



مؤسسه عالی آموزش و پژوهش
مدیریت و برنامه ریزی

اقتصادسنجی برای توسعه

چگونه علیت را از همبستگی جدا کنیم؟

Econometrics for Development

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موسسه نیاوران





اقتصاد سنجی برای توسعه

Econometrics for Development

Let's start with a real policy question:

– Does foreign aid improve economic development?

- Proponents of aid largely believe that aid will help countries make good investments and develop
- Skeptics say it is ineffective, or even hurt countries for various reasons (e.g., lead to more corruption, which hampers development)

It is therefore arguably important to understand the effects of foreign aid

QUESTION:

What factors might explain the correlation between aid and income?

Specifically, which of the following explanations do you think is the primary one?

1. Aid hampers GDP
2. Low GDP leads to more aid
3. Other factors determine both aid and GDP

Graph reflects: “Causal” Relationship

Graph reflects: “Reverse Causality”

Graph reflects: “Omitted Variable Bias”

Econometrics is a set of statistical techniques for exploring empirical relationships between variables.

"Relationship" can take two forms:

1. Correlation (or association): To say that a variable X is correlated (or associated) with a variable Y means that the variables “move together” in the data.
 - If X and Y are correlated (or associated), then knowing the value of X helps you predict the value of Y (and vice versa).

2. Causation: To say that a variable X is causally related to a variable Y means that changing the value of X in reality would lead to a change in the value of Y .

The important question for a policymaker is whether this relationship is causal.



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چالش ۱: سایر متغیرها موثر

Causality means that changes in a specific factor (X) lead to changes in an outcome (Y).

Challenge1: Y may be a function of many factors other than X.

We want to measure any changes in Y that are directly attributable to a change in X, not to these other factors. To do so, we have to think about the : **counterfactual**

counterfactual:

– Ask yourself “What would have happened otherwise if X did not occur?”

QUESTION: What is the counterfactual for the following example:

– Does getting a Master in Economics (X) affect your job prospects (Y)?

- The counterfactual: your job prospects (Y), had you never got the Master in Economics.

Challenge2: The challenge of causal inference is that we never observe the counterfactual!

Thus, we would like to “mimic” the counterfactual using data and statistical techniques (econometrics)

Variation in place or time ,...

credibility of research?

III – VALIDITY

- Validity represents a set of criteria by which the credibility of research may be judged.
- 1. Internal validity:** Does the relationship capture the causal effect of interest for the population represented by our sample?
 - 2. External validity:** Are the findings generalizable?
 - Do the conclusions hold for other places, times, or types of people?
 - Do other empirical studies investigating the similar research questions yield similar results?

Conceptually, randomized experiments are the "gold standard", the ideal method for estimating the causal effect of a "treatment" (program, intervention, etc.).

– Random assignment studies, social experiments, randomized controlled trials, randomized trials, etc.

– Tens of thousands have been run in the social sciences, and **hundreds of thousands in medicine.**

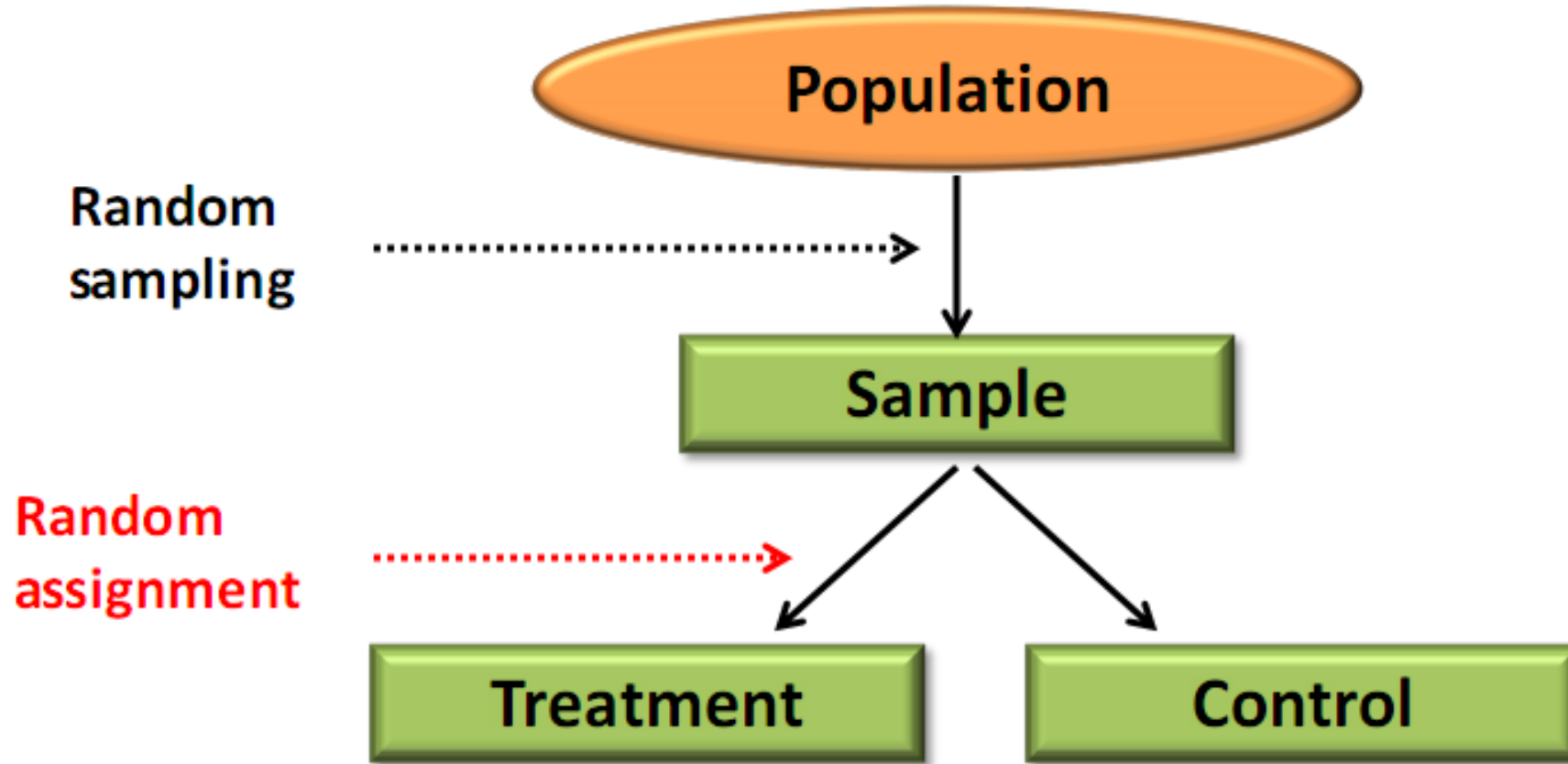
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روش طلایی: گام های کلیدی آزمایش تصادفی



The basic approach:

1. A sample of individuals is obtained from a population
2. Each individual is then randomly assigned to the treatment or control group
3. The treatment group is offered the treatment
4. The control group is not offered the treatment (and may get a placebo). The control group is meant to mimic the counterfactual

Compares two groups that are similar except for the “treatment”

- Example: Pacific Access Category (PAC) - New Zealand's immigration policy
- PAC allows 250 Tongans per year to migrate to New Zealand
- Given that more applications are received than the allowed quota, the Department of Labor randomly selects people from the applicant pool
 - Treatment: Successful ballots
 - Control: Unsuccessful ballots
 - This allows to test the effect of migration on earnings

Check whether the randomization generated two similar groups of individuals:

1. Review the protocol for the experiment and assess if it was followed
2. Check if the treatment and control groups are comparable prior to the treatment

Below is a table with mean background characteristics of the two groups, along with p-values from a t-test of the null hypothesis that the means of the two groups are equal:

	Unsuccessful ballots	Successful ballots	Difference	p-value
Age	33.859	33.500	-0.359	(0.740)
Years	11.641	12.108	0.467	(0.185)
Male (%)	0.513	0.583	0.071	(0.332)
Born on Tongatapu	0.795	0.758	-0.037	(0.551)
Height	169.592	171.740	2.148	(0.141)
Past Income	76.630	83.651	7.021	(0.567)
following family members living in NZ (%)				
Father / father-in-law	0.449	0.333	-0.115	(0.103)
Mother / mother-in-law	0.346	0.367	0.021	(0.770)
Brother / brother-in-law	0.705	0.733	0.028	(0.667)
Sister / sister-in-law	0.603	0.617	0.014	(0.843)

Based on the table above, did randomization “work”?

1. Yes
2. No
3. The table is irrelevant

To explore the effect of migration on income, we will perform:

– Estimation: What is the difference in means between the two groups?

–Hypothesis Testing: Are these means equal?

