# Impact Evaluation

## Theory and applications

Georges CASAMATTA (ECOPA)

Master TSE-EEE

2018/19

ECOPA

# Literature

- Imbens & Rubin (2015)  (randomized experiments)
- Angrist & Pischke (2 books)
- Cattaneo & Abadie (2018)

# Outline

- Exples:
  - Change in the price of a product. What is the impact on sales?
  - Impact of a new law/regulation
- Overview of literature
  - Ideal setting : randomized experiments. Members of control and treatment group selected randomly.
  - Departure from random assignment -> selection bias
  - Selection bias explained entirely by observable variables (unconfoundness assumption) -> regression, propensity score, matching
  - Unconfoundness does not hold:
    - Instrumental variables
    - Regression discontinuity
    - DiD, SCM
- ECOPA's case studies

ECOPA

# Potential outcomes

- Binary treatment: treated and untreated individuals
  - $Y_{0i}$: Potential outcome of individual $i$ in the absence of treatment
  - $Y_{1i}$: Potential outcome of individual $i$ when receiving the treatment
  - Treatment effect = $Y_{1i}$ - $Y_{0i}$
- Question: how to estimate the treatment effect?
- Problem: only one of the 2 outcomes is observed. How to estimate the **counterfactual**?
- For a treated individual, what would have been the outcome if not treated? And vice versa

ECOPA

# Treatment Effect

- Average treatment effect:

$$Avg_n[Y_{1i} - Y_{0i}] = \frac{1}{n}\sum_{i=1}^{n}[Y_{1i} - Y_{0i}] = \frac{1}{n}\sum_{i=1}^{n}Y_{1i} - \frac{1}{n}\sum_{i=1}^{n}Y_{0i}$$

- Assume that (homogenous treatment effect)

$Y_{1i}$=$Y_{0i}$+$\tau \Leftrightarrow \tau$= $Y_{1i}$- $Y_{0i}$

- $\tau$ is both the individual and average causal effect

# Selection Bias

- Estimator of average treatment effect:

$$Avg_n[Y_{1i}|W_i = 1] - Avg_n[Y_{0i}|W_i = 0]$$

- Difference in average (observed) outcomes in treatment and control group

$$Avg_n[Y_{1i}|W_i = 1] - Avg_n[Y_{0i}|W_i = 0]$$
$$= \{\tau + Avg_n[Y_{0i}|W_i = 1]\} - Avg_n[Y_{0i}|W_i = 0]$$
$$= \tau + \{Avg_n[Y_{0i}|W_i = 1] - Avg_n[Y_{0i}|W_i = 0]\}$$

- This last term is the **selection bias**
- Arises when <u>potential outcomes in the treatment and control group differ</u>

ECOPA

# Selection Bias – cont’d

- Exple: Insured people may be healthier, not because they are insured, but because they are more educated, richer, and so on.
- If the only source of selection bias is a set of differences in characteristics that can be observed and measured, selection bias is easy to fix.
- Some differences are however **unobserved**. Even in a sample consisting of insured and uninsured people with the same education, income, and employment status, the insured might have higher values of $Y_{0i}$.

ECOPA

# Random Assignment

- <u>Experimental random assignment eliminates selection bias</u>
- Start with a sample of people who are currently uninsured
- Provide health insurance to a randomly chosen subset of this sample
- Groups insured and uninsured by random assignment differ only in their insurance status
- Treatment must be randomly assigned in a sample that is large enough, so that treatment and control groups have similar characteristics, e.g. same proportion of men and women (Law of Large Numbers)

ECOPA

# Conditioning on observables

- In the absence of random assignment, **regression** can be used to estimate treatment effect if the selection bias is only due to observable characteristics
- $Y_i = \alpha + \tau W_i + \gamma X_i + \varepsilon_i$, with
  - $Y_i$ the outcome variable
  - $W_i$ the treatment variable
  - $X_i$ the control variable (observable characteristics)
  - $e_i$ the error term
- Allows to estimate $\tau$: the causal effect of treatment
- Other methods: matching, inverse probability weighting, …
- Problem: what if unobserved characteristics affect potential outcomes?

ECOPA

# Selection on unobservables

- Three possible approaches
    - Instrumental variables
    - Regression Discontinuity Design
    - Difference-in-Differences / Synthetic Control Method
- We will develop the two latter approaches

ECOPA

# Instrumental variables

- Mainly used in randomized experiment with imperfect compliance: experimental units fail to comply with the randomized assignment of the treatment.
- Exple: random assignment to charter schools (public schools with more autonomy) in the US.
- Imperfect compliance: some of those offered a seat choose to go elsewhere, while a few lottery losers find their way in by other means.

# Regression Discontinuity Design

- Applicable when each unit receives a score, or index, and only units whose score is above a known cutoff point are assigned to the treatment status, while the rest are assigned to control status.
- Exple: anti-poverty social programs assigned after ranking units based on a poverty index.
- W=1 if $X \geq c$, where $X$ denotes the score and $c$ denotes the cutoff point.
- Underlying idea: units near the cutoff are comparable.

ECOPA

# Difference in differences: Example

- Federal Reserve System organized into 12 districts, each run by a regional Federal Reserve Bank.
- Run on Mississippi banks in December 1930.
- The Atlanta Fed, running the Sixth District, favored lending to troubled banks, to the contrary of the St. Louis Fed (Eight District). The Mississippi State is split between these two districts.
- Following the crisis, the Atlanta Fed increased bank lending by about 40%.
- What is the impact of this monetary policy?

