# Statistical Reasoning

## Week 9

Sciences Po - Louis de Charsonville

Spring 2018

# Outline

# Research Paper

# Research Paper

## Timeline

| $1^{st}$ **draft** | Done |
|---|---|
| No Class | 3 April |
| $2^{nd}$ **draft** | **10 April** |
| Week 11 | 17 April |
| **Final draft** | **24 April** |

# Single Regression

## Simple regression by OLS

$$Y = \alpha + \beta X + \epsilon$$
$$\beta = \frac{Cov(X,Y)}{Var_X}$$
$$\alpha = \bar{Y} - \beta \bar{X}$$

- $\beta$ is the estimate the variation in $Y$ predicted by a change in one unit of $X$.
- The $p$-value test whether the coefficient is significantly different from 0.
- $R^2$ measures the *goodness of fit* and is the share of the variance of $Y$ explain by the model.

**Are CEO's wages correlated with sales ?**

**Are CEO's wages correlated with sales ?**

- Model :

$$Wages = \alpha + \beta\, Sales + \epsilon$$

- in Stata :
  - Plot the data

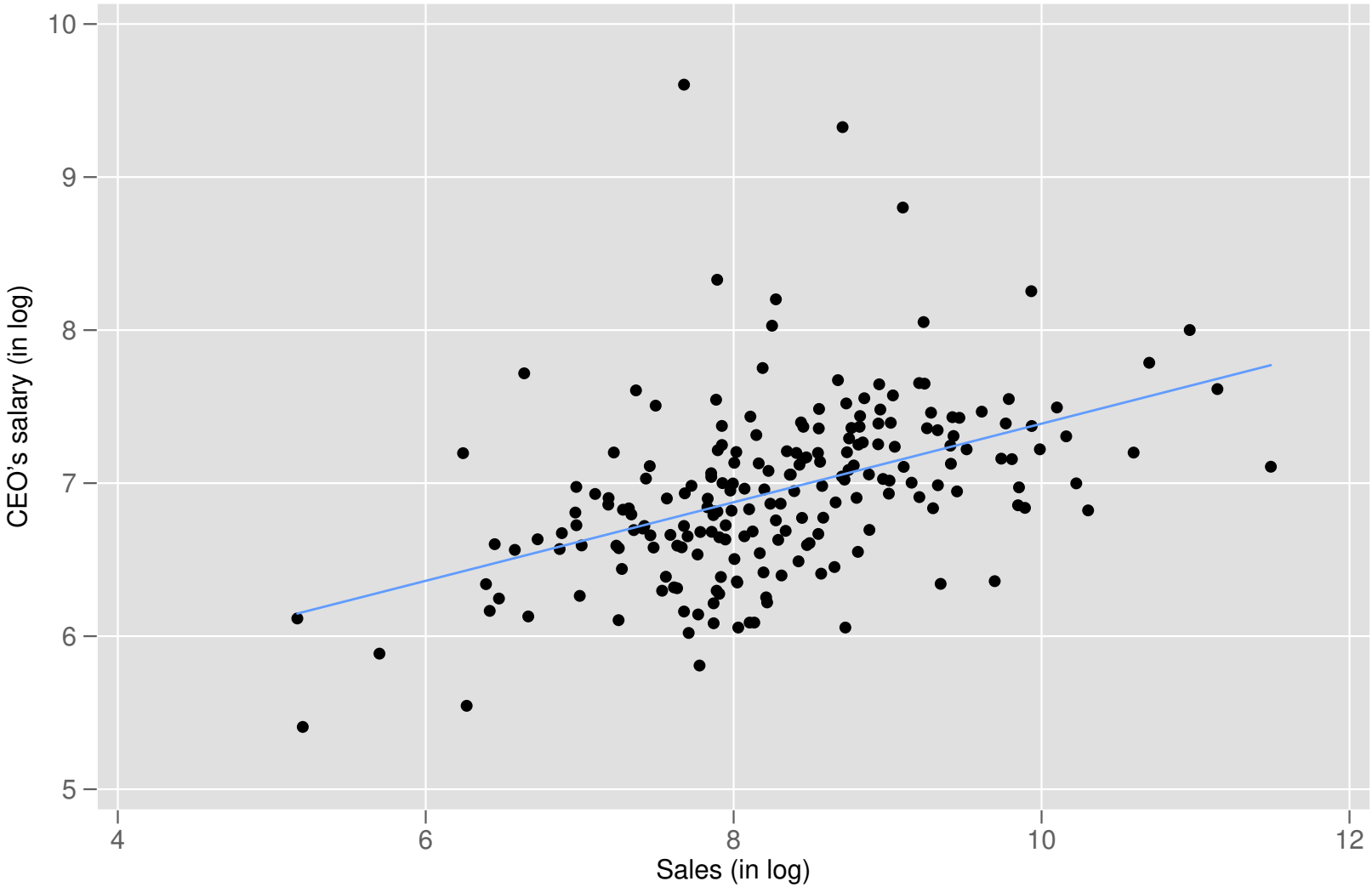
```
tw (sc lsalary lsales) (lfit lsalary lsales)
```