REVIEW OF BASIC HYPOTHESIS TESTING :

– Recall from we want to test the null hypothesis that the two groups of individuals have the same mean earnings, or:

$$H_0: \mu_S = \mu_U$$

(the subscripts denote "Successful Ballots" and "Unsuccessful Ballots")

To test this hypothesis, we need to construct the t-statistic:

$$t = \frac{\bar{Y}_S - \bar{Y}_U}{SE(\bar{Y}_S - \bar{Y}_U)}$$

$$SE(\bar{Y}_S - \bar{Y}_U) = \sqrt{\frac{(\sigma_{Y_S})^2}{N_S} + \frac{(\sigma_{Y_U})^2}{N_U}}$$

Stata output describing income variable (weekly income from work in New Zealand dollars) for unsuccessful applicants (=0) and successful applicants (=1):



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مثال ۱: سیاست مهاجرتی نیوزلند

```
. tab ballotsuccess if princapp==1 , sum(workincome)
```

ballotsucce ss	Summary of workincome		
	Mean	Std. Dev.	Freq.
0	104.05073	103.95111	78
1	265.77102	316.064	119
Total	201.73963	265.84575	197

difference in income of individuals:

$$265.77 - 104.05 = 161.72$$

QUESTION: What is the value of the t-statistic for testing the null hypothesis that the two groups have the same mean income?

$$SE(\bar{Y}_S - \bar{Y}_U) = \sqrt{\frac{(\sigma_{Y_S})^2}{N_S} + \frac{(\sigma_{Y_U})^2}{N_U}} = \sqrt{\frac{(103.95)^2}{78} + \frac{(316.06)^2}{119}} = 31.27$$
$$t = \frac{\bar{Y}_S - \bar{Y}_U}{SE(\bar{Y}_S - \bar{Y}_U)} = \frac{161.72}{31.27} = 5.17$$

QUESTION: Can you reject this null hypothesis? In other words, is this difference statistically significant at the 5% level? Explain in words what this means.

QUESTION: What is the value of the t-statistic for testing the null hypothesis that the two groups have the same mean income?

$$t = \frac{\bar{Y}_S - \bar{Y}_U}{SE(\bar{Y}_S - \bar{Y}_U)} = \frac{161.72}{31.27} = 5.17 > 1.96$$

- ✓ Reject the null hypothesis.
- ✓ That is, if there truly was no difference in the “population”, there is less than a 5% chance we would see a mean difference as large as 161.72



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مثال ۱: سیاست مهاجرتی نیوزلند

Does this study of the effects of migration have high internal validity?

A. Yes B. No

Does it have high external validity?

1. Yes 2. No 3. It depends

QUESTION: Does this study of migration have high internal validity?

– Yes, if the experiment was implemented properly in practice then it will capture a causal effect.

QUESTION: What about external validity?

– It depends on the context we want to extrapolate the results to.

– For example, can we extrapolate the results to Tongan migrants to Australia? Arguably yes. (hence, external validity in this case is high).

– British migrants? That's more problematic. (hence, external validity in this case is not very high).

– Also, you have to think about whether this study would remain relevant 20 years from now



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مطالعه بر اساس مشاهدات (ازمایش طبیعی)

OBSERVATIONAL STUDY

- The randomized experiment allowed us to isolate the impact of migration separately from other factors—this, we can conclude that migration caused an increase in income
- What can you do if you do not have a randomized experiment?

Observational Study: the researcher analyzes data from a situation over which he or she has had no control.



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مطالعه بر اساس مشاهدات (ازمایش طبیعی)

OBSERVATIONAL STUDY

Consider an observational study from Tonga:

- In addition to lottery participants, the authors also interviewed individuals who did not apply to PAC and who are from the same villages as applicants.
- For each individual, we have income (weekly income from work in New Zealand dollars) that will be our outcome Y and we know whether she is a migrant that will be our explanatory variable X

We can also use estimation and hypothesis testing to learn if those who migrated had different incomes than those who did not

```
. tab migrate , sum(workincome)
```

migrate	Summary of workincome		
	Mean	Std. Dev.	Freq.
0	48.598356	79.655825	739
1	307.272	323.91913	125
Total	86.022205	169.68074	864

QUESTION: What is the difference in income between migrants and non-migrants?

$$307.27 - 48.6 = 258.67$$

$$t = \frac{\bar{Y}_S - \bar{Y}_U}{SE(\bar{Y}_S - \bar{Y}_U)} = \frac{258.67}{29.12} = 8.88$$

- Yes, reject the null hypothesis.
- Migrants are associated with significantly higher income.

Now let's compare the characteristics of individuals who migrated and those who did not:

	Non-migrants	Migrants	Difference	p-value
Age	23.242	21.307	-1.935	(0.041)
Years of Education	5.952	3.274	-2.678	(0.000)
Male (%)	0.502	0.503	0.001	(0.978)
Born on Tongatapu	0.771	0.762	-0.009	(0.706)
Height	146.000	148.921	2.921	(0.219)
Past Income	40.817	64.064	23.247	(0.001)
following family members living in NZ (%)				
Father / father-in-law	0.328	0.265	-0.063	(0.013)
Mother / mother-in-law	0.285	0.313	0.027	(0.271)
Brother / brother-in-law	0.671	0.759	0.089	(0.000)
Sister / sister-in-law	0.553	0.580	0.027	(0.313)

QUESTION: What do the p-values tell you about these two groups?



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مطالعه بر اساس مشاهدات (ازمایش طبیعی)

Migration is also associated with socio-economic characteristics. Specifically, migrants:

- are younger
- have fewer years of education
- have higher past income
- are less likely to have a father/father in law already living in New Zealand
- are more likely to have a brother/brother in law already living in New Zealand



اقتصاد سنجی برای توسعه

مطالعه بر اساس مشاهدات (ازمایش طبیعی)

QUESTION: Does this study of migration have high internal validity?

– No! Since migrants are so different already to begin with, we cannot isolate the causal effect of migration with any certainty

QUESTION: What about external validity?

– It depends on the context we want to extrapolate the results to.

– For example, we may expect a very similar correlation for other Tongan migrants, but not for British migrants.

Most importantly, from a policy making perspective, there is little point in extrapolating a result that has very low internal validity.



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جمع بندی: مطالعه بر اساس مشاهدات (ازمایش طبیعی)

CONCLUSION

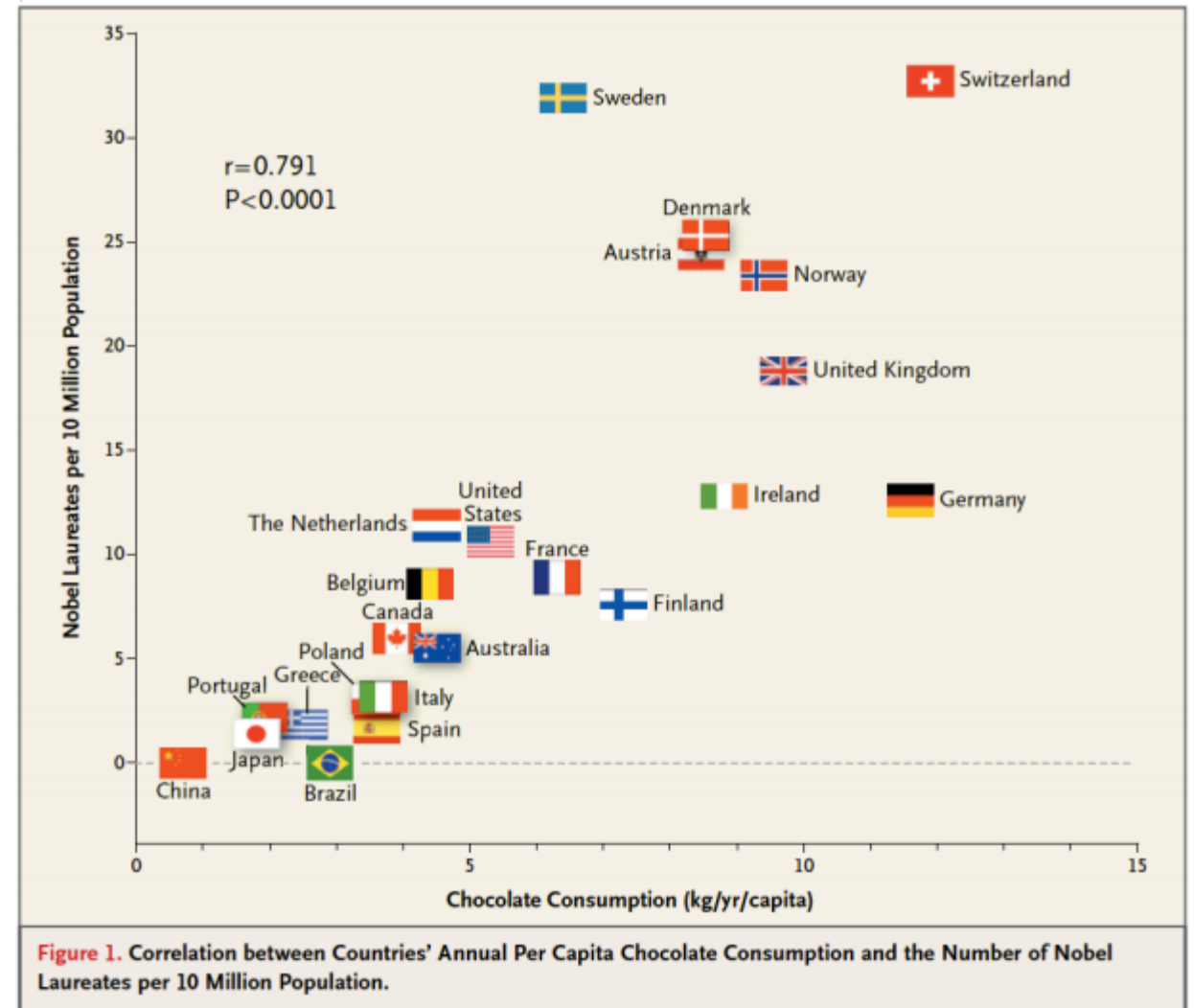
- In observational studies, the difference in mean outcomes between groups is not usually a good estimate of a causal effect because the groups often differ in ways other than the factor of interest.
- Econometrics provides statistical techniques that allow us to try to isolate the “causal” effect of X on Y when we have observational data

