Event data

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Pandemics and the financial markets

Event Data and Sensor Data

Event data is any data that you want to measure about an event

Sensor data is the output of a device that detects and responds to some type of input from the physical environment.

Event Studies

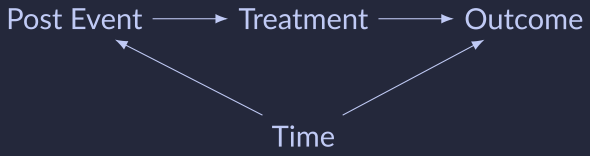
Event study is probably the oldest and simplest causal inference research design

- effect of stock splits on stock prices (Dolley 1933; MacKinlay 1997)
- the information content of earnings announcements (Ball and Brown (1968))

Fama calls event studies a test of how quickly security prices reflect public information announcements (Fama 1991, p. 1576).

($\neq$ Marketing lit: assume market efficiency to measure the value of campaign, ..)

Causal Diagram for Event Studies Design



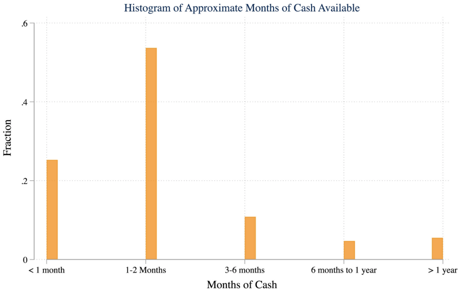
The impact of COVID-19 on small business

- Treatment=Pandemic $\rightarrow$ Outcome=Survival
  - Time series: looking at pre and post pandemics outcome
- Pandemic $\leftarrow$ After Event $\leftarrow$ Time $\rightarrow$ Outcome
  - All the stuff that changes over time independently of the Pandemics

Financial Fragility of Small Business

Survey to SME: “roughly how much cash (e.g. in savings, checking) do you have access to without seeking further loans or money from family or friends to pay for your business?”

Fig. 5.



Months of cash. This figure plots firms’ months of cash available as a multiple of January 2020 expenses. We compute this measure by taking the midpoint of categorical responses for the amount of cash on hand and dividing by the midpoint of the categorical response for typical monthly expenses prior to the crisis. The sample size is 4,176.

Bartik et al. (2020), The impact of COVID-19 on small business outcomes

Counterfactuals

Would those firms that went bankrupt, have gone bankrupt even without the pandemics?

1. whatever was going on before would have continued doing its thing if not for the treatment
2. how the actual outcome deviates from that prediction
3. the extent of the deviation is the effect of treatment

Pre-Trend Analysis

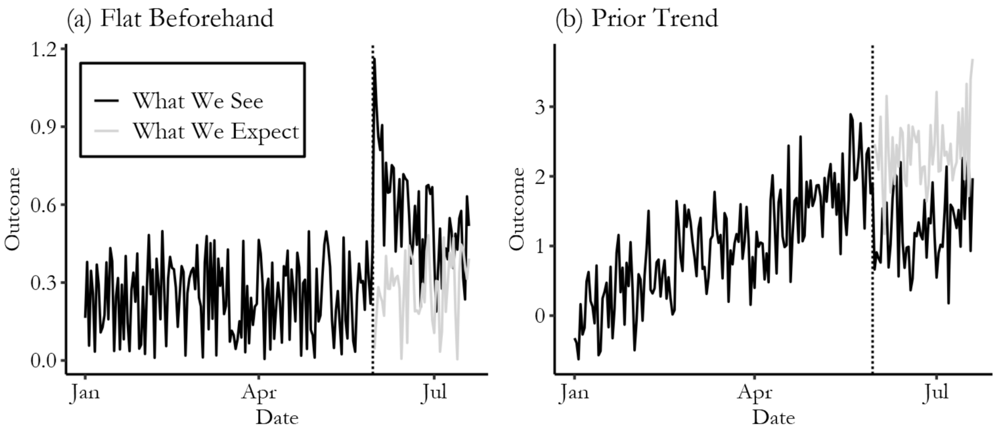


Figure 17.2: Two Examples of Graphs Representing Event Studies

Approaches to Pre-Trends

1. Ignore it! When is this good?
    - panel (a)
    - high-frequency data
2. Predict After-Event Data Using Before-Event Data
    - look at the outcome data you have leading up to the event
    - use the patterns in that data to predict what the outcome would be afterwards

