2.2e-16
```

$$\log(\text{PC. GDP})_{it} = \alpha_1 + \alpha_2 C_{2i} + \ldots\ldots \alpha_{84} C_{84i} + \beta_1 * \log(\text{patent. res})_{it} + \beta_2 * \log(\text{patent. non})_{it} + \beta_3 * \log(\text{fixed. broadband})_{it} + \mu_{it}$$

IV Econometrics Models and Results

3. FE within group

$$\log[\text{PC. GDP}]_{it} = \beta_1 * \log[\text{patent. res}]_{it} + \beta_2 * \log[\text{patent. non}]_{it} + \beta_3 * \log[\text{fixed. broadband}]_{it} + \mu_{it}$$

```
Unbalanced Panel: n = 84, T = 2-10, N = 775

Residuals:
      Min.    1st Qu.     Median    3rd Qu.       Max.
-0.5541916 -0.0764921  0.0066618  0.0800716  0.4528274

Coefficients:
                Estimate Std. Error t-value  Pr(>|t|)
patent.res      0.065793   0.014989  4.3893 1.316e-05 ***
patent.non      0.015055   0.011651  1.2921    0.1968
fixed.broadband 0.144988   0.009144 15.8561 < 2.2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Total Sum of Squares:    17.107
Residual Sum of Squares: 12.214
R-Squared:      0.28599
Adj. R-Squared: 0.19673
F-statistic: 91.8551 on 3 and 688 DF, p-value: < 2.22e-16
```

Table 5: Fixed Effects (demeaned) results

IV Econometrics Models and Results

4. Random effects

$$\log(\text{PC. GDP})_{it} = \beta_0 + \beta_1 * \log(\text{patent. res})_{it} + \beta_2 * \log(\text{patent. non})_{it} + \beta_3 * \log(\text{fixed. broadband})_{it} + \omega_{it} \quad (\omega_{it} = \mu_{it} + \varepsilon_i)$$

Test whether the unique errors are correlated with the regressors

```
        Hausman Test

data:  GDP ~ patent.res + patent.non + fixed.broadband
chisq = 18.372, df = 3, p-value = 0.0003687
alternative hypothesis: one model is inconsistent
```

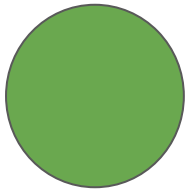
Figure 4: Hausman Test

```
Unbalanced Panel: n = 84, T = 2-10, N = 775

Effects:
                  var std.dev share
idiosyncratic 0.01775 0.13324 0.043
individual    0.39237 0.62639 0.957
theta:
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
 0.8513  0.9329  0.9329  0.9306  0.9329  0.9329

Residuals:
    Min.  1st Qu.   Median     Mean  3rd Qu.     Max.
-0.63249 -0.08796  0.01003  0.00018  0.09909  0.59669

Coefficients:
                 Estimate Std. Error t-value  Pr(>|t|)
(Intercept)     8.2992409  0.1232159 67.3553 < 2.2e-16 ***
patent.res      0.0831701  0.0145959  5.6982 1.723e-08 ***
patent.non      0.0188179  0.0119582  1.5736     0.116
fixed.broadband 0.1686012  0.0098863 17.0540 < 2.2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Total Sum of Squares:    26.743
Residual Sum of Squares: 16.673
R-Squared:      0.37657
Adj. R-Squared: 0.37414
F-statistic: 155.215 on 3 and 771 DF, p-value: < 2.22e-16
```

Table 6: Random Effects

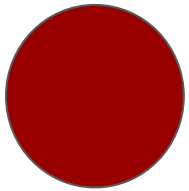
IV Econometrics Models and Results

Stationary



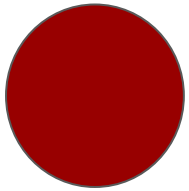
```
        Augmented Dickey-Fuller Test

data:  Panel.set$GDP
Dickey-Fuller = -6.9367, Lag order = 2, p-value = 0.01
alternative hypothesis: stationary
```

Serial Correlation (autocorrelation)



```
      Breusch-Godfrey/Wooldridge test for serial correlation in panel models

data:  GDP ~ patent.res + patent.non + fixed.broadband
chisq = 172.31, df = 2, p-value < 2.2e-16
alternative hypothesis: serial correlation in idiosyncratic errors
```

Heteroskedasticity



```
       Breusch-Pagan test

data:  GDP ~ patent.res + patent.non + fixed.broadband + factor(country.name)
BP = 442.9, df = 86, p-value < 2.2e-16
```

Figure 5: Data Diagnostics

IV Econometrics Models and Results