ECOPA

# Difference in differences: Example – cont'd

- On July 1, 1931, about 8 months after the beginning of the crisis, 132 banks were open in the Eighth District and 121 were open in the Sixth District, a deficit of 11 banks in the Sixth District.
- This suggests easy money was counterproductive.
- However, the Sixth and Eighth Districts were <u>similar but not identical</u>.
- On July 1, 1930, before the crisis, 135 banks were open in the in the Sixth District and 165 in the Eighth.
- <u>A simple comparison on the treatment and control units is not enough</u>.

ECOPA

# Difference in differences: Example – cont’d

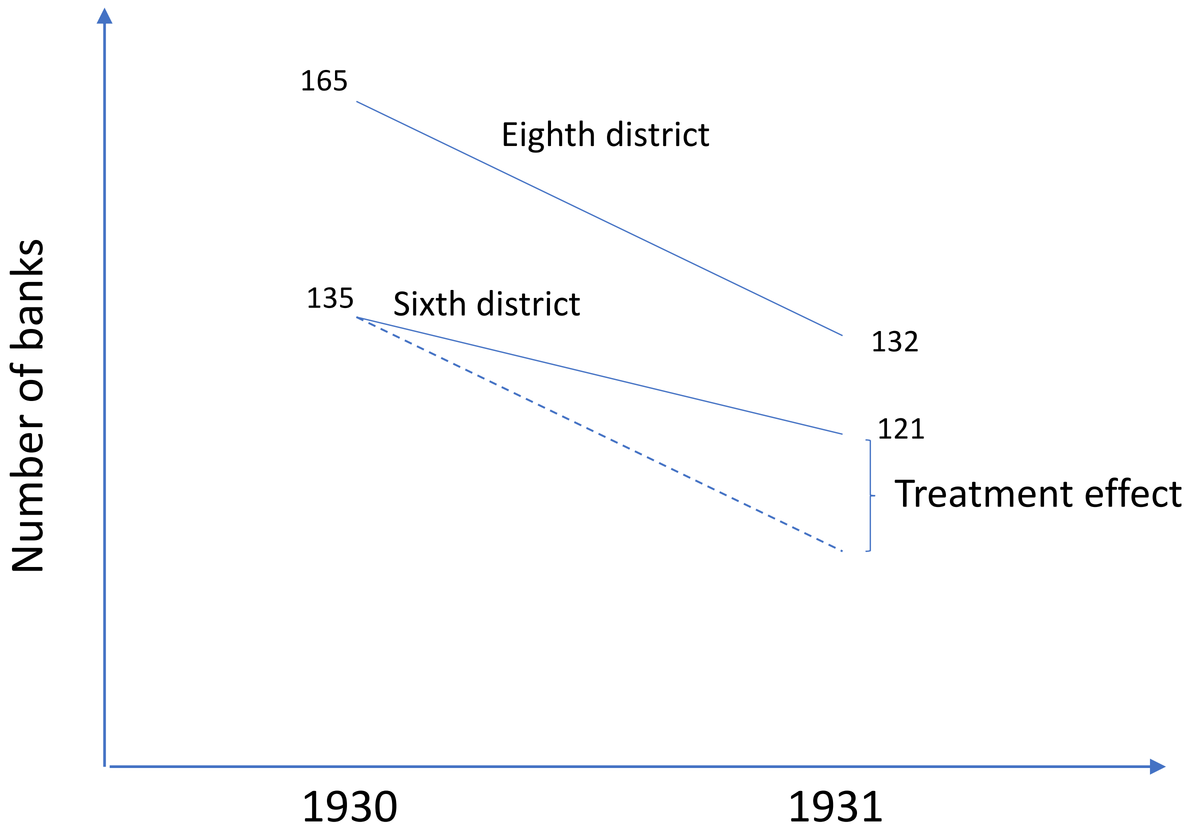
- Let denote $Y_{d,t}$ the number of banks open in District d in year t.
- The DiD estimate $\tau_{DiD}$ of the effect of easy money in the Sixth District is:

$$\begin{aligned}\tau_{DiD} &= \left(Y_{6,1931} - Y_{6,1930}\right) - \left(Y_{8,1931} - Y_{8,1930}\right) \\ &= (121 - 135) - (132 - 165) \\ &= 19\end{aligned}$$

- Comparing changes instead of levels adjusts for the fact that in the pre-treatment period, the Eighth District had more banks than the Sixth.

ECOPA

# Difference in differences: Example – cont'd




Dotted line = counterfactual outcome ($Y_{0i}$), tells what would have happened in the Sixth District had everything evolved as it did in the Eighth

# Difference in differences: Example – cont’d

- The DiD counterfactual comes from a strong assumption: parallel trends.
- DiD presumes that, absent any policy differences, the Eighth District trend is what we should have expected to see in the Sixth.
- With more data (time periods), this assumption can be tested.

# Difference in differences: Theory

- Generalization (to many periods and units) of DiD: panel data regression

$$Y_{it} = \tau W_{it} + \mu_i + \delta_t + \varepsilon_{it},$$

where

- $\mu_i$ as a time invariant individual effect;
- $\delta_t$ is a time effect, common across units;
- only $Y_{it}$ and $W_{it}$ are observed.