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Practical Corner

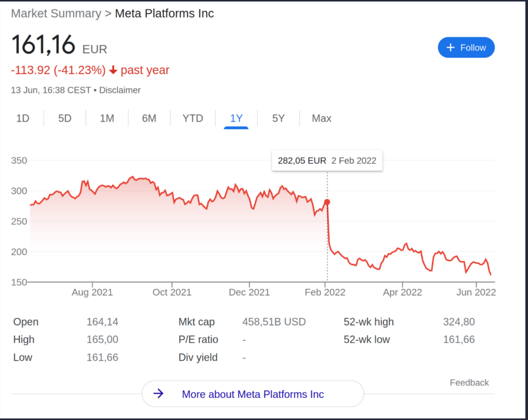
Boeing stock plunges again after coronavirus bailout quest spooks investors

Practical Corner

```
event <- ymd("2020-02-20")
boeing <- boeing %>% mutate(Date= format(as.Date(boeing$Date), "%Y-%m-%d")) %>%
  filter(Date >= ymd('2019-01-12') &
           Date <= ymd('2020-04-30'))

# And observation data
window_around_event <- boeing %>%
  filter(Date >= event - days(35) &
           Date <= event + days(45))

# Graph the results
ggplot(window_around_event, aes(x = ymd(Date), y = as.integer(Open), group = 1))
  geom_line(color="steelblue") +
  geom_vline(aes(xintercept = ymd(event)), linetype = 'dashed', color="yellow") +
  ylab("") + xlab("Nasdaq Real Time Price (USD)")
```

Event Study Design with Stock Markets

On February 2nd 2022, Meta (FB) release that its global daily active users declined from the previous quarter for the first time, to 1.929 billion from 1.930 billion. More Here



Event Study Design with Stock Markets

1. Event Identification:
    - (e.g., dividends, MA, stock buyback, laws or regulation, privatization vs. nationalization, celebrity endorsements, name changes, or brand extensions etc.).
    - Events must affect either cash flows or on the value of the firm (A. Sorescu, Warren, and Ertekin 2017, 191)

2. pick an estimation period

3. pick an observation period

Event Study Design

1. Use the data from the estimation period to estimate a model that can make a prediction of the stock's return in each period:
   1.1 Means-adjusted returns model: average in the estimation period $\hat{R} = \bar{R}$
   1.2 Market-adjusted returns models: Use the market return in each period $\hat{R} = R_M$
   1.3 Risk-adjusted returns model: relation in the estimation period btw returns

$$R = \alpha + \beta R_M + \epsilon$$

$$\hat{R} \quad \text{est.} \quad E[R|R_M]$$

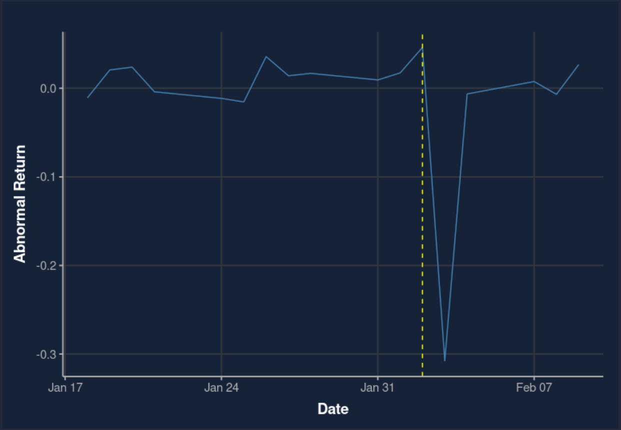
2. Calculate abnormal return $AR = R - \hat{R}$
3. Is AR constant during the observation period?

```r
library(tidyverse); library(lubridate)
sp500 <- read_csv("~/08-event-study/sp_500.csv")
meta <- read_csv("~/08-event-study/META.csv")

event <- ymd("2022-02-02")
# Create estimation data set
sp500 <- sp500 %>%
  mutate(returnSP=(Open-lag(Close))/Open, Date=format(as.Date(Date), "%Y-%m-%d"))
meta <- meta %>%
  mutate(returnM=(Open-lag(Close))/Open, Date=format(as.Date(Date), "%Y-%m-%d"))

est_data <- left_join(sp500, meta, by=c("Date")) %>%
  select(Date, returnM, returnSP) %>% filter(Date < event - days(4) )

# And observation data
obs_data <- est_data %>%
  filter(Date >= event - days(15) & Date <= event + days(7))
```

```r
# Estimate a model predicting stock price with market return
m <- lm(return_meta ~ return_sp_500, data = est_data)
# Get AR
obs_data <- obs_data %>%
  # Using mean of estimation return
  mutate(AR_mean = return_meta - mean(est_data$return_meta),
         # Then comparing to market return
         AR_market = return_meta - return_sp_500,
         # Then using model fit with estimation data
         risk_predict = predict(m, newdata = obs_data),
         AR_risk = return_meta - risk_predict)

# Graph the results
ggplot(obs_data, aes(x = ymd(Date), y = AR_risk, group=1)) +
  geom_line(color="steelblue") +
  geom_vline(aes(xintercept = ymd(event)), linetype = 'dashed', color="yellow") +
  ylab("Abnormal Return") + xlab("Date") +
  scale_colour_Publication() + theme_dark_blue()
```