  - Regression

```
reg lsalary lsales
```

# Simple Regression - Reminder





```
. reg lsalary lsales
```

| Source | SS | df | MS | | |
|---|---|---|---|---|---|
| Model | 14.0661688 | 1 | 14.0661688 | Number of obs | = 209 |
| | | | | F(1, 207) | = 55.30 |
| Residual | 52.6559944 | 207 | .254376785 | Prob > F | = 0.0000 |
| | | | | R-squared | = 0.2108 |
| | | | | Adj R-squared | = 0.2070 |
| Total | 66.7221632 | 208 | .320779631 | Root MSE | = .50436 |

| lsalary | Coef. | Std. Err. | t | P>\|t\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| lsales | .2566717 | .0345167 | 7.44 | 0.000 | .1886224 | .3247209 |
| _cons | 4.821997 | .2883396 | 16.72 | 0.000 | 4.253538 | 5.390455 |

## Hoes does the type of the firm impact the results ?

```
reg lsalary lsales if finance ==0
```

| Source | SS | df | MS | | |
|---|---|---|---|---|---|
| | | | | Number of obs | = 163 |
| | | | | F(1, 161) | = 47.08 |
| Model | 12.4512191 | 1 | 12.4512191 | Prob > F | = 0.0000 |
| Residual | 42.5750911 | 161 | .26444156 | R-squared | = 0.2263 |
| | | | | Adj R-squared | = 0.2215 |
| Total | 55.0263102 | 162 | .339668582 | Root MSE | = .51424 |

| lsalary | Coef. | Std. Err. | t | P>\|t\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| lsales | .2584878 | .0376703 | 6.86 | 0.000 | .1840962 | .3328795 |
| _cons | 4.782085 | .3141753 | 15.22 | 0.000 | 4.161649 | 5.402521 |

```
reg lsalary lsales if finance ==1
```

| Source | SS | df | MS | | |
|---|---|---|---|---|---|
| | | | | Number of obs | = 46 |
| | | | | F(1, 44) | = 6.49 |
| Model | 1.41543601 | 1 | 1.41543601 | Prob > F | = 0.0144 |
| Residual | 9.60192044 | 44 | .218225465 | R-squared | = 0.1285 |
| | | | | Adj R-squared | = 0.1087 |
| Total | 11.0173565 | 45 | .244830143 | Root MSE | = .46715 |

| lsalary | Coef. | Std. Err. | t | P>\|t\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| lsales | .229666 | .0901788 | 2.55 | 0.014 | .0479226 | .4114093 |
| _cons | 5.136137 | .7576192 | 6.78 | 0.000 | 3.609256 | 6.663018 |

# Multiple Regression

# Multiple Linear Regression - Introduction

- First step into **Multivariate statistics**
- 1 dependent variable $Y$ (should be continuous), multiple regressors $X_1, X_2, \ldots X_k$ (can be quantitative, ordinal)
- Can *control* the effect of $X_i$ : disentangling effects of multiple independent variables.
- Determine which variable is the strongest predictor

# Multiple Linear Regression - Model

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k + \epsilon$$

## Partial derivatives

- Each coefficient is calculated by **holding all others constant** (*ceteris paribus*)
- It represents *net effects* (that's why control variables are so important).