- This equation describes potential outcomes:

$$Y_{0it} = \mu_i + \delta_t + \varepsilon_{it}$$
$$Y_{1it} = \tau + \mu_i + \delta_t + \varepsilon_{it}$$

- $\tau = Y_{1it} - Y_{0it}$ is the treatment effect

ECOPA

# Difference in differences – cont'd

- Assume two periods only:
  - Period $t = 0$ is the pre-intervention period, before the treatment is available, so $W_{i0} = 0$ for all $i$;
  - Period $t = 1$ is the post-treatment period, when a fraction of the population units are exposed to the treatment.
- Assume also $E[\varepsilon_{it}|W_{it}] = E[\varepsilon_{it}]$.
- Then:

$$\boldsymbol{E}[Y_{i1}|W_{i1} = 1] = \tau + \boldsymbol{E}[\mu_i|W_{i1} = \mathbf{1}] + \delta_1 + \boldsymbol{E}[\varepsilon_{i1}]$$
$$\boldsymbol{E}[Y_{i0}|W_{i1} = 1] = \boldsymbol{E}[\mu_i|W_{i1} = \mathbf{1}] + \delta_0 + \boldsymbol{E}[\varepsilon_{i0}]$$
$$\boldsymbol{E}[Y_{i1}|W_{i0} = \mathbf{0}] = \boldsymbol{E}[\mu_i|W_{i1} = \mathbf{0}] + \delta_1 + \boldsymbol{E}[\varepsilon_{i1}]$$
$$\boldsymbol{E}[Y_{i0}|W_{i1} = \mathbf{0}] = \boldsymbol{E}[\mu_i|W_{i1} = \mathbf{0}] + \delta_0 + \boldsymbol{E}[\varepsilon_{i0}]$$

ECOPA

# Difference in differences – cont'd

- It follows that:

$$\tau = \left[E[Y_{i1}|W_{i1} = 1] - E[Y_{i1}|W_{i1} = 0]\right] - \left[E[Y_{i0}|W_{i1} = 1] - E[Y_{i0}|W_{i1} = 0]\right] = E[\Delta Y_i|W_{i1} = 1] - E[\Delta Y_i|W_{i1} = 0].$$

- $\hat{\tau}$ , the sample analog of $\tau$,is the DiD estimator: difference between groups in the differences across time.
- Crucial assumption = parallel trends. Using $E[\varepsilon_{it}|W_{it}] = E[\varepsilon_{it}]$, it can be shown (exercise) that:

$$E[\Delta Y_{0i}|W_{i1} = 1] = E[\Delta Y_{0i}|W_{i1} = 0].$$

In the absence of the treatment, the average outcome for the treated and the average outcome for the nontreated would have experienced the same variation over time.

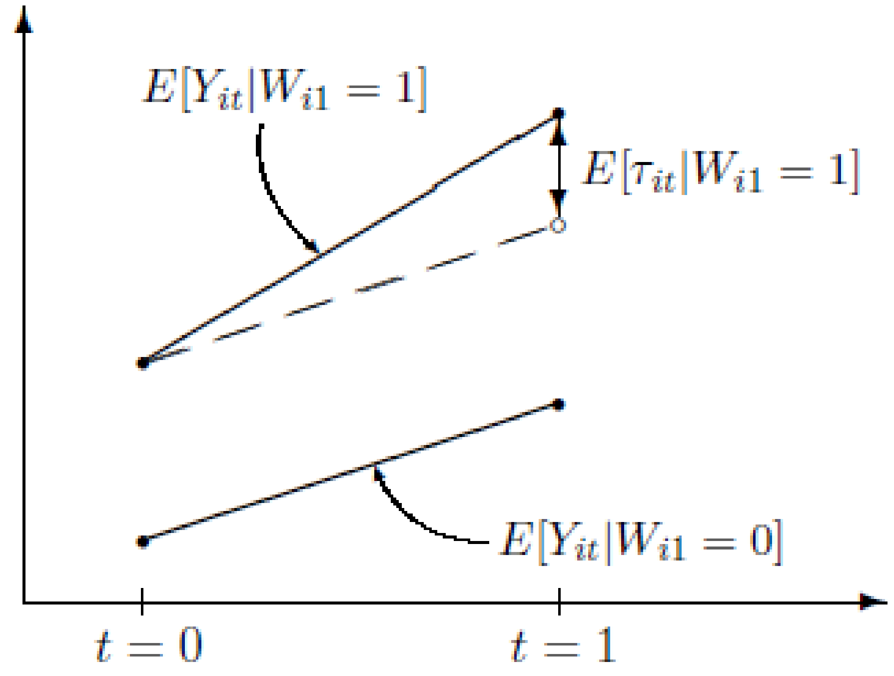
# Difference in differences – cont'd

- Demonstration:

$$E(Y_{0i1}|W_{i1}=1) \; = E(\mu_i|W_{i1}=1)+\delta_1+E(\varepsilon_{i1}|W_{i1}=1)$$
$$= E(\mu_i|W_{i1}=1)+\delta_1+E(\varepsilon_{i1})$$
$$E(Y_{0i0}|W_{i1}=1) \; = E(\mu_i|W_{i1}=1)+\delta_0+E(\varepsilon_{i0})$$
$$E(Y_{0i1}|W_{i1}=0) \; = E(\mu_i|W_{i1}=0)+\delta_1+E(\varepsilon_{i1})$$
$$E(Y_{0i0}|W_{i1}=0) \; = E(\mu_i|W_{i1}=0)+\delta_0+E(\varepsilon_{i0})$$

ECOPA

# Difference in differences – cont’d



# Synthetic Control Method

- DiD estimators often used to evaluate the effects of events or interventions that affect entire aggregate units, such as states, school districts, or countries = comparative case studies.
- Synthetic control estimator provides a data driven procedure to create a comparison unit in comparative case studies. A synthetic control is a weighted average of untreated units chosen to reproduce characteristics of the treated unit before the intervention.
- Advantage with respect to DiD: does not rely on the parallel trends assumption.