Meta returns around the announcement of drop in users' accounts

Meta (FB) global daily active users declined from the previous quarter for the first time, to 1.929 billion from 1.930 billion.



Event Studies with Regression

What if you're interested in an event that changes the time series in a long-lasting way?

$$Outcome = \beta_0 + \beta_1 t + \beta_2 After + \beta_3 t \times After + \epsilon$$

where is the time period and $After$ is a binary variable equal to 1 anytime after the event

- Pros: more-precise estimate of the time trend than going day by day
- Cons: data tends to be "sticky" over time, autocorrelation inflates your test statistics (heteroskedasticity- and autocorrelation-consistent (HAC) standard errors)

Capturing longer term effects

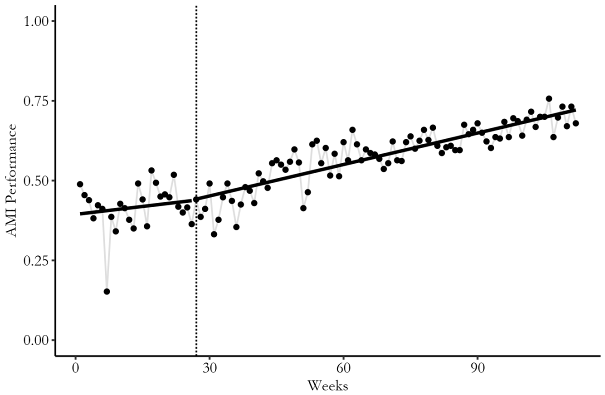
Does an English policy put in place in mid-2010 to improve quality of health care received in the ambulance on the way to the hospital on the chances of heart attack and stroke afterwards?

Taljaard et al. (2014) use a regression-based approach to event studies to evaluate the effect of a policy intervention on health outcomes.

That's what Taljaard et al. (2014) look at. They run a regression of heart attack performance (AMI, or Acute Myocardial Infarction performance) on $Week - 27$ (subtracting 27 "centers" $Week$ at the event period, which allows the coefficient on $Week - 27$ to represent the jump in the line), $After$ (an indicator variable for being after the 27-week mark of the data where the policy was introduced), and an interaction term between the two:[11]

$$AMI = \beta_0 + \beta_1(Week - 27) + \beta_2 After + \beta_3(Week - 27) \times After + \varepsilon \quad (17.2)$$

Their results for heart attack can be summarized by Figure 17.5. You can see the two lines that are fit to the points on the left and right sides of the event's starting period. That's the interaction term at work. The line to the left of 27 weeks is $\beta_0 + \beta_1(Week - 27)$, and the line to the right is $(\beta_0 + \beta_2) + (\beta_1 + \beta_3)(Week - 27)$.