## Least squares

The model is still optimized by minimizing the squared error terms

## Warning

The model is still assuming *linear*, *additive* relationships.

**Does skipping lectures affect your educational attainment ?**

- **Dependent Variable** : $GPA$ score after graduation
- **Independent Variable** : Average nb of skipped lectures per week
- **Controls** :
  - High School GPA
  - Parents are college graduate
  - Has a personal computer
  - Gender
  - Age
  - Weekly alcohol consumption

## Stata

### Without controls

`reg colGPA skipper`

```
. reg colGPA skipped, beta
```

| Source | SS | df | MS | | |
|---|---|---|---|---|---|
| Model | 1.33028272 | 1 | 1.33028272 | Prob > F | 0.0017 |
| Residual | 18.0758167 | 139 | .130041847 | R-squared | 0.0685 |
| | | | | Adj R-squared | 0.0618 |
| Total | 19.4060994 | 140 | .138614996 | Root MSE | .36061 |

| Number of obs | = | 141 |
|---|---|---|
| F(1, 139) | = | 10.23 |

| colGPA | Coef. | Std. Err. | t | P>\|t\| | Beta |
|---|---|---|---|---|---|
| skipped | -.0895215 | .0279896 | -3.20 | 0.002 | -.26182 |
| _cons | 3.153084 | .0427751 | 73.71 | 0.000 | . |

## Stata

### With controls

```
reg colGPA skipped hsGPA PC male age alcohol, beta
```

| Source | SS | df | MS | | |
|---|---|---|---|---|---|
| Model | 5.26849772 | 6 | .878082954 | Number of obs | = 141 |
| Residual | 14.1376017 | 134 | .10550449 | F(6, 134) | = 8.32 |
| | | | | Prob > F | = 0.0000 |
| | | | | R-squared | = 0.2715 |
| | | | | Adj R-squared | = 0.2389 |
| Total | 19.4060994 | 140 | .138614996 | Root MSE | = .32481 |

| colGPA | Coef. | Std. Err. | t | P>\|t\| | Beta |
|---|---|---|---|---|---|
| skipped | -.0765573 | .0276927 | -2.76 | 0.007 | -.2239042 |
| hsGPA | .4910405 | .0911268 | 5.39 | 0.000 | .4219506 |
| PC | .1345645 | .0575223 | 2.34 | 0.021 | .1774824 |
| male | .018962 | .0598633 | 0.32 | 0.752 | .0255246 |
| age | .0262554 | .0226128 | 1.16 | 0.248 | .0896358 |
| alcohol | .0309068 | .0222811 | 1.39 | 0.168 | .1141188 |
| _cons | .7980128 | .6400507 | 1.25 | 0.215 | . |

# Dummies in a regression

## Single coefficient

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 (0) + \epsilon$$
$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 (1) + \epsilon$$

The omitted category $X_3 = 0$ is called the **reference category** and is part of the **baseline model** $Y = \alpha$, for which all coefficients are null.

## Example

$$Income = \alpha + \beta_1 age + \beta_2 education + 0.male + \epsilon$$
$$Income = \alpha + \beta_1 age + \beta_2 education + 1.female + \epsilon$$

# Categorical variables

Categorical variables can be used as **dummies**, e.g. binary recodes of each category that are tested agains a **reference category** to provide coefficients for the net effect of each category.

## Stata

```
reg colGPA skipped hsGPA i.grad, beta
```

| Source | SS | df | MS | Number of obs | = | 141 |
|---|---|---|---|---|---|---|
| | | | | F(5, 135) | = | 7.90 |
| Model | 4.39380249 | 5 | .878760499 | Prob > F | = | 0.0000 |
| Residual | 15.012297 | 135 | .1112022 | R-squared | = | 0.2264 |
| | | | | Adj R-squared | = | 0.1978 |
| Total | 19.4060994 | 140 | .138614996 | Root MSE | = | .33347 |

| colGPA | Coef. | Std. Err. | t | P>\|t\| | Beta |
|---|---|---|---|---|---|
| skipped | -.0795378 | .0261501 | -3.04 | 0.003 | -.2326212 |
| hsGPA | .4429045 | .0910527 | 4.86 | 0.000 | .3805873 |
| grad | | | | | |
| 2 | .1133509 | .1988868 | 0.57 | 0.570 | .0440907 |
| 3 | -.0290666 | .0615775 | -0.47 | 0.638 | -.0391736 |
| 4 | -.0096835 | .1035004 | -0.09 | 0.926 | -.0075515 |
| _cons | 1.648639 | .3241498 | 5.09 | 0.000 | . |