ECOPA

# Synthetic Control Method – cont'd

- $J+1$ units observed in periods $1,2,\ldots,T$.
- Unit 1 is exposed to the intervention during period $T_0+1,\ldots,T$. The remaining J units are an untreated reservoir of potential controls (a "donor pool").
- Let $\boldsymbol{w}=(w_2,\ldots,w_{J+1})'$ with $w_j \geq 0$ and $w_2+\cdots+w_{J+1}=1$. Each value of **w** represents a potential synthetic control.
- Let $\mathbf{Y}_j=(Y_{j,1},\ldots,Y_{j,T_0})'$ the vector of observed outcomes for units $j \in \{1,\ldots,J+1\}$ in the pre-treatment periods.

ECOPA

# Synthetic Control Method – cont'd

- Let $X_1$ be a $(k \times 1)$ vector of pre-intervention characteristics for the treated unit; similarly, let $X_0$ be a $(k \times J)$ matrix which contains the same variables for the unaffected units.
- Those characteristics can be not only covariates that explain the outcome variable, but also linear combinations of the variables in $\mathbf{Y}_j$.
- Exple: if the outcome variable is a country's per capita GDP and $T_0 = 12$, $X_j$ may contain the investment rate, some measures of human capital and institutional quality, population, and the average per capita GDP from 1 to 4, from 5 to 8 and from 9 to 12.

ECOPA

# Synthetic Control Method – cont'd

- The vector $\boldsymbol{w}^* = \left(w_2{}^*, \ldots, w_{J+1}{}^*\right)'$ is chosen to minimize $\|X_1 - X_0\boldsymbol{w}\|$, subject to the weight constraints.
- The synthetic control estimator of the effect of the treatment for the treated unit in a post-intervention period $t$ ($t \geq T_0$) is:

$$\hat{\tau}_{1t} = Y_{1t} - \sum_{j=2}^{J+1} w_j^* Y_{jt} \,.$$

# Synthetic Control Method – cont'd

- Application: Germany reunification

TABLE 1 Synthetic and Regression Weights for West Germany

| Country | Synthetic Control Weight | Regression Weight | Country | Synthetic Control Weight | Regression Weight |
|---|---|---|---|---|---|
| Australia | 0 | 0.12 | Netherlands | 0.09 | 0.14 |
| Austria | 0.42 | 0.26 | New Zealand | 0 | 0.12 |
| Belgium | 0 | 0 | Norway | 0 | 0.04 |
| Denmark | 0 | 0.08 | Portugal | 0 | −0.08 |
| France | 0 | 0.04 | Spain | 0 | −0.01 |
| Greece | 0 | −0.09 | Switzerland | 0.11 | 0.05 |
| Italy | 0 | −0.05 | United Kingdom | 0 | 0.06 |
| Japan | 0.16 | 0.19 | United States | 0.22 | 0.13 |

TABLE 2 Economic Growth Predictor Means before German Reunification

| | West Germany | Synthetic West Germany | OECD Sample |
|---|---|---|---|
| GDP per capita | 15808.9 | 15802.2 | 8021.1 |
| Trade openness | 56.8 | 56.9 | 31.9 |
| Inflation rate | 2.6 | 3.5 | 7.4 |
| Industry share | 34.5 | 34.4 | 34.2 |
| Schooling | 55.5 | 55.2 | 44.1 |
| Investment rate | 27.0 | 27.0 | 25.9 |

*Notes:* GDP per capita, inflation rate, trade openness, and industry share are averaged for the 1981–90 period. Investment rate and schooling are averaged for the 1980–85 period. The last column reports a population-weighted average for the 16 OECD countries in the donor pool.