Event Study Design vs other Designs

Traditional Event Study Design exploit the variability BEFORE/AFTER events

Variants

- multiple treated groups, all of which are treated at different times, whether or not there's also a control group
- Event study with a control: compare with a group unaffected by the event
  - Diff-in-Diff estimator
  - synthetic control

  $\rightarrow$ Identification requires the exogeneous
- Economic Models to inform the counterfactual

  $\rightarrow$ Structural estimations

Event Studies with Multiple Affected Groups

The Meta announcement might affect only Meta's stock

How about the announcement of the introduction of DGPR in the EU that should affect all the stocks (TECH related) companies traded there?

$$Outcome_{it} = \beta_i + \beta_1 t + \beta_2 After_t + \beta_3 t \times After_t + \epsilon_{it}$$

where i indexes firms, t is the time period and $After$ is a binary variable equal to 1 in any time after the event

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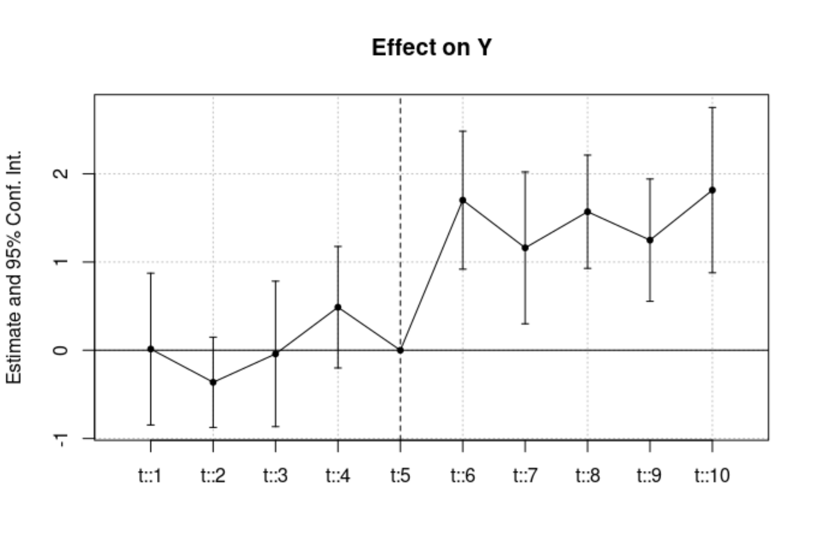
```r
library(tidyverse); library(fixest)
set.seed(10)

# Create data with 10 groups and 10 time periods
df <- crossing(id = 1:10, t = 1:10) %>%
  # Add an event in period 6 with a one-period positive effect
  mutate(Y = rnorm(n()) + 1.5*(t >= 6))

# Use i() in feols to include time dummies,
# specifying that we want to drop t = 5 as the reference
m <- feols(Y ~ i(t, ref = 5), data = df,
           cluster = 'id')

# Plot the results, except for the intercep,# and add a line joining
# them and a space and line for the reference group
coefplot(m, drop = '(Intercept)',
         pt.join = TRUE, ref = c('t:5' = 6), ref.line = TRUE)
```


Effect on Y
Estimate and 95% Conf. Int.
2
1
0
-1
t::1
t::2
t::3
t::4
t:5
t::6
t::7
t::8
t::9
t::10

Regression Discontinuity Design

The UK minimum wage at 22 years of age: a regression discontinuity approach

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[Received July 2011. Final revision August 2012]

Summary. A regression discontinuity approach is used to analyse the effect of the legislated increase in the UK national minimum wage that occurs at age 22 years on various labour market outcomes. Using data from the Labour Force Survey we find an increase of 3–4 percentage points in the rate of employment of low skilled individuals. Unemployment declines among men and inactivity among women. We find no such effect before the national minimum wage was introduced and no robust impacts at age 21 or 23 years. Our results are robust to a range of specification tests.

Keywords: Labour supply; Minimum wages; Policy evaluation; Regression discontinuity; Youth labour market

in France on labour supply. Define a dummy variable that is an indicator for whether someone has passed their 22nd birthday:

$$\text{Dum}_i = \begin{cases} 1 & \text{if } \text{age}_i \geqslant 22, \\ 0 & \text{if } \text{age}_i < 22 \end{cases}$$

where age_i is the individual's age measured in years. We then estimate the following reduced form regression:

$$y_i = f(\text{age}_i, a) + \beta\,\text{Dum}_i + \delta X_i + u_i. \qquad (1)$$

- y_i is an employment-related measure for individual i (i.e. a dummy indicating employment status),
- f(age,a) is a flexible polynomial in age with parameters a
- X_i is a set of covariates for individual i

β is the (causal) effect on employment of the increase in the NMW from the youth to the adult rate.