## Radio and the Rise of the Nazis in Prewar Germany

*(QJE 2015)*

*Adena, Enikolopov, Petrova, Santarosa, and Ekaterina Zhuravskaya*

### Motivation

- Dictators often come to power through a democratic process rather than military coups
  - Examples : Mugabe, Lukashenko, Chavez, Hitler
- How do future dictators persuade voters to support them ?
- When is propaganda more and less effective ?

Slides from material of E.Zhuravskaya

**Main messages**

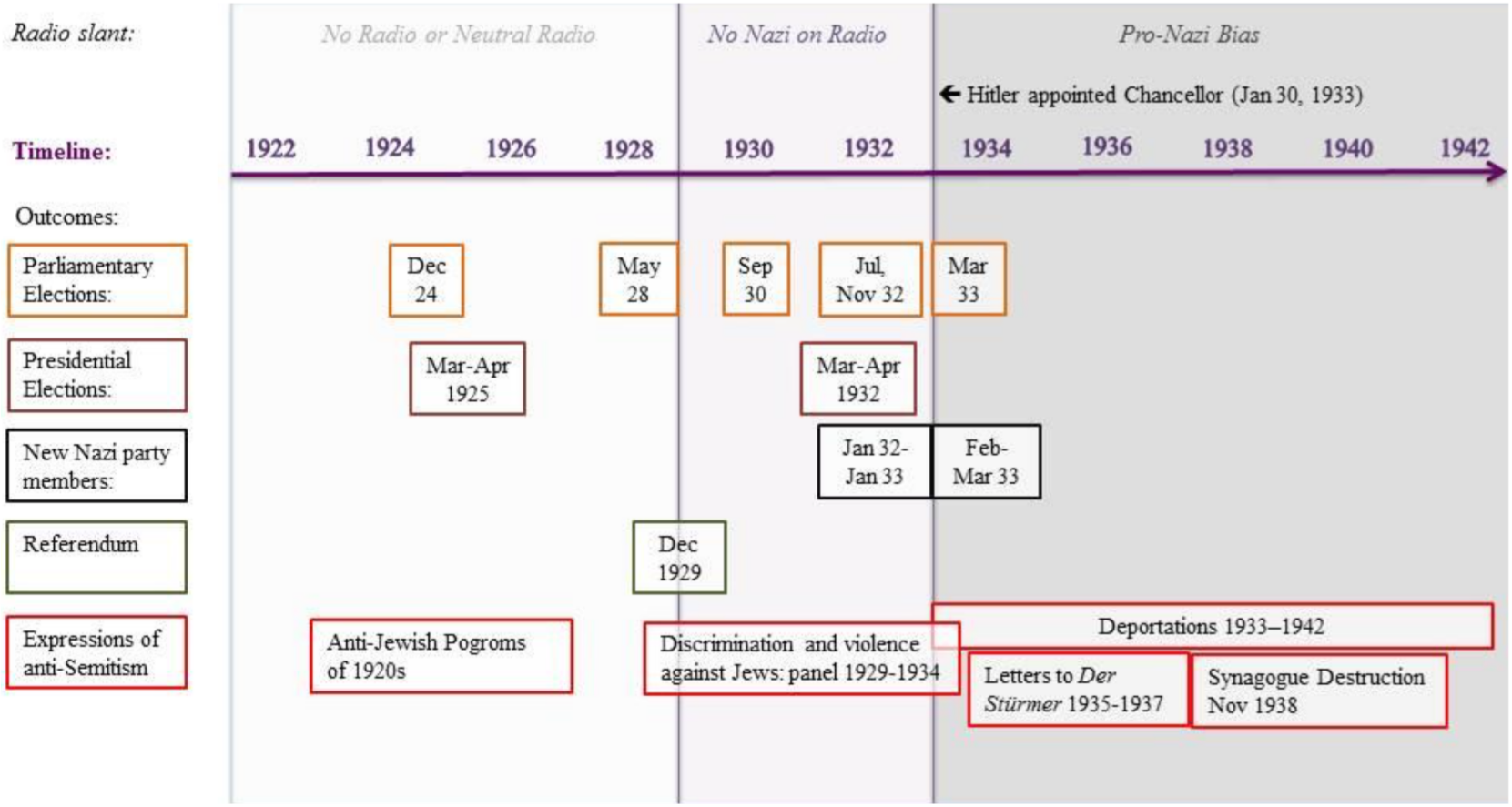
- Whether future dictators or pro-democratic forces have control over mass media and whether extremist speech is allowed plays a role in preservation or collapse of immature democracies
- Propaganda can be very effective in maintaining popular support for dictator's policies, but it can also backfire and lead to lower support for the dictator
  - depending on listeners predisposition to the message