ECOPA

# Synthetic Control Method – cont'd

FIGURE 1 Trends in per Capita GDP: West Germany versus Rest of the OECD Sample

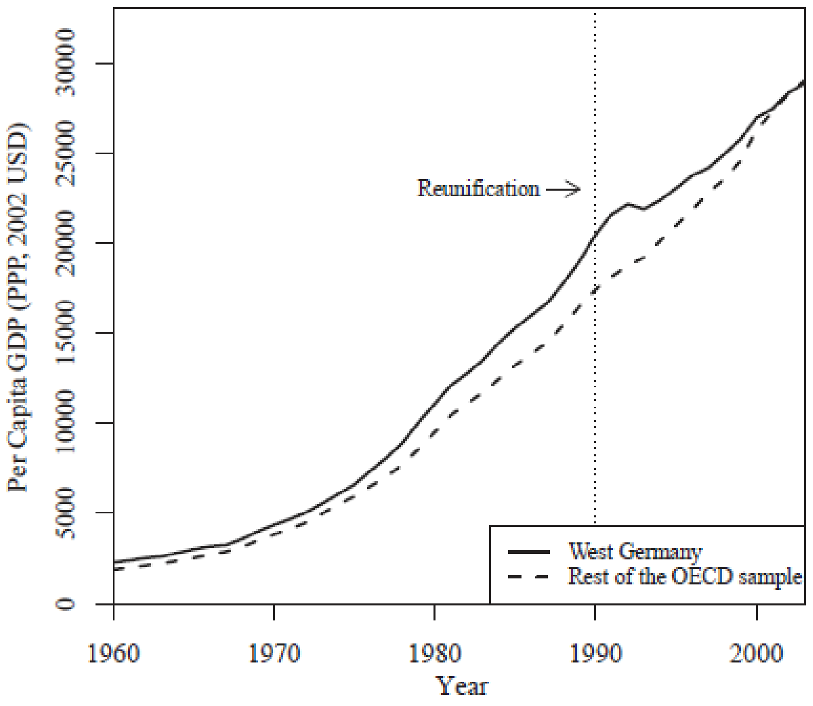
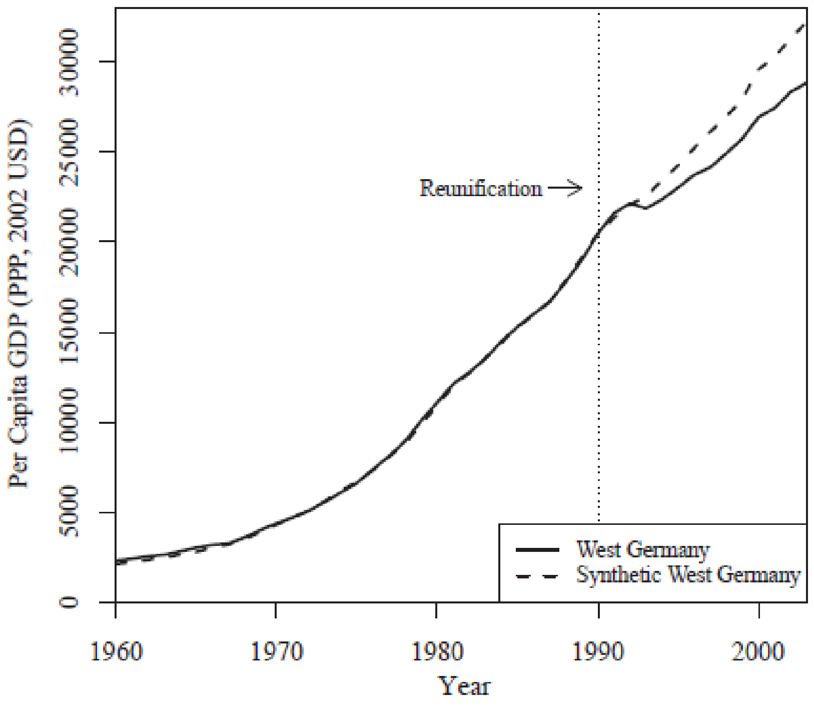



FIGURE 2 Trends in per Capita GDP: West Germany versus Synthetic West Germany




ECOPA

# Synthetic Control Method – cont'd

- Inference: placebo tests
  1. Apply the SCM iteratively to each unit in the donor pool
  2. Compute the test statistics:

$$MSPE\_Ratio_j = \frac{\sum_{t=T_0+1}^{T}\left(Y_{jt} - \hat{Y}_{jt}\right)^2/(T - T_0)}{\sum_{t=1}^{T_0}\left(Y_{jt} - \hat{Y}_{jt}\right)^2/T_0}$$

  which is the ratio of the mean squared prediction errors in the post- and pre-reform periods.

  3. This allows to compute the p-value:

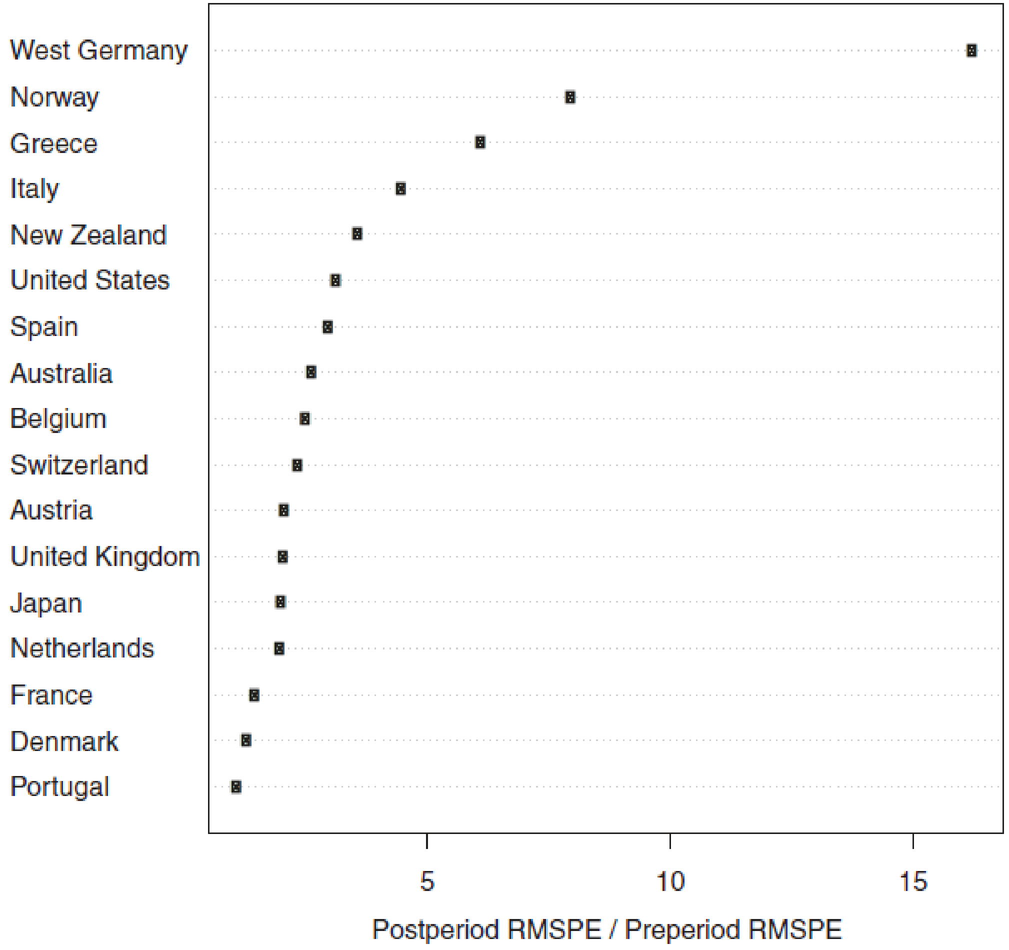
$$p = \frac{\sum_{j=1}^{J+1} I(MSPE\_Ratio_j \geq MSPE\_Ratio_1)}{J + 1}$$