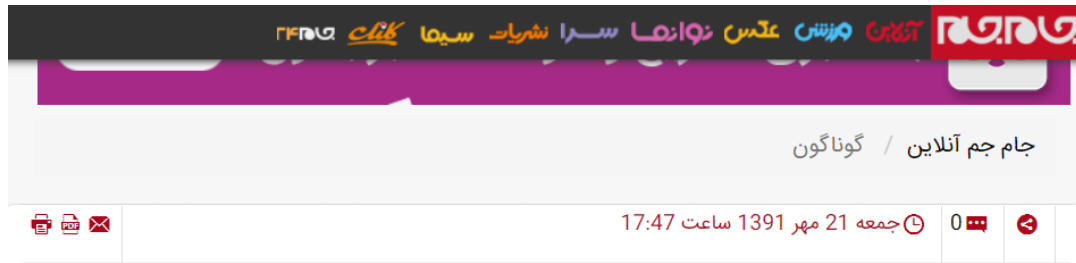


The NEW ENGLAND
JOURNAL of MEDICINE

Chocolate Consumption, Cognitive Function, and Nobel Laureates

Dietary flavonoids, abundant in plant-based foods, have been shown to improve cognitive function. Specifically, a reduction in the risk of dementia, enhanced performance on some cognitive tests, and improved cognitive function in elderly patients with mild impairment have been associated with a regular intake of





شکلات بخورید برنده جایزه نوبل شوید

هرچه می توانید شکلات بخورید تا شانس شما برای دریافت جایزه نوبل افزایش یابد.

به گزارش روز جمعه جام جم آنلاین به نقل از رویترز، براساس مطالعه ای که در نشریه پزشکی "New England Journal of Medicine" منتشر شد، هرچه در یک کشور مصرف شکلات بیشتر باشد به نسبت جمعیتش تعداد بیشتری جایزه نوبل دریافت می کند.

در واقع، از این نظر سوئیس در صدر فهرست است و سوئد و دانمارک مقامهای بعدی را در اختیار دارند.

آمریکا که در اواخر فهرست قرار دارد باید مصرف سالیانه شکلاتش را 125 میلیون کیلو گرم افزایش دهد تا به نام آن یک نفر به دریافت کنندگان نوبل این کشور افزوده شود.

ارتباط جایزه نوبل و خوردن شکلات

تحقیقات جدید دانشمندان مصرف شکلات را با تعداد برندگان جایزه نوبل در یک کشور مرتبط دانسته و نشان داده است که مصرف شیرینی می تواند به قدرت مغز بیافزاید.

به گزارش افکارنیوز به نقل از مهر، براساس نتایج تحقیقاتی که در مجله پزشکی نیوانگلند منتشر شده، دکتر فرانز مسرلی از بیمارستان روزولت سنت لوک و دانشگاه کلمبیا در نیویورک، شواهدی وجود دارد که نشان می دهد فلاوانول ها در چای سبز و شکلات می توانند به کاهش و یا حتی وارونه شدن زوال عقل کمک کند، ادعایی که ممکن است برخی کارشناسان پزشکی با آن مخالفت کنند.

با این وجود دکتر مسرلی این مسئله که آیا سرانه مصرف شکلات در یک کشور به تعداد جوایز نوبل آن(نشانه احتمالی از عملکرد شناختی یک کشور) ارتباط دارد یا خیر پرداخته است.

این محقق با استفاده از اطلاعات برخی تولید کنندگان شکلات در ۲۳ کشور جهان به ارتباط قوی و شگفت انگیزی رسیده است.

با در نظرگیری جمعیت، سوئیس در مصرف شکلات و دریافت جایزه نوبل در صدر جدول قرار دارد. آمریکا همراه هلند، ایرلند، فرانسه، بلژیک و آلمان در میانه این جدول قرار دارند و انتهای آن چین، ژاپن و برزیل قرار گرفته است.



اقتصاد سنجی برای توسعه

مثال ۲: آیا نفرت پراکنی رسانه های جمعی می تواند موجب خشونت قومی باشد؟

Another example: Can “hate speech” broadcasted by mass media fuel ethnic violence?

- Lots of anecdotal evidence, but not solid causal evidence
- Example from 1994 Rwandan Genocide
 - Radio Television Libre des Mille Collines (RTLM) called for the extermination of the Tutsi minority population
- To investigate whether the radio station fueled participation in the genocide – whether it caused more participation – collected data on RTLM radio coverage (X) and violence (Y) in Rwandan villages.



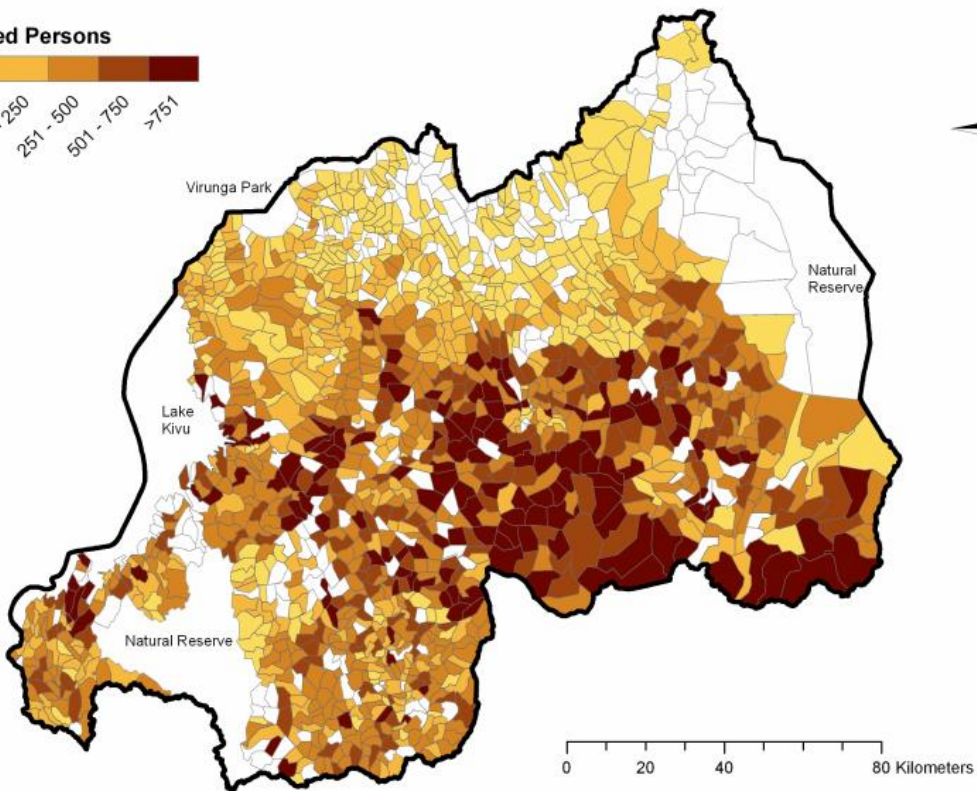
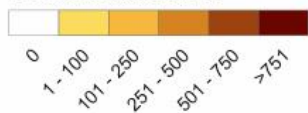
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مثال ۲: آیا نفرت پراکنی رسانه های جمعی می تواند موجب خشونت قومی باشد؟