**Why Nazi Germany ?**

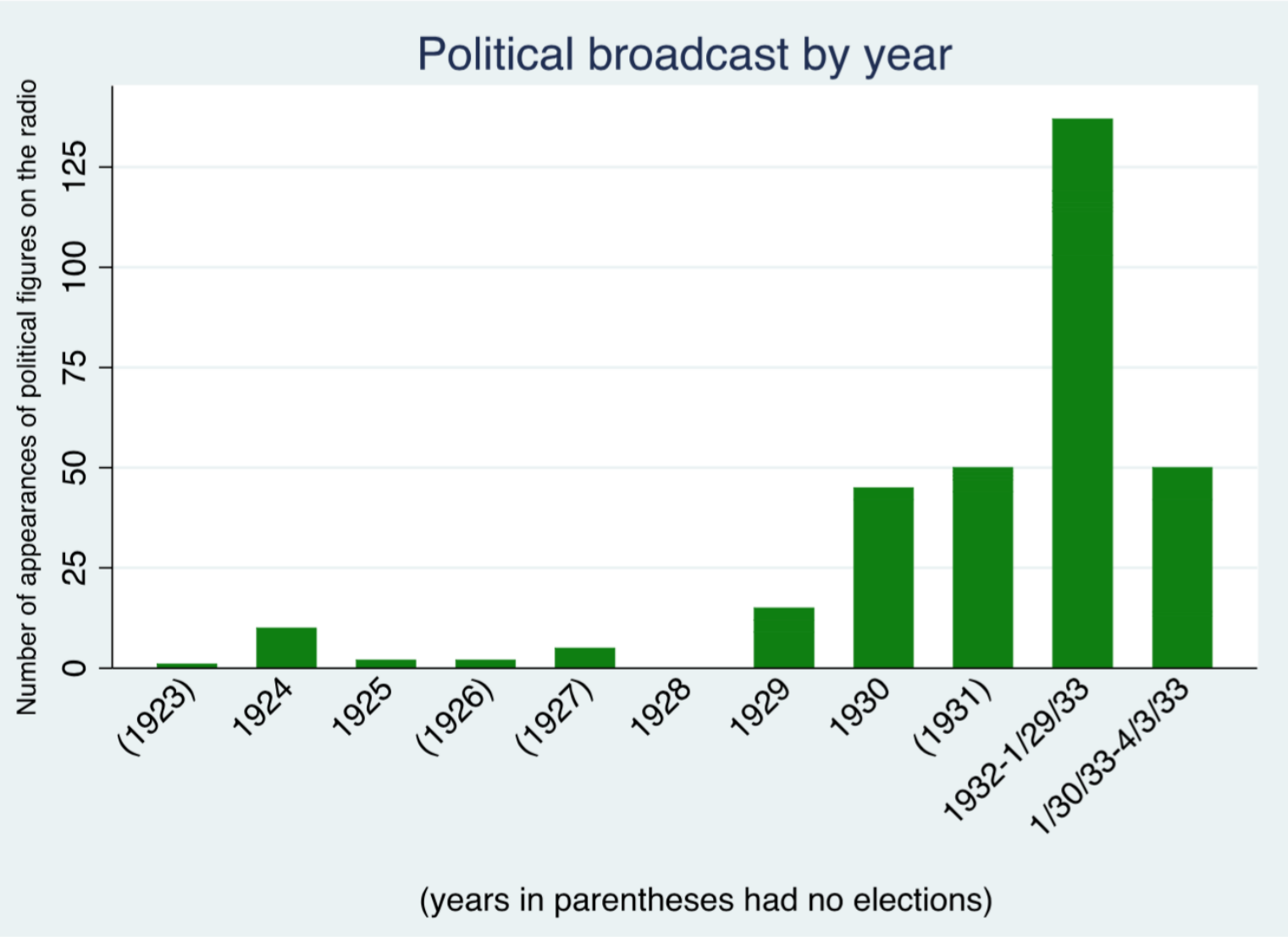
- The rise of the Third Reich is the most prominent example of a collapse of democracy without a military coup.
  - The Nazis won the March 1933 election (Nazi party got 43.9% of popular vote +8% for DNVP, their coalition partner) ; 18 days later parliament passed the Enabling Act.
- The Nazis themselves strongly believed in media power.
  - Aug 1933 : J.Goebbels "It would not have been possible for us to take power or to use it in the ways we have without the radio."