  where $I(.)$ is the indicator function.

  4. Reject the null hypothesis of no effect if $p$ is less than some pre-specified significance level, such as the traditional value of 0.05

ECOPA

# Synthetic Control Method – cont'd




P-value = $1/17 \approx 0.059$

# Case study: OSCARO pricing

# Pricing and elasticities

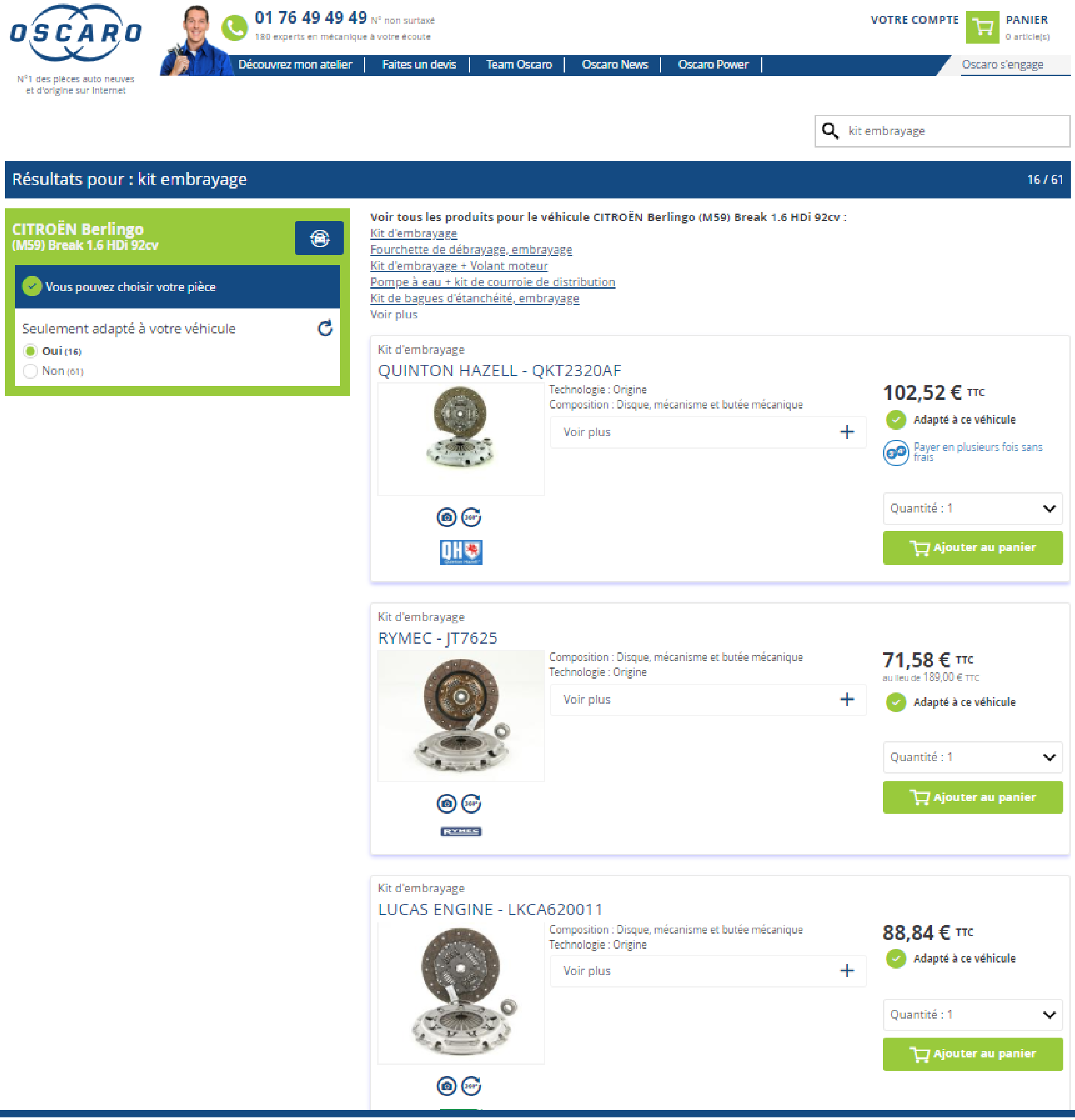
- OSCARO = leader of auto parts on internet
- Optimal pricing based on price elasticities
- By which percentage will the sales increase if the price of a product is decreased by 1%?
- Estimation of elasticities is a crucial issue for the pricing decision

ECOPA

# Estimation of aggregate elasticities

- Measure of aggregate elasticity at the category level
- What is the response of the total quantity sold when the average price in the category vary by 1%?
- Category need to be homogenous -> genart (generic article)
- Exple: Clutch kit
- Quasi experiment: in a given period of time, prices of part of OSCARO's catalog unchanged -> control group.