```
Coefficients:
                Estimate Std. Error t-value  Pr(>|t|)
patent.res      0.065793   0.014989  4.3893 1.316e-05 ***
patent.non      0.015055   0.011651  1.2921    0.1968
fixed.broadband 0.144988   0.009144 15.8561 < 2.2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Table 5: Fixed Effects (demeaned) results

```
t test of coefficients:

                Estimate Std. Error t value  Pr(>|t|)
patent.res      0.065793   0.032921  1.9985   0.04605 *
patent.non      0.015055   0.016611  0.9063   0.36508
fixed.broadband 0.144988   0.019485  7.4411 2.988e-13 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Table 7: Robust covariance matrix estimation (Sandwich estimator)

V Conclusion

- Fixed Effects within group model
- Positive relationships

- Moving forward:
- Handling missing data
- Magnitude of income groups
- Tax on intellectual property?

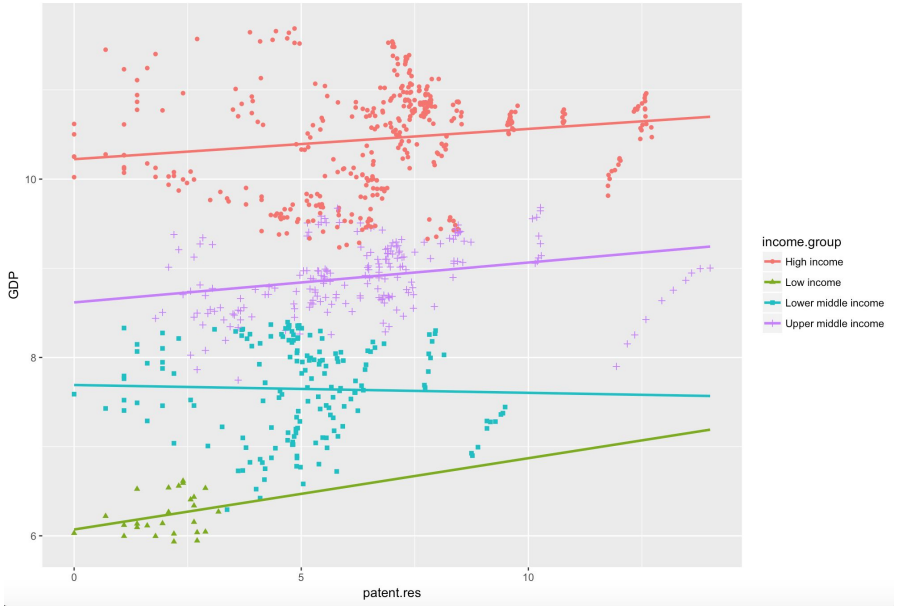


Figure 2: Magnitude of innovation among income groups

VI Q & A

Thank you!

"There are three kinds of lies: lies, damned lies, and **statistics**."

- Mark Twain

```
> fixef(fixed)
          Argentina             Armenia           Australia             Austria
           8.391422            7.664746            9.793956            9.731701
         Azerbaijan        Bahamas, The             Bahrain          Bangladesh
           8.022746            9.723445            9.462814            6.534737
            Belarus             Belgium              Bhutan              Brazil
           7.793387            9.704047            7.565307            8.209199
           Bulgaria              Canada               Chile               China
           8.072642            9.543262            8.617120            7.213715
           Colombia          Costa Rica             Croatia      Czech Republic
           8.011129            8.624762            8.679896            8.926570
            Denmark  Dominican Republic    Egypt, Arab Rep.             Estonia
           9.890714            8.227825            7.272120            9.002973
            Finland              France             Georgia             Germany
           9.719377            9.364872            7.473907            9.330679
             Greece           Guatemala Hong Kong SAR, China             Hungary
           9.177109            7.803222            9.505958            8.575983
            Iceland               India             Ireland              Israel
          10.017198            6.470177           10.000603            9.312345
            Jamaica               Japan              Jordan               Kenya
           8.004863            9.141706            7.704929            6.993444
        Korea, Rep.     Kyrgyz Republic              Latvia           Lithuania
           8.620284            6.627845            8.730763            8.746216
         Luxembourg     Macao SAR, China      Macedonia, FYR          Madagascar
          10.745213           10.402604            7.833908            6.338016
           Malaysia               Malta              Mexico             Moldova
           8.264425            9.358486            8.220399            6.858837
            Morocco          Mozambique               Nepal         Netherlands
           7.413413            6.357020            6.401604            9.705487
```

Table 8: Display the fixed effects (constants for each country)