# How does propaganda work ?

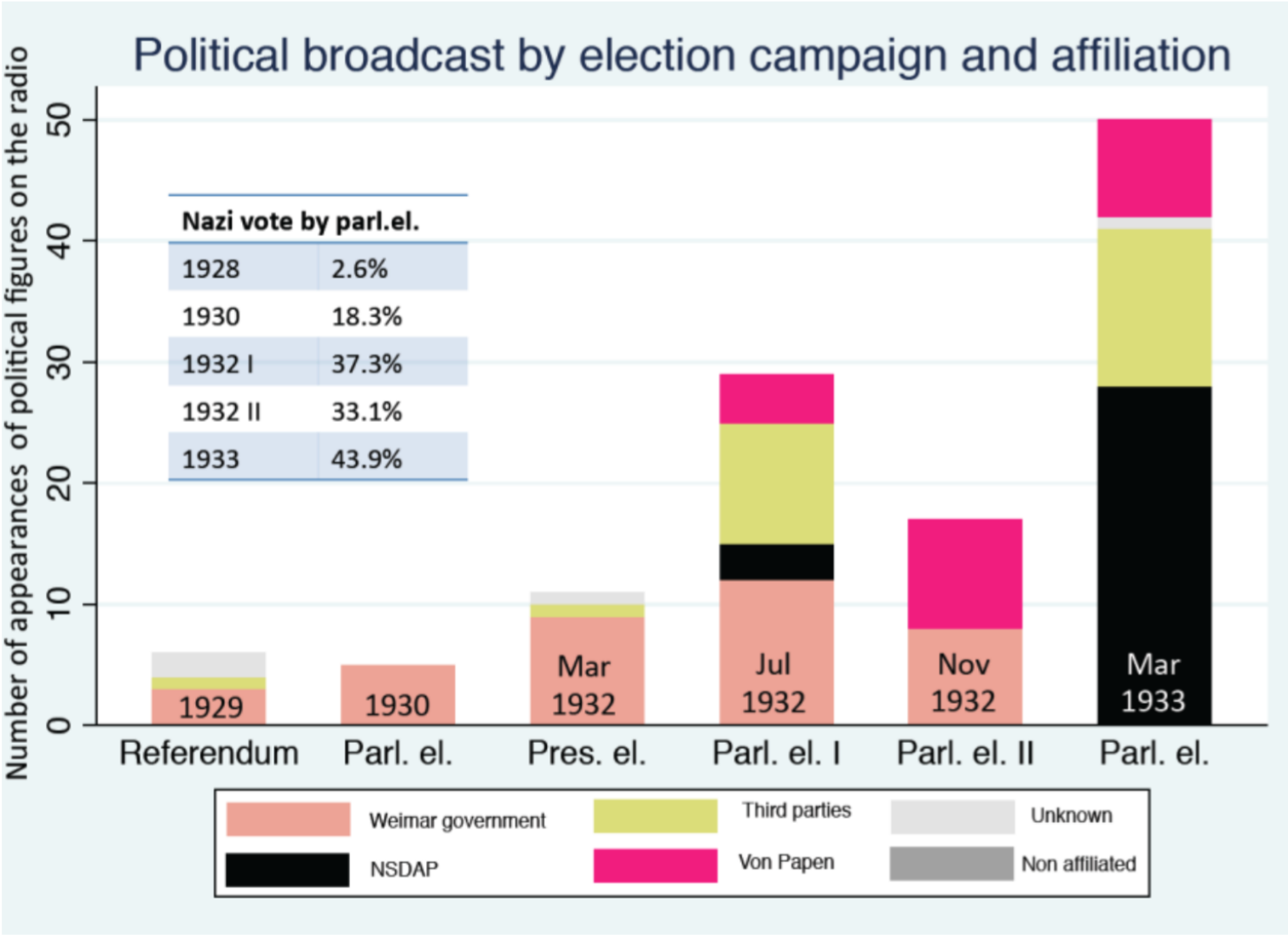




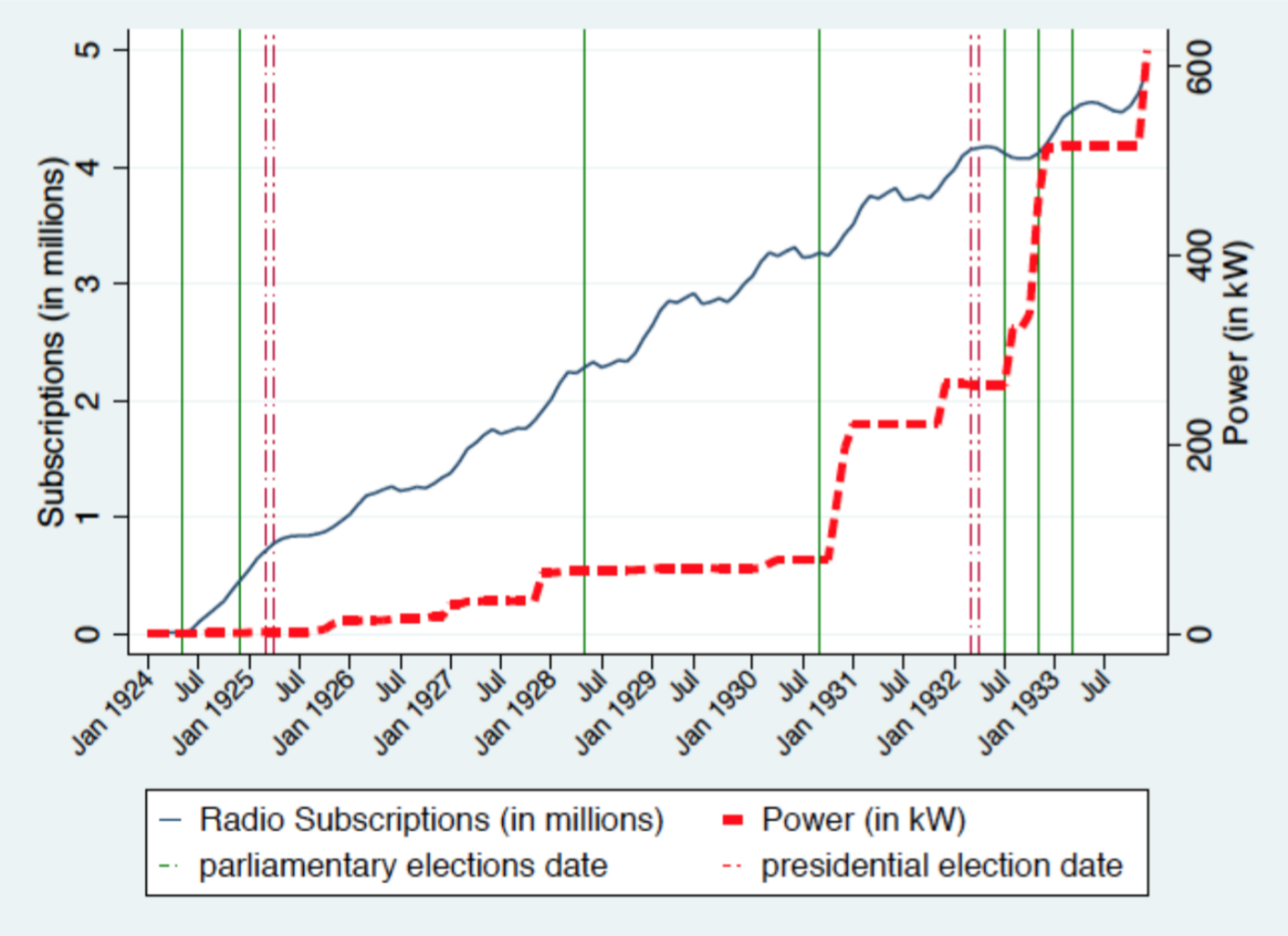
## Radio became more and more political



## Access to radio was unequal



## Radio expanded quickly



## Cross-section on first difference

$$\Delta y_{it} = \beta_{0t} + \beta_{1t} RadioExposure_{it} + \beta_{2t} X_{it} + \phi_p + \epsilon_t$$

With :

- $y_{it}$ share of votes for the Nazis
- $RadioExposure_{it}$ signal strength
- $X_{it}$ a vector of controls
  - Determinants of transmitter location
  - Socio-economic controls : census variables, including shares of Jews and Catholics, blue- and white-collar workers, WWI participation, property tax, welfare recipients
  - Voting preferences in 1924
  - Robust to controlling for newspapers, cinemas, and location of Hitler's speeches
- $\phi_p$ provinces fixed effects

## Output

**Panel A. Reduced form estimation**

| | Change in Vote Share of the Nazi Party Since Previous Elections | | | |
|---|---|---|---|---|
| *Election dates:* | *Sep 1930* (*Change from May 1928*) | | *Mar 1933* (*Change from Nov 1932*) | |
| | (1) | (2) | (3) | (4) |
| Radio signal strength | -0.061*** | | 0.045** | |
| | [0.022] | | [0.020] | |