ECOPA


OSCARO
N°1 des pièces auto neuves et d'origine sur Internet
01 76 49 49 49 N° non surtaxé
180 experts en mécanique à votre écoute
VOTRE COMPTE
PANIER
0 article(s)
Découvrez mon atelier
Faites un devis
Team Oscaro
Oscaro News
Oscaro Power
Oscaro s'engage
kit embrayage
Résultats pour : kit embrayage
16 / 61
CITROËN Berlingo
(M59) Break 1.6 HDi 92cv
Vous pouvez choisir votre pièce
Seulement adapté à votre véhicule
Oui (16)
Non (61)
Voir tous les produits pour le véhicule CITROËN Berlingo (M59) Break 1.6 HDi 92cv :
Kit d'embrayage
Fourchette de débrayage, embrayage
Kit d'embrayage + Volant moteur
Pompe à eau + kit de courroie de distribution
Kit de bagues d'étanchéité, embrayage
Voir plus
Kit d'embrayage
QUINTON HAZELL - QKT2320AF
Technologie : Origine
Composition : Disque, mécanisme et butée mécanique
Voir plus
102,52 € TTC
Adapté à ce véhicule
Payer en plusieurs fois sans frais
Quantité : 1
Ajouter au panier
Kit d'embrayage
RYMEC - JT7625
Composition : Disque, mécanisme et butée mécanique
Technologie : Origine
Voir plus
71,58 € TTC
au lieu de 189,00 € TTC
Adapté à ce véhicule
Quantité : 1
Ajouter au panier
Kit d'embrayage
LUCAS ENGINE - LKCA620011
Composition : Disque, mécanisme et butée mécanique
Technologie : Origine
Voir plus
88,84 € TTC
Adapté à ce véhicule
Quantité : 1
Ajouter au panier

ECOPA

# Estimation of aggregate elasticities – cont'd

- Price before treatment of product i = $p_i^0$, after treatment = $p_i^1$
- Price variation : $\Delta p$ = $p_i^1 - p_i^0$; $\Delta p = 0$ for untreated products
- Panel data regression:

$$Y_{it} = \tau * \frac{\Delta p}{p_{i0}} + \mu_i + \delta_t + \varepsilon_{it},$$

where

- $Y_{it}$ is the quantity sold of product i on day t;
- $\Delta p / p_{i0}$ is the percentage price variation of product $i$ (treatment intensity)

- $E(Y_{oit} | W_{it} = 0) = E(Y_{1it} | W_{it} = 1) - \tau E\left(\frac{\Delta p}{p_{i0}}\right)$

RHS is estimated

ECOPA

# Evaluation des actions pricing

## Genart 479 : Kit d'embrayage

| Début test | Début traitement | Fin test | Nbre articles genart (vus) | Nbre articles traités | Prix moyen articles traités – avant traitement | Prix moyen articles traités – après traitement | Variation du prix moyen |
|---|---|---|---|---|---|---|---|
| 25/08/2018 | 08/09/2018 | 27/09/2018 | 10 321 | 9 060<br>(87.78 %) | 180.65 € | 174.47 € | -6.18 €<br>(-3.42 %) |

**Résultats**

| | Réalisé* | Sans traitement (estimé)* | Effet du traitement | Intervalle de confiance |
|---|---|---|---|---|
| **Volume** | 235 | 184 | +51 (+27.96 %) | [+39,+64] |
| **CA** | 27 960 € | 24 945 € | +3 015 € (+12.09 %) | [+1 874 €,+4 157 €] |
| **Marge** | 4 6148 € | 4 860 € | -242 € (-4.98 %) | [-679 €,+195 €] |

*Moyenne quotidienne

# Case study: SCM analysis

# Evaluation of the OHADA Uniform Act on Secured Transactions

- Established in 1993, the Organisation for the Harmonization of Business Law in Africa (OHADA) – made up of 17 countries – devises initiatives for francophone Africa, supplying uniform legal and regulatory frameworks.
- The UA on Secured Transactions (2010) was published in the *OHADA Official Gazette* on December 15, 2010, and came into force on May 16, 2011
- Key objective: support <u>access to credit</u> by providing new collateral mechanisms

ECOPA

# UA on Secured Transactions: SCM

- Variables used:
  - ➢ Impact variable: Domestic credit to private sector (percent of GDP)
  - ➢ Control variables:
    - Liquid liabilities to GDP (percent)
    - GDP growth (annual percent)
    - Agriculture, value added (percent of GDP)
    - Industry, value added (percent of GDP)
    - Services, value added (percent of GDP)
  - ➢ Control variables averaged over the entire pre-reform period
  - ➢ Pre-reform values of the impact variable are also used to construct the synthetic control unit

ECOPA

# UA on Secured Transactions: SCM – cont'd

- Time coverage:
  - Analysis conducted for the 1995 to 2015 period
  - Year of the reform = 2011
  - Pre-reform years: 1995 to 2010
- Selection of control countries:
  - ✓ Step1: *Basic pool of control countries*