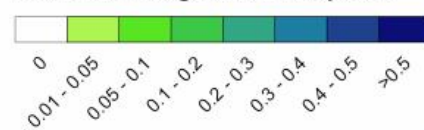
Total Violence

Prosecuted Persons

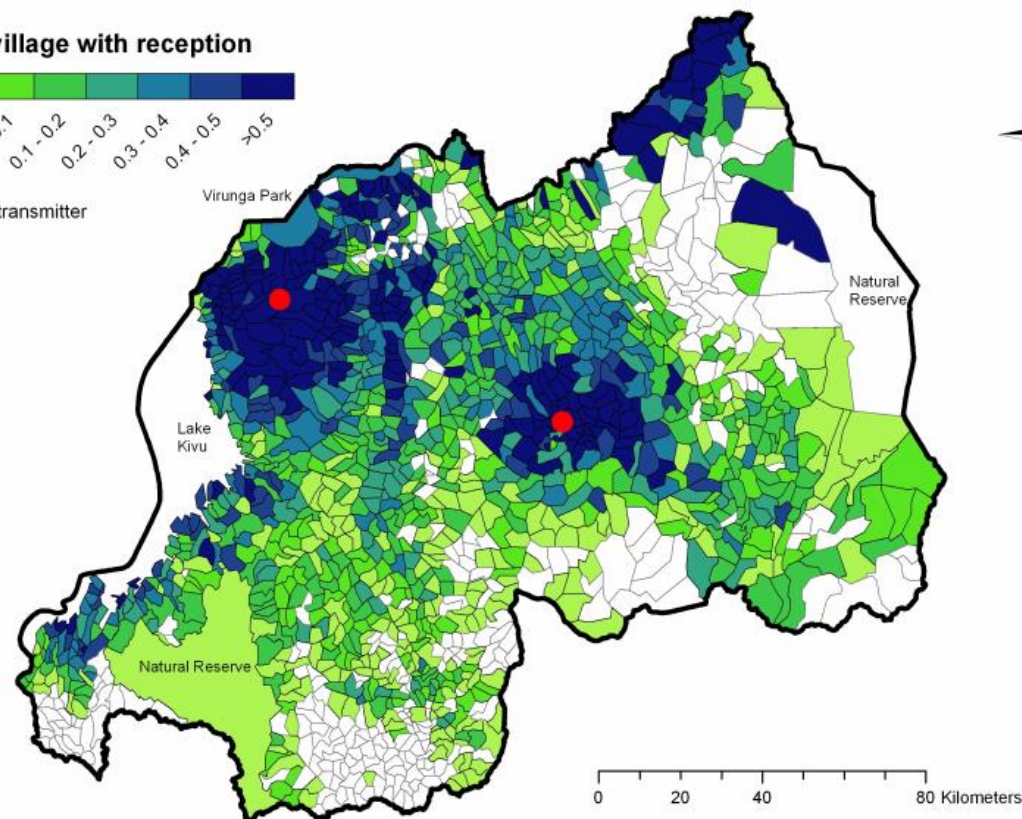


Radio Coverage, RTLM

Share of village with reception



● RTLM transmitter





اقتصاد سنجی برای توسعه

مثال ۲: آیا نفرت پراکنی رسانه های جمعی می تواند موجب خشونت قومی باشد؟

QUESTION: What other factors besides radio may determine the level of ethnic violence in a village?

- Ethnic animosity
- Militia presence
- Poverty
- Education
- Other factors...



اقتصاد سنجی برای توسعه

مثال ۲: آیا نفرت پراکنی رسانه های جمعی می تواند موجب خشونت قومی باشد؟

To estimate the causal effect of X on Y , we need to “rule out” other variables that may be partly responsible for the observed association between X and Y .

When a randomized experiment is not feasible multiple regression analysis lets us do this by letting us to “hold constant” or “statistically account for” these other variables, even in observational data.

اقتصاد سنجی برای توسعه

مثال ۲: آیا نفرت پراکنی رسانه های جمعی می تواند موجب خشونت قومی باشد؟

$$GenocideCases_i = \beta_0 + \beta_1 RTL Mreception_i + \varepsilon_i$$

Now let's look at the data set (1065 villages)

– Stata has calculated the best-fit line

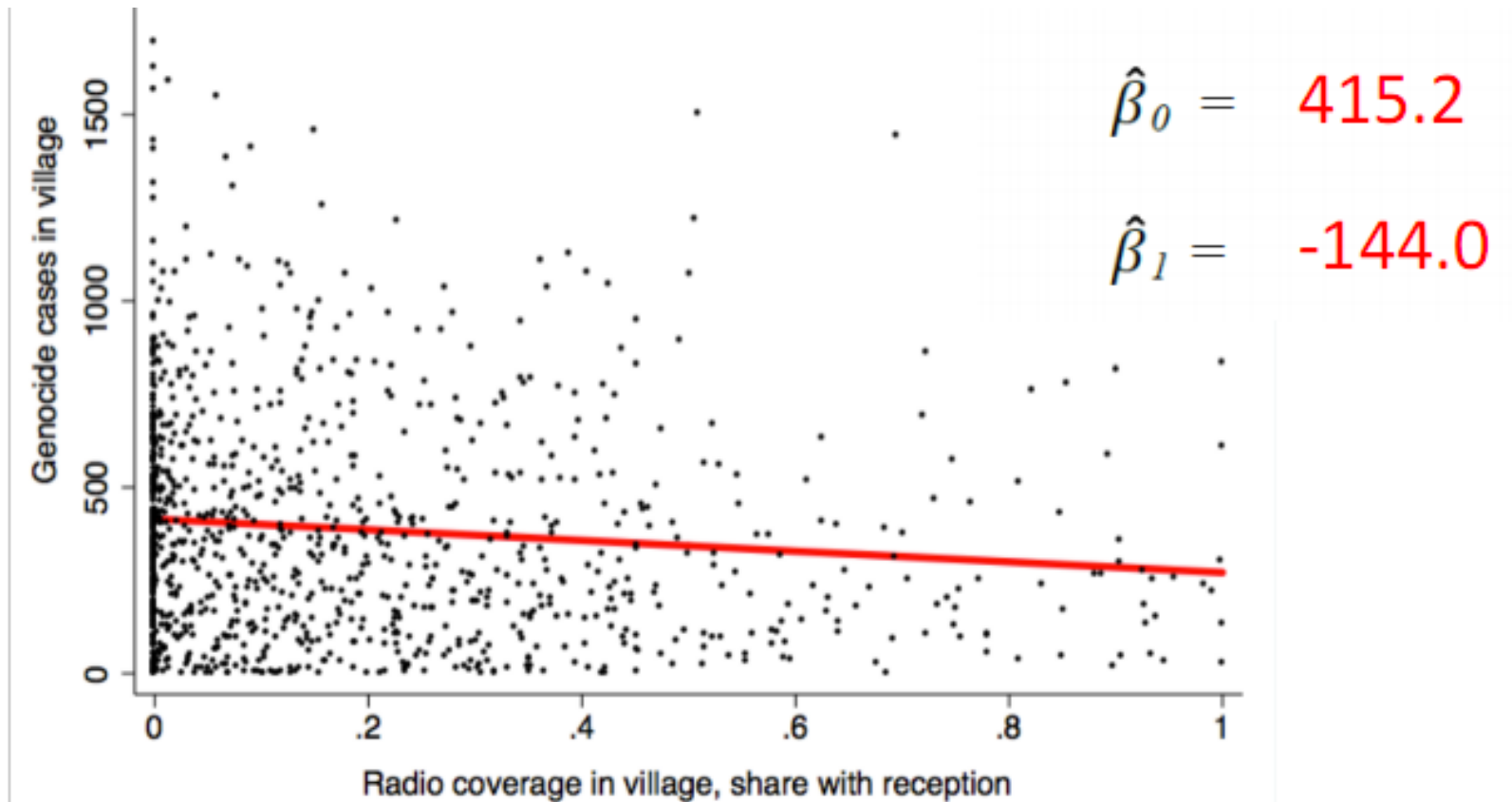
$$\widehat{GenocideCases} = 415.2 - 144.0 * RTL Mreception$$



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مثال ۲: آیا نفرت پراکنی رسانه های جمعی می تواند موجب خشونت قومی باشد؟



QUESTION: Is the association between radio coverage and genocide cases positive, negative or zero? • **Negative!**



اقتصادسنجی برای توسعه

مثال ۲: آیا نفرت پراکنی رسانه های جمعی می تواند موجب خشونت قومی باشد؟
مشکل متغیرهای متعدد موثر

The central problem with observational data is that many factors may be changing along with the factor of interest, so that isolating a single factor's causal impact is a very difficult task.

Multiple regression is one way that we try to solve this problem

Multiple regression estimates the effect of one variable (X) on another (Y), while “holding constant” other factors that may be responsible for the observed association between X and Y



اقتصاد سنجی برای توسعه

مثال ۲: آیا نفرت پراکنی رسانه های جمعی می تواند موجب خشونت قومی باشد؟
مشکل متغیرهای متعدد موثر

“Holding constant” is similar to ceteris paribus and can also be referred to as

- “holding fixed”
- “controlling for”
- “statistically accounting for”
- “conditional on”

Many other factors that determine violence that potentially could coincide with good radio reception