| Radio Signal Strength, non-linear transformation | | -0.217*** | | 0.128* |
| | | [0.071] | | [0.071] |
| Region fixed effects | Yes | Yes | Yes | Yes |
| Baseline controls | Yes | Yes | Yes | Yes |
| Observations | 958 | 958 | 918 | 918 |

# Research advices

**Describe the overall model**

- Total number of observations
- R-Squared
- *p*-value of the overall model (*F*-statistic)

**Describe the coefficient fof your IVs**

- *ceteris paribus*, what is the effect of $x$ on $y$
- sign of the coefficient
- *p*-value of the coefficient
- Interpret the standardized coefficient, $\beta$, in order to compare the magnitude of each independent variable.

⚠ **Only the magnitude of the betas can be compared between independent variables, not the coefficients**

## Summarizing a Multiple Linear Regression Model

*"We ran a multiple regression analysis to examine the determinants of perception of the environment in France. Four predictors were included in the model : education, social class, trust in government, and age. Together, these factors account for 12% of the variance in environmental perceptions (R- Squared=0.12). All the variables except social class are signficiant (the p-values associated to the coefficients are lower than 0.05). Education and trust in government are the strongest predictors (beta=0.20) and are positively associated with environmental perceptions. Age is negatively related to environmental perceptions."*

# Descriptive and inferential bivariate statistics

**Describe the Relationship**

- Both variables are continuous `sc, pwcorr`
- If IV is a dummy : compare means `bysort, ttest`
- Both variables are categorical Cross-tabulations, Cramer's V

**Signifiance**

- Look at $p$-values of each kind of test (ttest, $\chi_2$)

# Don't confuse **Strengh** and **Significance**

- Cramer's V and Pearson's R are **not** statistical tests, but tell you the strength of the association ;
- Chi-2 and t-tests are **statistical tests** : they tell you whether the relationship is significant or not ;
- The `pwcorr` command with option `sig` or `star` provides both : Pearson's R and significance of the correlation ;
- In a regression model, the R-squared tells you the explanatory power of the predictor variables ;
- The *p*-values associated to the coefficients in the regression model tell you the statistical signifiance of the predictor.