The effect of the threshold on the employment

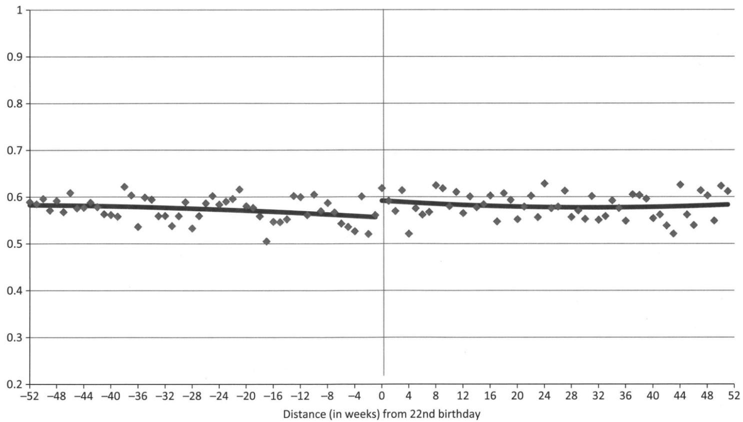


Fig. 2. Employment rate by age in weeks for all low skilled individuals (source, LFS); ♦, actual; ———, predicted

Caption

Diff in Diff Design

Estimator

- Baseline value is β_0 in control group,
  - Estimable by pre-treatment average $\bar{Y}_{1,control}$,
- Treatment group differs in baseline period by β_1
  - $\bar{Y}_{1,treat}$ estimates $\beta_1 + \beta_0$
- Effect of time is δ_0 on treatment and control units
  - $\bar{Y}_{2,control}$ estimates $\beta_0 + \delta_0$
- Treatment effect is δ_1
  - $\bar{Y}_{2,treat}$ estimates $\beta_0 + \delta_0 + \beta_1 + \delta_1$

$$\begin{aligned}\hat{\delta}_1 &= (\bar{Y}_{2,treat} - \bar{Y}_{2,control}) - (\bar{Y}_{1,treat} - \bar{Y}_{1,control}) \\ &= (\bar{Y}_{2,treat} - \bar{Y}_{1,treat}) - (\bar{Y}_{2,control} - \bar{Y}_{1,control})\end{aligned}$$

Table of outcomes

Time / Unit	**Before**	**After**	**After-Before**
Control	β_0	$\beta_0 + \delta_0$	δ_0
————	———	———————	—————
Treatment	$\beta_0 + \beta_1$	$\beta_0 + \delta_0 + \beta_1 + \delta_1$	$\delta_0 + \delta_1$
————	———	———————	—————
Treatment - Control	β_1	$\beta_1 + \delta_1$	δ_1

Card & Krueger (1994)

Example: Minimum wage in New Jersey and Pennsylvania

- Card & Krueger (1994) study effect of rise in New Jersey minimum wage on employment in fast food restaurants
- NJ raised minimum wage from $4.25 to $5.05 in 1992
  - PA kept it the same
- Compare employment in fast food stores near the border to control for common trends in employment
  - e.g. business cycle effects
- Need to believe that NJ not growing faster/slower than PA

Employees per store by state and time (Card & Krueger Table 3)

Time / Unit	1991	1992	After-Before
PA	23.33	21.17	-2.16
———	———	———	———
NJ	20.44	21.03	0.59
———	———	———	———
NJ - PA	-2.89	-0.14	2.76

Interpretation

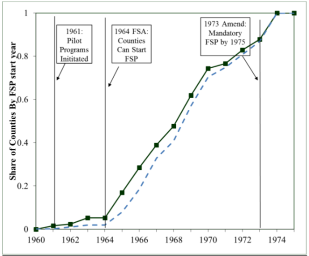
- PA fast food employment shrank, while NJ fast food employment grew slightly
- If we believe nothing different going on in two states aside from minimum wage, this suggests minimum wage raised employment
- Inconsistent with theory that higher minimum wage lowers unemployment

Multiple affected Groups

Staggered adoption: everyone is treated, but treatment length differs by group
Use: policy is introduced in many different states during many different time periods

Hoynes et al. (2016) use staggered roll-out as their identification strategy to assess the long-run effects of childhood access to the safety net