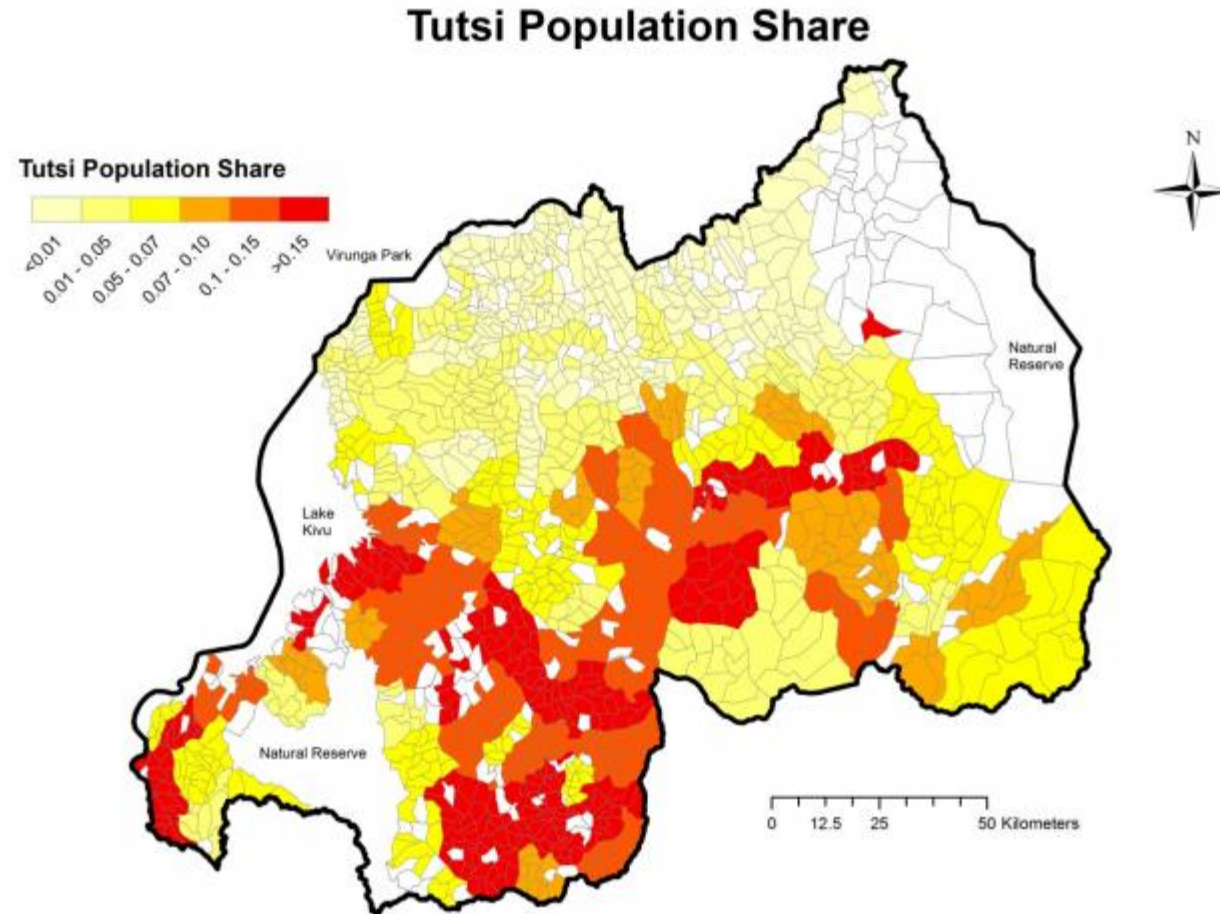


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مثال ۲: آیا نفرت پراکنی رسانه های جمعی می تواند موجب خشونت قومی باشد؟
مشکل متغیرهای متعدد موثر

- One such potential factor is the ethnic composition in the village





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مثال ۲: آیا نفرت پراکنی رسانه های جمعی می تواند موجب خشونت قومی باشد؟
مشکل متغیرهای متعدد موثر

Next, we will learn how to control for other factors

– For example, ethnic composition in the Rwanda example

We will start with the simplest case of just controlling for one factor

MULTIPLE REGRESSION WITH TWO EXPLANATORY VARIABLES

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + u$$

The most important fact for you to remember here is that:

The slope coefficient β_1 tells us the average change in Y associated with a one-unit change in X1, holding X2 constant.

اقتصادسنجی برای توسعه

مثال ۲: آیا نفرت پراکنی رسانه های جمعی می تواند موجب خشونت قومی باشد؟
مشکل متغیرهای متعدد موثر

- Regression Model #1:

```
reg genocidecase rtlm_recept, robust
```

Linear regression

Number of obs = 1065

	Coef.	Robust Std. Err.	t	P> t	[95% Conf. Interval]	
genocidecase						
rtlm_recept	-143.9731	43.42642	-3.32	0.001	-229.1843	-58.7618
_cons	415.1541	12.93184	32.10	0.000	389.7793	440.529

اقتصادسنجی برای توسعه

مثال ۲: آیا نفرت پراکنی رسانه های جمعی می تواند موجب خشونت قومی باشد؟
مشکل متغیرهای متعدد موثر

- Regression Model #2:

```
reg genocidecase rtlm_recept tutsi, robust
```

```
Linear regression                                Number of obs =      1065
```

genocidecase	Coef.	Robust Std. Err.	t	P> t	[95% Conf. Interval]	
rtlm_recept	-54.35922	45.6824	-1.19	0.234	-143.9972	35.2788
tutsi	954.5448	151.8917	6.28	0.000	656.5029	1252.587
_cons	303.6028	20.66818	14.69	0.000	263.0476	344.1579



اقتصاد سنجی برای توسعه

مثال ۲: آیا نفرت پراکنی رسانه های جمعی می تواند موجب خشونت قومی باشد؟
مشکل متغیرهای متعدد موثر

QUESTION: What is the estimated value of the RTLM reception coefficient?

- o Model 1: -144.0
- o Model 2: -54.4

QUESTION: Is this coefficient statistically significant at the 5% level?

- o Model 1: Yes. ($p = 0.001 < 0.05$)
- o Model 2: No. ($p = 0.23 > 0.05$)



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مشکل متغیرهای متعدد موثر

QUESTION: Which of these models is more likely to estimate the causal impact of RTLM reception?

- The second model

Why?

- Because in the bivariate case we cannot rule out that the association between reception and violence is driven by ethnic composition, But we can rule that out in the second model

- NOTE: The second model may not reflect a causal effect either, since there are many other important factors we are not controlling for



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مدیریت و برنامه ریزی

اقتصاد سنجی برای توسعه

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مشکل متغیرهای متعدد موثر

- How does multiple regression hold constant other factors?
- To understand this on a deeper level. **Frisch-Waugh Theorem!**
- Tells us that the β_1 we get from our multiple regression is exactly the same estimate if we:
 - STEP 1: Regress Y on X2, saving the residuals
 - STEP 2: Regress X1 on X2, saving the residuals
 - STEP 3: Regress the residuals from step 1 on the residuals from step 2

In other words, β_1 in the multiple regression, measures the relationship between "the part of Y unexplained by X2" and "the part of X1 unexplained by X2". (This is "holding constant")

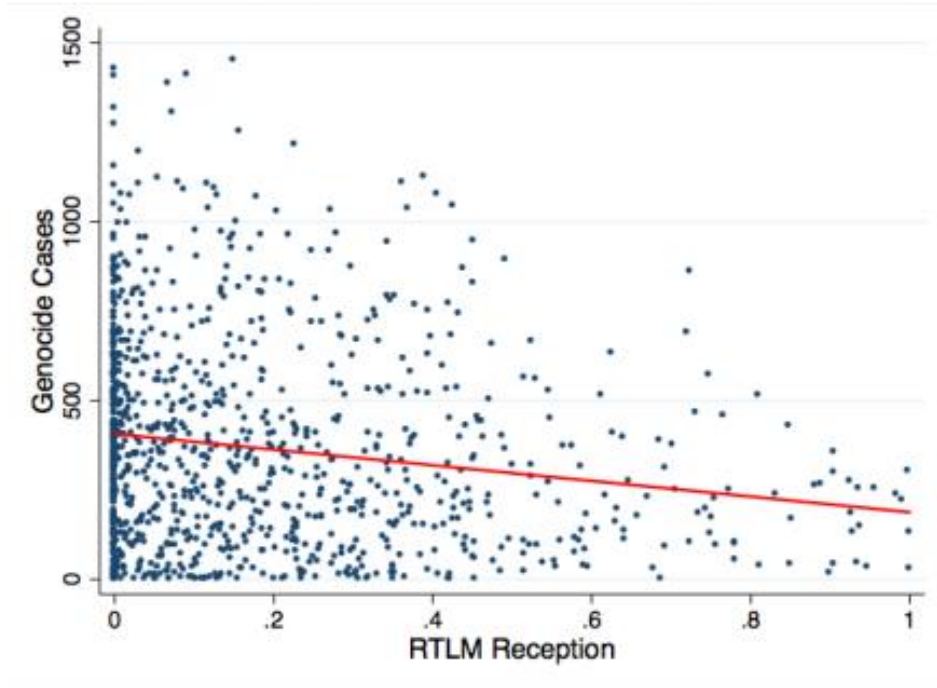


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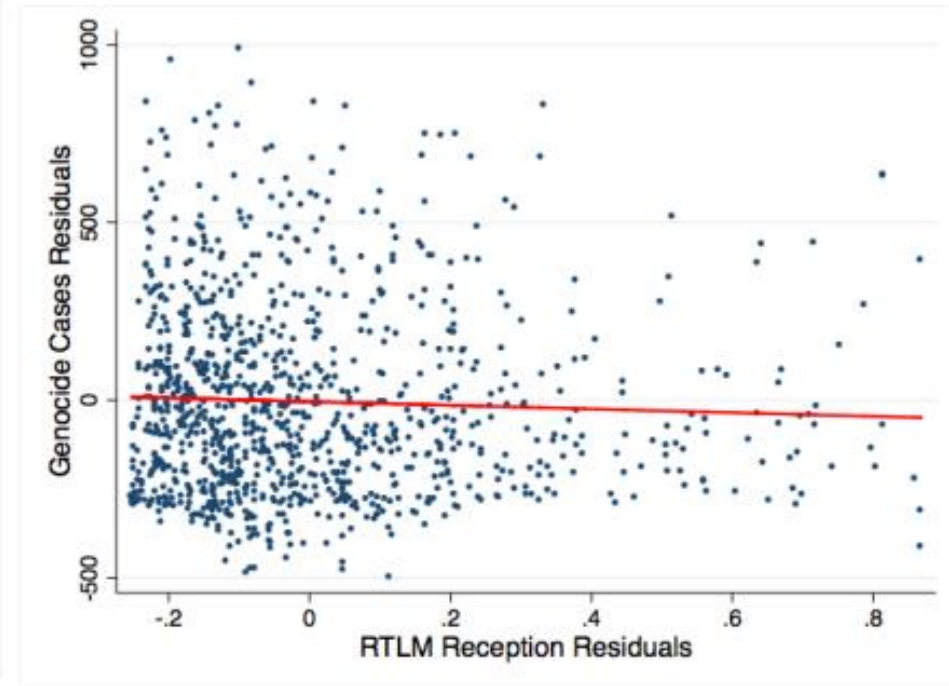
مثال ۲: آیا نفرت پراکنی رسانه های جمعی می تواند موجب خشونت قومی باشد؟
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Original bivariate regression