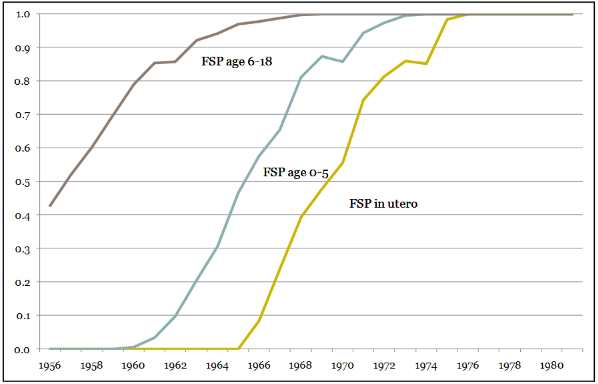
Appendix Figure 1: Weighted Percent of Counties with Food Stamp Program, 1960-1975



Source: Authors' tabulations of food stamp administrative data (U.S. Department of Agriculture, various years). Counties are weighted by their 1960 population. Solid line uses all counties and dashed line uses counties represented in the PSID sample.

Multiple affected Groups

Appendix Figure 2: Food Stamp Exposure in Early Life, Variation by Birth Cohort



Note: Authors' tabulations of food stamp administrative data (U.S. Department of Agriculture, various years) and PSID sample.

Economic models as Counterfactuals

Immagine that you want to evaluate the effect of the effect of the enforcement of a Regional Trade Agreement between countries on their trade flows.

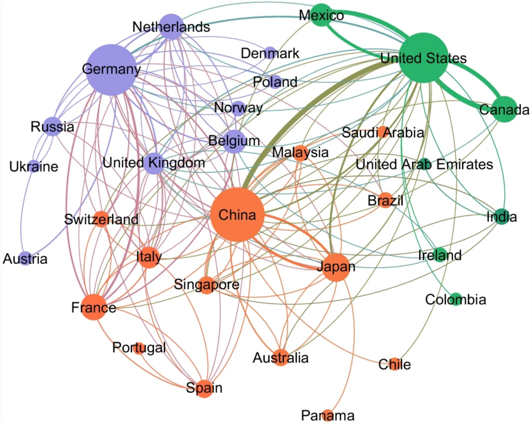
What are Regional Trading Agreements? Regional trading agreements refer to a treaty that is signed by two or more countries to encourage the free movement of goods and services across the borders of its members.

Economic models as Counterfactuals

Immagine that you want to evaluate the effect of the effect of the enforcement of a Regional Trade Agreement between countries on their trade flows.

What are the drivers of trade?

From: Analysis of the global trade network using exponential random graph models



The trades network is depicted using a sample of all trades in 2011. Node sizes and edge thicknesses are proportional to degree and edge weight, respectively. The countries in the same community calculated using the Louvain algorithm are depicted using the same color

Box 1 Analogy between the Newtonian theory of gravitation and the gravity trade model

To see the remarkable resemblance between the trade gravity equation and the corresponding equation from physics, two terms, T_{ij}^{θ} and $\tilde{G}$ have to be defined in equation (1-8) as reported in the right-hand side of the table below.

Newton's Law of Universal Gravitation	*Gravity Trade Model*
$F_{ij} = G\frac{M_i M_j}{D_{ij}^2}$	$X_{ij} = \tilde{G}\frac{Y_i E_j}{T_{ij}^{\theta}}$
where:	where:
– F_{ij}: gravitational force between objects *i* and *j*	– X_{ij}: exports from countries *i* and *j*
– G: gravitational constant	– $\tilde{G}$: inverse of world production $\tilde{G} \equiv 1/Y$
– M_i: object *i*'s mass	– Y_i: country *i*'s domestic production
– M_j: object *j*'s mass	– E_j: country *j*'s aggregate expenditure
– D_{ij}: distance between objects *i* and *j*	– T_{ij}^{θ}: total trade costs between countries *i* and *j* $T_{ij}^{\theta} \equiv \left(t_{ij}/\left(\Pi_i P_j\right)\right)^{\sigma-1}$

Based on the metaphor of Newton's Law of Universal Gravitation, the gravity model of trade predicts that international trade (gravitational force) between two countries (objects) is directly proportional to the product of their sizes (masses) and inversely proportional to the trade frictions (the square of distance) between them.

Counterfactuals in Trade

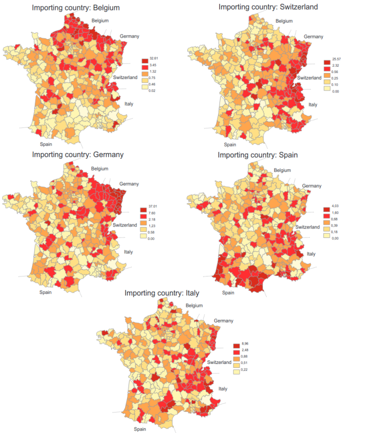
$\text{Trade flows}_{ij} = \text{Size}_i \times \text{Size}_j \times \text{Frictions to trade}_{ij}$

- Size=$\frac{Y_i E_j}{Y}$
- Frictions:

1. Bilateral trade cost between partners i and j, $t_i j$, is typically approximated in the literature by various geographic and trade policy variables, such as bilateral distance, tariffs etc.
2. The structural term Pj , coined by Anderson and van Wincoop (2003) as inward multilateral resistance represents importer j's ease of market access.
3. The structural term Πi , defined as outward multilateral resistances by Anderson and van Wincoop (2003), measures exporter i's ease of market access

Intensive Margin of Trade: Export Value

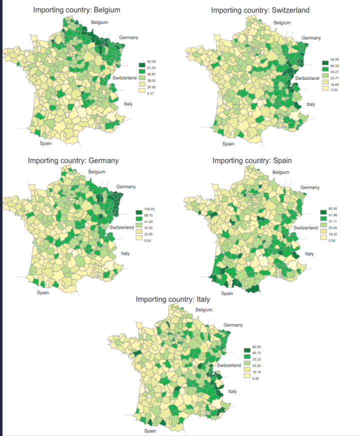
Figure 1: Mean value of individual-firm exports (single-region firms, 1992)



Head and Mayer (2014)

Extensive Margin of Trade: Number of non-zero trade flows

Figure 2: Percentage of firms which export (single-region firms, 1992)



Head and Mayer (2014)

Reduced Form Estimation

Two Commonly-Used Reduced-Form Estimators

1. OLS Estimation:

$$lnX_{ij} = \underbrace{\beta_d lnDist_{ij} + Controls_{ij} + M_i + X_j}_{\beta Z_{ij}} + \epsilon_{ij}. \tag{1}$$

   - moment condition: $\sum_{ij} Z_{ij} \dot{(} lnX_ij - ln\hat{X}_{ij}) = 0$

2. PPML Estimation:

$$Xij = exp\underbrace{(\beta_d lnDist + ij + Controls_{ij} + M_i + X_j)}_{\beta Z_{ij}} + \epsilon_{ij} \tag{2}$$

   - moment condition: $\sum_{ij} Z_{ij} \dot{(} X_ij - \hat{X}_{ij}) = 0$

PPML vs OLS

Advantages of the PPML estimator:

1. It can naturally account for zeros
2. The estimated fixed effects, $\hat{M}_i$ and $\hat{X}_i$, are consistent with equilibrium conditions (Fally, 2015).
3. Provides consistent estimates in the presence of heteroskedasticity.

Disadvantage of the PPML estimator: it is prone to small sample bias.

Estimating the effects of being part of an RTA

$$X_{ij,t} = \exp\left[\pi_{i,t} + \chi_{j,t} + \beta_{DIST}\ln DIST_{ij} + \beta_{RTA}RTA_{ij,t} + \beta_{TARIFF}\tilde{\tau}_{ij,t}\right] \times \varepsilon_{ij,t} \qquad (1\text{-}15)$$

The variable ln $DIST_{ij}$ denotes the logarithm of bilateral distance between countries *i* and *j*. The covariate $RTA_{ij,t}$ represents an indicator variable taking the value of one if there is a RTA between countries *i* and *j* at time *t*, and zero otherwise. For expositional purposes, both variables ln $DIST_{ij}$ and $RTA_{ij,t}$ will be used, respectively, as representative continuous variable and dummy variable in gravity regressions. Finally, $\tilde{\tau}_{ij,t} = \ln(1 + tariff_{ij,t})$ accounts for bilateral tariffs, where $tariff_{ij,t}$ is the ad-valorem tariff that country *j* imposes on imports from country *i* at time *t*. Importantly, as emphasized earlier, the coefficient on bilateral tariffs, $\tilde{\tau}_{ij,t}$, can be interpreted in the context of the structural gravity model as the trade elasticity of substitution, namely $\beta_{TARIFF} = -\sigma$. Overall, the interpretation of the coefficient on tariffs in gravity regressions depends on the trade flow data used to estimate the model, which here are assumed to be expressed at *cost, insurance and freight (c.i.f) prices*, but not tariffs. See Appendix B of this chapter for further details.