Negative slope

Bivariate regression from Step 3



Flat slope (almost)

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مثال ۲: آیا نفرت پراکنی رسانه های جمعی می تواند موجب خشونت قومی باشد؟
مشکل متغیرهای متعدد موثر

MULTIPLE REGRESSION MODEL WITH K EXPLANATORY VARIABLES

General case:

- PRF: $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_k X_k + u$
- SRF: $Y = \hat{\beta}_0 + \hat{\beta}_1 X_1 + \hat{\beta}_2 X_2 + \dots + \hat{\beta}_k X_k + \hat{u}$

اقتصاد سنجی برای توسعه

مثال ۲: آیا نفرت پراکنی رسانه های جمعی می تواند موجب خشونت قومی باشد؟
مشکل متغیرهای متعدد موثر

Let's return to the Rwanda example, and add two more variable

- pop: number of people living in the village in 1991
- dist_to_town: distance to the nearest major town (in kilometers)

```
reg genocidecase rtlm_recept tutsi pop dist_to_town, robust
```

Linear regression

Number of obs = 420

genocidecase	Coef.	Robust Std. Err.	t	P> t	[95% Conf. Interval]	
rtlm_recept	-47.50275	47.67281	-1.00	0.319	-141.0466	46.04106
tutsi	1141.256	145.8651	7.82	0.000	855.039	1427.473
pop	.0391106	.0090845	4.31	0.000	.021285	.0569362
dist_to_town	3.152982	.9006917	3.50	0.000	1.385641	4.920323
_cons	30.76174	42.94016	0.72	0.474	-53.49562	115.0191



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مشکل متغیرهای متعدد موثر

QUESTION: Interpret the coefficient on `rtlm_recept`.

- Full radio coverage (going from zero to full) is associated with 47 fewer genocide cases, holding constant Tutsi population share, population size, and distance to major town.

QUESTION: Is that coefficient statistically significant at the 5% level?

- No $|t|=1.00 < 1.96$



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مشکل متغیرهای متعدد موثر

Dependent variable: Number of genocide cases

	(1)	(2)	(3)
RTLM reception	-143.97*** (43.43)	-54.36 (45.68)	-47.50 (47.67)
Tutsi population share		954.54*** (151.89)	1141.26*** (145.87)
Population size			0.04*** (0.01)
Distance to the nearest major town			3.15*** (0.90)
Constant	415.15*** (12.93)	303.60*** (20.67)	30.76 (42.94)
Observations	1065	1065	1065

Robust standard errors in parentheses. Significance levels: *** 1%, ** 5%, * 10%.



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مدیریت و برنامه ریزی

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مشکل متغیرهای متعدد موثر

QUESTION: What happens to the relationship between RTLM reception and genocide violence as more controls are added to the regressions? Why do you think that is the case?

The slope becomes flatter (less negative).

Intuition: Reducing "bias".



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مدیریت و برنامه ریزی

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مشکل متغیرهای متعدد موثر: جمع بندی

CONCLUDING REMARKS

- Multiple regression estimates the effect of one variable (X) on another (Y) while holding constant other factors that may be responsible for the observed association between X and Y.
- We do this because without holding constant other factors, it is unlikely that the estimated association reflects a causal effect.
- This begs the question: Which variables do we need to control for?
 - To answer that, we will learn about “omitted variable bias”

WHAT IS OMITTED VARIABLE BIAS?

- The goal is still to estimate the causal effect of RTL M reception on violence
- We started by estimating the bivariate PRF:

$$GenocideCases = \alpha_0 + \alpha_1 RTL Mreception + v$$

QUESTION: why is the α_1 generated by this regression unlikely to provide a causal estimate of the effect of radio reception?

This is called “omitted variable bias”

Why don't we correct this problem by adding the relevant variables to the model?

Three key reasons:

1. We are looking at someone else's analysis and considering what might be wrong with it
2. We simply don't have the necessary data
3. We don't know what to control for

Therefore, it is important to understand how omitted variable bias affects our estimates

Assume the true PRF is given below:

“Long” regression (true):

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + u$$

...but we omit X , and instead we estimate the following:

“Short” regression:

$$Y = \alpha_0 + \alpha_1 X_1 + v$$

We are trying to estimate the true causal impact of β_1 but instead can only estimate a different quantity, α_1

The question is: How different are the two estimates?

Bias – the difference between the true impact (long regression) and the impact we estimate when we omit a variable (short regression):

$$\text{Bias} = \alpha_1 - \beta_1$$

You may encounter discussions of bias in which the estimated effect is described as understated or overstated, relative to the true causal effect. Also, the estimate can be incorrectly signed.

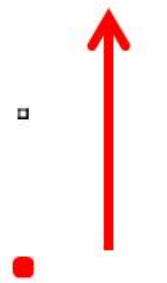
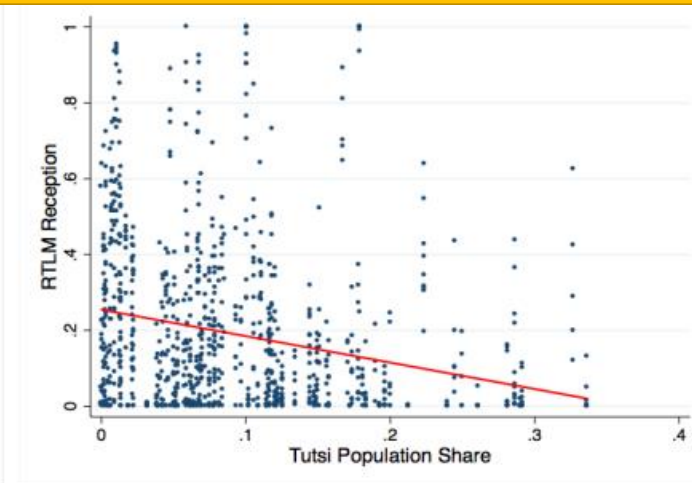
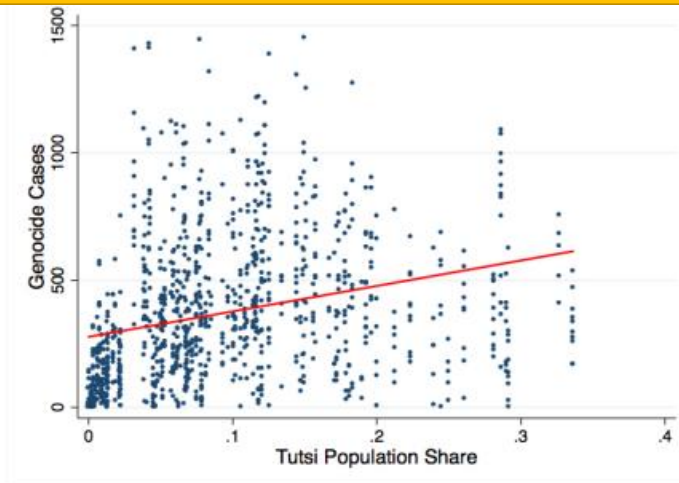
– Overstated (overestimated) “too steep”

- Omitting variable makes the magnitude of the estimate larger than the true effect in absolute terms (farther from zero)

– Understated (underestimated) “too flat”

- Omitting variable makes the magnitude of the estimate smaller than the truth

- Both cases above apply only if the estimated coefficient and true coefficient and have the same sign
 - If the true coefficient and the estimated coefficient have opposite signs, the estimate is incorrectly signed.
 - This leads to extremely incorrect conclusions about the effect of a given intervention!



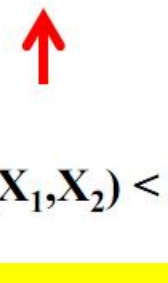
$$\text{Corr}(X_1, X_2) > 0$$

$$\beta_2 > 0$$

$$\beta_2 < 0$$

+

-



$$\text{Corr}(X_1, X_2) < 0$$



-

+

– What is the effect of democracy on public spending?

- Mulligan et al. (2004) used data from about 130 countries to assess this question
- The main results are reproduced on the next slide (standard errors in parentheses)

اقتصاد سنجی برای توسعه

تورش متغیر محذوف: دموکراسی و مخارج دولتی



Table 1
Democracy and Spending Policy across Countries

Independent variables	Dependent variable: Government consumption, 1960-1990 (each is a percentage of GDP)	
	(1)	(2)
Democracy index, 1960-1990	-1.27 (2.14)	1.57 (1.99)
Communist dummy	-0.87 (1.75)	-0.45 (1.66)
British legal origin	2.80 (1.28)	2.91 (1.17)
Percentage of population aged 65+, 1960-1990	0.01 (0.25)	0.25 (0.23)
Log(population)/10, 1960-1990	-9.77 (2.54)	-8.16 (3.36)
Real GDP per capita, 1960-1989 average, log	-2.96 (0.75)	-4.58 (0.76)
Share of value added from agriculture, 1960-1990		
Military spending, percentage of GDP		0.60 (0.14)
Adj-R-squared	.27	.38
Countries	131	125

	$\text{Corr}(X_1, X_2) > 0$	$\text{Corr}(X_1, X_2) < 0$
$\beta_2 > 0$	+	-
$\beta_2 < 0$	-	+

PARTING THOUGHTS

- Omitted variable bias is probably the single most widespread problem in studies attempting to measure the impacts of public policies or other interventions (note that internal validity is low if there is a bias)

- When you read these articles, ask yourself: is there another story that explains the pattern in the data that the researchers have found?
- With more practice, you will develop an intuition for the sign of this bias, which will help you understand more clearly how the reported impact of the policy relates to the true impact of the policy

We can capture categorical information by defining a dummy variable (i.e. a zero-one variable).

- “binary variable”
- “indicator variable”

Bribe example:

bribe = 1 if the teacher expects to pay a bribe

0 if the teacher does not expect to pay a bribe

The values zero and one are arbitrary, but this assumption makes the analysis easy to interpret. Consider the following data from 2004, covering 770 teachers

<i>observation</i>	<i>hours</i>	<i>bribe</i>	<i>nobribe</i>	<i>years</i>	<i>tot_students</i>	<i>time</i>
1	4	0	1	18	46	5
2	2	0	1	15	52	5
3	3	1	0	12	100	35
4	2	1	0	5	93	10
5	3	1	0	20	91	10
6	10	0	1	6	33	10
.
770	14	1	0	2	38	3

What are the characteristics of teacher n.3?

- Spent three hours per week preparing for class
- Was expecting to pay a bribe to access her salary
- Had taught for 12 years at the current school
- Had 100 students
- Spent 35 minutes to reach the school during the rainy season

<i>observation</i>	<i>hours</i>	<i>bribe</i>	<i>nobribe</i>	<i>years</i>	<i>tot students</i>	<i>time</i>
1	4	0	1	18	46	5
2	2	0	1	15	52	5
3	3	1	0	12	100	35
4	2	1	0	5	93	10
5	3	1	0	20	91	10
6	10	0	1	6	33	10
.
770	14	1	0	2	38	3



اقتصادسنجی برای توسعه

متغیر مصنوعی (Dummy)

QUESTION: What does bribe + nobribe always equal?

bribe + nobribe = 1 (always)

When a set of variables always add up to a fixed number, we call those variables multicollinear (or collinear)

- Can lead us into the “dummy variable trap”
- More on this later in the lecture...

. ttest hours, by(bribe) unequal

Two-sample t test with unequal variances

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
0	122	12.0082	.5353632	5.913279	10.9483	13.06809
1	648	8.046296	.2165283	5.511911	7.621113	8.471479
combined	770	8.674026	.2075174	5.758375	8.266658	9.081394
diff		3.9619	.5774931		2.821569	5.102232

diff = mean(0) - mean(1)

t = 6.8605

Ho: diff = 0

Satterthwaite's degrees of freedom = 163.009

QUESTION: From this Stata output, evaluate the:

- Sample average preparation by teachers expecting to pay a bribe? By teachers not expecting to pay a bribe?
- Not expecting to pay a bribe: 12 hours
- expecting to pay a bribe: 8 hours

QUESTION: From this Stata output, evaluate the:

- Difference in the sample average preparation between the two groups of teachers?
- 4 hours more spent preparing by teachers not expecting to pay a bribe



اقتصادسنجی برای توسعه

متغیر مصنوعی (Dummy)

Can you reject the null hypothesis that there is no difference in hours spent preparing between teachers expecting to pay a bribe and not expecting to pay a bribe in the “population”?

$|t|=6.9 > 1.96$ Yes, we reject the null

We can also perform this same analysis using bivariate regression techniques

- PRF: $hours_i = \beta_0 + \beta_1 bribe_i + u_i$
- SRF: $\widehat{hours}_i = \hat{\beta}_0 + \hat{\beta}_1 bribe_i$

Teachers that are not expecting to pay a bribe?

$$\widehat{hours}_i = \hat{\beta}_0 + \hat{\beta}_1 * 0 = \hat{\beta}_0$$

Teachers that are expecting to pay a bribe?

$$\widehat{hours}_i = \hat{\beta}_0 + \hat{\beta}_1 * 1 = \hat{\beta}_0 + \hat{\beta}_1$$



اقتصاد سنجی برای توسعه

متغیر مصنوعی (Dummy)

What is the interpretation of β_1 ?

(Mean preparation of teachers expecting to pay a bribe) –
(Mean preparation of teachers not expecting to pay a bribe)

$$\widehat{hours}_i = \hat{\beta}_0 + \hat{\beta}_1 * 0 = \hat{\beta}_0$$

$$\widehat{hours}_i = \hat{\beta}_0 + \hat{\beta}_1 * 1 = \hat{\beta}_0 + \hat{\beta}_1$$

```
. reg hours bribe, robust
```

Linear regression

```
Number of obs   =       770
F(1, 768)       =       47.29
Prob > F        =       0.0000
R-squared       =       0.0632
Root MSE       =       5.5771
```

$$\widehat{hours}_i = \hat{\beta}_0 + \hat{\beta}_1 bribe_i$$

hours	Coef.	Robust Std. Err.	t	P> t	[95% Conf. Interval]	
bribe	-3.9619	.5761413	-6.88	0.000	-5.092899	-2.830902
_cons	12.0082	.5338583	22.49	0.000	10.9602	13.05619



اقتصاد سنجی برای توسعه

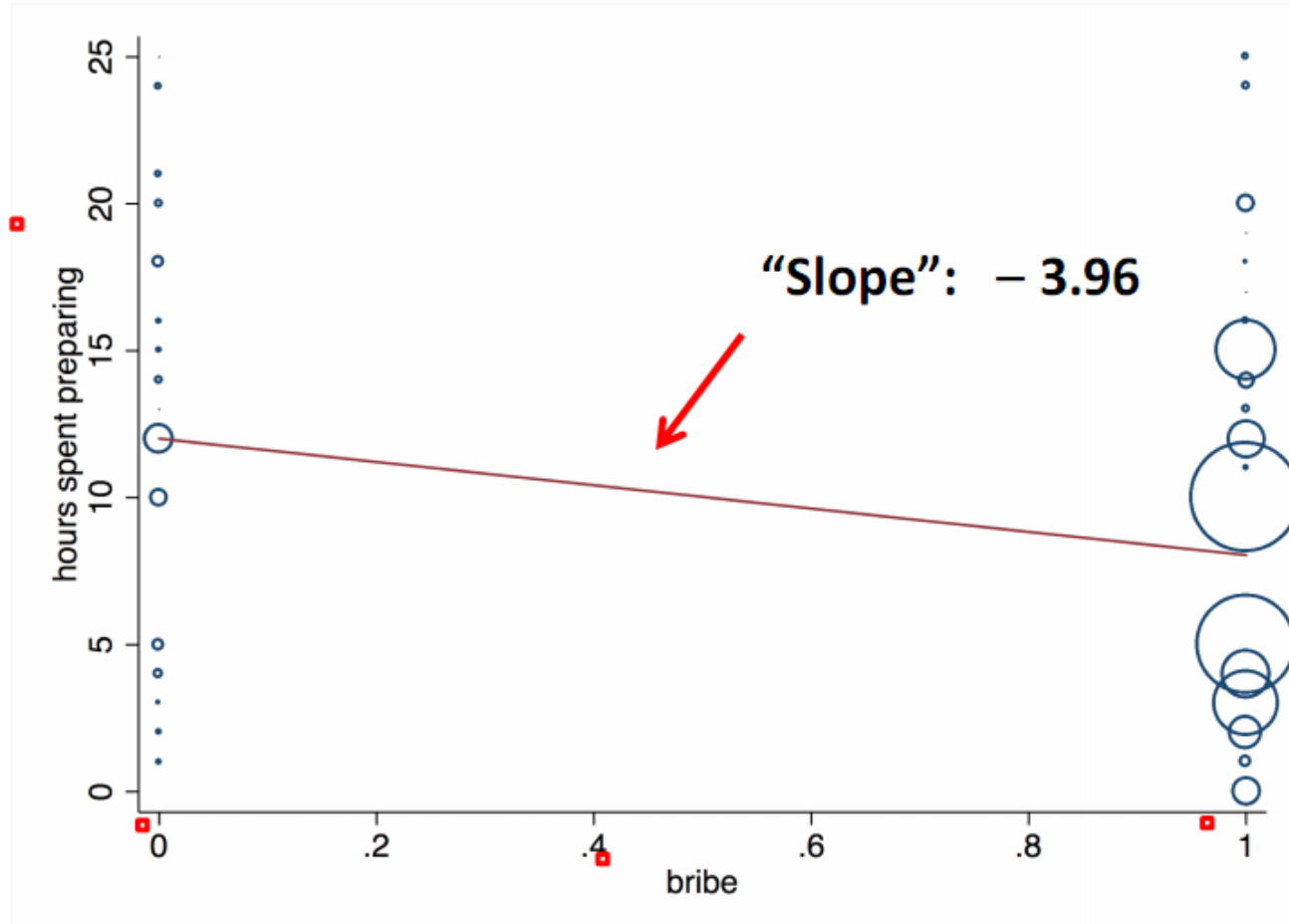
متغیر مصنوعی (Dummy)

QUESTION: What is the predicted preparation for teachers not expecting to pay a bribe?

What is the predicted preparation for teachers expecting to pay a bribe?

QUESTION: What is the predicted difference in preparation between the two groups of teachers?