Caption: Yoto V. Yotov et al.

Meta Analysis of gravity estimates

Table 3.4 Estimates of Typical Gravity Variables

	All Gravity				Structural Gravity			
Estimates:	**Median**	**Mean**	**s.d.**	**#**	**Median**	**Mean**	**s.d.**	**#**
Origin GDP	.97	.98	.42	700	.86	.74	.45	31
Destination GDP	.85	.84	.28	671	.67	.58	.41	29
Distance	−.89	−.93	.4	1835	−1.14	−1.1	.41	328
Contiguity	.49	.53	.57	1066	.52	.66	.65	266
Common language	.49	.54	.44	680	.33	.39	.29	205
Colonial link	.91	.92	.61	147	.84	.75	.49	60
RTA/FTA	.47	.59	.5	257	.28	.36	.42	108
EU	.23	.14	.56	329	.19	.16	.5	26
NAFTA	.39	.43	.67	94	.53	.76	.64	17
Common currency	.87	.79	.48	104	.98	.86	.39	37
Home	1.93	1.96	1.28	279	1.55	1.9	1.68	71

Notes: The number of estimates is 2508, obtained from 159 papers. Structural gravity refers here to some use of country fixed effects or ratio-type method.

Source: Head and Mayer (2014, Handbook Chapter)

The effect of RTAs

Table 3 Estimating the Effects of Regional Trade Agreements

	(1) *OLS*	(2) *PPML*	(3) *INTRA*	(4) *ENDG*	(5) *LEAD*	(6) *PHSNG*	(7) *GLBZN*
Log distance	–1.216	–0.822	–0.800				
	(0.039)**	(0.031)**	(0.030)**				
Contiguity	0.223	0.416	0.393				
	(0.203)	(0.083)**	(0.079)**				
Common language	0.661	0.250	0.244				
	(0.082)**	(0.077)**	(0.077)**				
Colony	0.670	–0.205	–0.182				
	(0.149)**	(0.114)$^{+}$	(0.113)				
RTA	–0.004	0.191	0.409	0.557	0.520	0.291	0.116
	(0.054)	(0.066)**	(0.069)**	(0.102)**	(0.086)**	(0.089)**	(0.087)
RTA(*t* + 4)					0.077		
					(0.092)		
RTA(*t* – 4)						0.414	0.288
						(0.067)**	(0.062)**
RTA(*t* – 8)						0.169	0.069
						(0.043)**	(0.048)
RTA(*t* – 12)						0.119	0.002
						(0.030)**	(0.029)
International border 1986							–0.706
							(0.048)**
International border 1990							–0.480
							(0.043)**
International border 1994							–0.367
							(0.033)**
International border 1998							–0.158
							(0.023)**
International border 2002							–0.141
							(0.017)**
Observations	25689	28152	28566	28482	28482	28482	28482
Total RTA effect						0.992	0.475
						(0.094)**	(0.109)**
Intra-national trade	No	No	Yes	Yes	Yes	Yes	Yes

Source: Authors' calculations

Notes: All estimates are obtained with data for the years 1986, 1990, 1994, 1998, 2002, and 2006, and use exporter-time and importer-time fixed effects. The estimates of the fixed effects are omitted for brevity. Columns (1) and (2) use data on *international* trade flows only. Column (1) applies the OLS estimator and column (2) uses the PPML estimator. Column (3) adds *intra-national* trade observations and uses country-specific dummies for internal trade. Column (4) adds pair fixed effects. The estimates of the pair fixed effects are omitted for brevity. Column (5) introduces RTA lead. Column (6) allows for phasing-in effects of RTAs. Finally, column (7) accounts for the effects of globalization. Standard errors are clustered by country pair and are reported in parentheses. The *p*-values read as follows: $^{+}$ $p < 0.10$; * $p < 0.05$; and ** $p > 0.01$.

Other studies using the Gravity framework as counterfactual

- Effect of trade liberalizations (NAFTA, Mexico-US Canada) trade agreements, etc.
- Eu integration
- Migration flows

Sources

- About event data design, Nick Huntington-Klein, here
- About Gravity estimation, here