- To see this relationship graphically:



- This shows how a bivariate regression with a dummy variable can be used to conduct a comparison-of-means test between two groups
- The two approaches (difference in means and bivariate regression) will yield the same results
- The key to interpreting coefficients on dummy variables is to know the omitted group against which comparisons are made

Here, teachers not expecting to pay a bribe were the omitted group and we were comparing teachers who were expecting to pay a bribe to them

Key concept: In this example we chose teachers not expecting to pay a bribe omitted group, that is, the group against which comparisons are made

$$hours_i = \alpha_0 + \alpha_1 nobribe_i + u_i$$

QUESTION: What do α_0 and α_1 represent?

$$hours_i = \alpha_0 + \alpha_1 nobribe_i + u_i$$

α_0 : Average hours spent preparing by teachers expecting to pay a bribe , in the sample

α_1 : The average difference in hours spent preparing between teachers who do not expect to bribe and those who do, in the sample



اقتصادسنجی برای توسعه

متغیر مصنوعی (Dummy)

Linear regression

Number of obs = 770
F(1, 768) = 47.29
Prob > F = 0.0000
R-squared = 0.0632
Root MSE = 5.5771

hours	Coef.	Robust Std. Err.
nobribe	3.9619	.5761413
_cons	8.046296	.2166427

Linear regression

Number of obs = 770
F(1, 768) = 47.29
Prob > F = 0.0000
R-squared = 0.0632
Root MSE = 5.5771

hours	Coef.	Robust Std. Err.	t	P> t	[95% Conf. Interval]
bribe	-3.9619	.5761413	-6.88	0.000	-5.092899 -2.830902
_cons	12.0082	.5338583	22.49	0.000	10.9602 13.05619

اقتصادسنجی برای توسعه

متغیر مصنوعی (Dummy): هم خطی یا دام دامی

Finally, what if we had included both the bribe and nobribe dummy variables in the regression?

$$hours_i = \beta_0 + \beta_1 bribe_i + \beta_2 nobribe_i + u_i$$

Linear regression		Number of obs	=	770		
		F(1, 768)	=	47.29		
		Prob > F	=	0.0000		
		R-squared	=	0.0632		
		Root MSE	=	5.5771		
hours	Coef.	Robust Std. Err.	t	P> t	[95% Conf. Interval]	
bribe	-3.9619	.5761413	-6.88	0.000	-5.092899	-2.830902
nobribe	0	(omitted)				
_cons	12.0082	.5338583	22.49	0.000	10.9602	13.05619



اقتصادسنجی برای توسعه

متغیر مصنوعی (Dummy): هم خطی یا Dummy Trap

QUESTION: Why did Stata omit nobribe from the regression?

- Because “nobribe” is collinear with bribe (the dummy variable trap)
- Intuitively, it does not make sense to control for “nobribe” when estimating the coefficient for bribe

Occurs when you try to include a complete set of collinear variables in a regression simultaneously

Stata protects you from making this mistake



اقتصادسنجی برای توسعه

متغیر مصنوعی (Dummy): هم خطی یا Dummy Trap

What if we want to compare more than two groups?

- In the data, countries are categorized into seven provinces:
 - Province 1: Bantey Meanchey
 - Province 2: Kanpong Cham
 - Province 3: Kampong Chhnang
 - Province 4: Kampot
 - Province 5: Kratie
 - Province 6: Prey Veng
 - Province 7: Sihanoukville

In this case, we create 7 separate dummy variables Each one representing a province:

- *province1*: = 1 if country is in Province 1 (= 0 otherwise)
- *province2*: = 1 if country is in Province 2 (= 0 otherwise)
- *province3*: = 1 if country is in Province 3 (= 0 otherwise)
- *province4*: = 1 if country is in Province 4 (= 0 otherwise)
- *province5*: = 1 if country is in Province 5 (= 0 otherwise)
- *province6*: = 1 if country is in Province 6 (= 0 otherwise)
- *province7*: = 1 if country is in Province 7 (= 0 otherwise)



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متغیر مصنوعی (Dummy): هم خطی یا Dummy Trap

Example of the data:

<i>observation</i>	<i>province1</i>	<i>province2</i>	<i>province3</i>	<i>province4</i>	<i>province5</i>	<i>province6</i>	<i>province7</i>
1	0	0	0	0	0	1	0
2	1	0	0	0	0	0	0
3	0	0	0	0	0	1	0
4	0	1	0	0	0	0	0
.
770	0	0	0	0	0	1	0

اقتصاد سنجی برای توسعه

متغیر مصنوعی (Dummy): هم خطی یا Dummy Trap

Dependent variable: *hours*

	(1)	(2)	(3)
<i>bribe</i>	-3.96 (0.576)	-4.90 (0.505)	-5.06 (0.492)
<i>province2</i>		2.22 (0.502)	2.56 (0.519)
<i>province3</i>		5.51 (0.718)	5.53 (0.729)
<i>province4</i>		6.12 (0.685)	6.14 (0.685)
<i>province5</i>		4.58 (0.685)	4.61 (0.694)
<i>province6</i>		5.49 (0.638)	6.00 (0.648)
<i>province7</i>		8.08 (1.063)	7.64 (1.042)
<i>years</i>			-0.07 (0.026)
<i>tot_students</i>			-0.00 (0.009)
<i>time</i>			0.00 (0.012)
<i>constant</i>	12.01 (0.534)	8.92 (0.580)	9.71 (0.838)
<i>observations</i>	770	770	757

Robust standard errors in parentheses.

QUESTION: How would you interpret the *province3* coefficient in regression 2?

Holding constant whether a teacher expects to pay a bribe, teachers in Kampong Chhnang spend 5 hours and 30 minutes more in preparing for class than teachers in Bantey Meanchey province, on average.

Is it statistically significant?

$$|t| = 5.51 / 0.718 \\ = 7.67 > 1.96 \\ \text{(significant)}$$



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اقتصاد سنجی برای توسعه

متغیر مصنوعی (Dummy): هم خطی یا Dummy Trap

	Dependent variable: hours		
	(1)	(2)	(3)
bribe	-3.96 (0.576)	-4.90 (0.505)	-5.06 (0.492)
province2		2.22 (0.502)	2.56 (0.519)
province3		5.51 (0.718)	5.53 (0.729)
province4		6.12 (0.685)	6.14 (0.685)
province5		4.58 (0.685)	4.61 (0.694)
province6		5.49 (0.638)	6.00 (0.648)
province7		8.08 (1.063)	7.64 (1.042)
years			-0.07 (0.026)
tot_students			-0.00 (0.009)
time			0.00 (0.012)
constant	12.01 (0.534)	8.92 (0.580)	9.71 (0.838)
observations	770	770	757

Robust standard errors in parentheses.

QUESTION: How would you interpret the bribe coefficient in regression 3? Is it statistically

significant? Holding constant province, number of students, time spent travelling to school, and years spent at the school, teachers expecting to pay a bribe to access their salary spend on average 5 hours less preparing for class, compared to teachers not expecting to pay a bribe.

Is it statistically significant?

This is statistically significant.

$$|t| = 5.06 / 0.492 = 10.28 > 1.96$$



مؤسسه عالی آموزش و پژوهش
مدیریت و برنامه ریزی

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متغیر مصنوعی (Dummy): جمع بندی

- Dummy variables take only the values 0 and 1
- They are used to describe data that fall into two or more categories
- Dummy variables can be used to estimate treatment effects in randomized experiments, comparing the treatment and control group
- The key to interpreting dummy variables is to be clear about which is the omitted category that the group of interest is being compared to

- Binary Dependent Variables
- Interactions
- Fixed Effects
- Instrumental Variables
- Difference-in-Difference
- Regression+Discontinuity

سه کتاب درسی بسیار مفید توصیه می‌شود تا بتوانید مفاهیم اقتصادسنجی را کاملاً درک کنید و موضوعات هر موضوع با بخش‌هایی توصیه شده در این کتاب همراه است.

Stock, J. and Watson, M., Introduction to Econometrics, updated 3rd edition, Addison-Wesley (2007)

Angrist, J. and Pischke, J-S., Mastering 'Metrics, Princeton University Press (2015)

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مباحث مهم آتی



شماره	عنوان	قسمت های مرتبط کتاب اول	قسمت های مرتبط کتاب دوم
بخش اول : مبانی			
1	علیت چیست و چگونه شواهد علی بیابیم*	1.2,9.1,9.2	
2	مبانی رگرسیون	4.1-2,51-2,6.2-3	2.1-2.2
3	اریبی و اریبی نمونه*	5.3, 6.1	2.3
4	متغیر ساختگی (Dummy)*	5.3	
5	رگرسیون غیر خطی	8.2 ,11(431-441)	
6	اثرات متقابل (Interactions)	8.3	
بخش دوم: روشهای استنباط علیت			
7	اثرات ثابت (Fixed Effects)*	10.3, 10.4	5
8	تفاضل در تفاضل (Differences-in-Differences)*	13.4	5
9	متغیرهای ابزاری (Instrumental Variables)*	12.1,12.3	3
10	رگرسیون ناپیوسته (Regression Discontinuity)	13.4	4
11	آزمایش های میدانی (Field Experiments)	13.2	1

با تشکر از دست اندرکاران موسسه عالی آموزش و پژوهش مدیریت و برنامه به خصوص

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و سپاس بسیار از حسن توجه شما

به امید توجه بیشتر به مباحث دقیق توسعه