    Potential control countries = 122 non-OHADA Sub-Saharan African countries and countries elsewhere in the world with low, lower-middle, and upper-middle-income economies, per World Bank classification (GNI per capita less than $12,475).
  - ✓ Step2: *Filtering Out Control Countries That Implemented Similar Reforms During the Intervention Period*

    - Doing Business project (World Bank) provides objective measures of business regulations for local firms in 190 economies
    - 'Getting credit' indicator, between 0 and 100, is a measure of access to credit
    - Countries were excluded if the difference between their minimum and maximum values was at least 18.75, the increase in the score observed in OHADA countries
    - After this filter was applied, the donor pool dropped 52 countries

ECOPA

# UA on Secured Transactions: SCM – cont'd

- Selection of control countries:
  - ✓Step3: *Filtering Out Control Countries with Missing Values*

  Some countries were dropped because of missing values for either the impact variable or the control variables. Exact criteria for eliminating countries based on missing values were:

    - The impact variable measurements were required for all years in the analysis, both pre and post-reform. Countries with even one missing observation of this variable were removed. 21 countries were removed for this reason.
    - Control variables were averaged over the pre-intervention period. Countries with no observations on any of the control variables over the pre-intervention period were removed. Countries removed for this reason were Haiti and Samoa.
    - In addition, 2 OHADA countries – Democratic Republic of Congo and Guinea – were discarded because impact variable values were missing, leaving 15 OHADA countries.

ECOPA

# UA on Secured Transactions: SCM – cont'd

- Selection of control countries:
  - ✓Step4: *Final Pool of Control Countries*

    The following 46 control countries remained and were used as the final donor pool for this evaluation: Algeria, Angola, Argentina, Bangladesh, Belize, Botswana, Brazil, Burundi, Colombia, Djibouti, Dominica, Ecuador, El Salvador, Fiji, Grenada, Guyana, Jamaica, Jordan, Kenya, Lesotho, Madagascar, Malawi, Malaysia, Mexico, Moldova, Mozambique, Myanmar, Namibia, Nepal, Nicaragua, Nigeria, Panama, Pakistan, Paraguay, Seychelles, Sierra Leone, South Africa, St. Lucia, St. Vincent and the Grenadines, Sudan, Suriname, Swaziland, Tanzania, Thailand, Turkey, and Uganda.

ECOPA

# UA on Secured Transactions: SCM – cont'd

- Valid synthetic controls:
  - ✓ Credible analysis requires that the values of the synthetic control unit's pre-intervention outcome trajectory closely approximates the one of the treated unit
  - ✓ Absolute measure of fit: Root Mean Square Prediction Error

$$RMSPE - Pre = \left( \frac{1}{16} \sum_{t=1995}^{2010} \left( Y_{1t} - \sum_{j=2}^{J+1} w_j^* Y_{jt} \right)^2 \right)^{\frac{1}{2}}$$

  - ✓ Relative measure of fit:

$$RMSPE - Pre/Mean - Pre$$

with

$$Mean - Pre = \frac{1}{16} \sum_{t=1995}^{2010} Y_{1t}$$

  - ✓ Countries were retained if this ratio was lower than 0.2.
  - ✓ 10 countries – out of 15 – satisfied this criterion

ECOPA

# UA on Secured Transactions: SCM – cont’d

- Size of impact:
  - ✓The impact in each post-reform year (2011 to 2015) appears as the gap between the observed impact variable and its value in the synthetic control unit
  - ✓The impact variable – domestic credit to the private sector – is expressed as a percentage of GDP and converted into a monetary value (United States dollars) by multiplying it by GDP
  - ✓Summing this transformed variable over the post-reform years provides the total *absolute* size of impact
  - ✓The *relative* size of impact can be defined as the ratio of absolute impact on the value of the impact variable in the baseline year (2010) just preceding the reform

ECOPA

actions on Domestic Credit

Table 3: Impact of the UA on Secured Transactions on Domestic Credit

# UA on Secured Transactions: SCM – cont’d

| Impact | Country | RMSPE-Pre | Mean-Pre | RMSPE-Pre / Mean-Pre | Size of Impact (millions) | Relative Impact (2010 domestic credit) |
|---|---|---|---|---|---|---|
| **No** | *Benin* | 1.06 | 11.65 | 0.09 | $103.60 | 0.07 |
| **Yes** | *Burkina Faso* | 0.99 | 12.14 | 0.08 | $893.70 | 0.62 |
| **Yes** | *Cameroon* | 0.34 | 9.19 | 0.04 | $417.00 | 0.14 |
| **Yes** | *Central African Republic* | 0.62 | 6.00 | 0.10 | $32.85 | 0.18 |
| **Yes** | *Comoros* | 0.68 | 11.39 | 0.06 | $30.29 | 0.32 |
| **No** | *Côte d'Ivoire* | 0.53 | 14.10 | 0.04 | $153.30 | 0.04 |
| **No** | *Gabon* | 1.15 | 9.59 | 0.12 | $-174.40 | -0.15 |
| **Yes** | *Mali* | 1.03 | 13.11 | 0.08 | $607.00 | 0.35 |
| **Yes** | *Senegal* | 0.53 | 18.38 | 0.03 | $1111.00 | 0.34 |
| **Yes** | *Togo* | 1.87 | 16.31 | 0.11 | $729.10 | 1.03 |


ECOPA

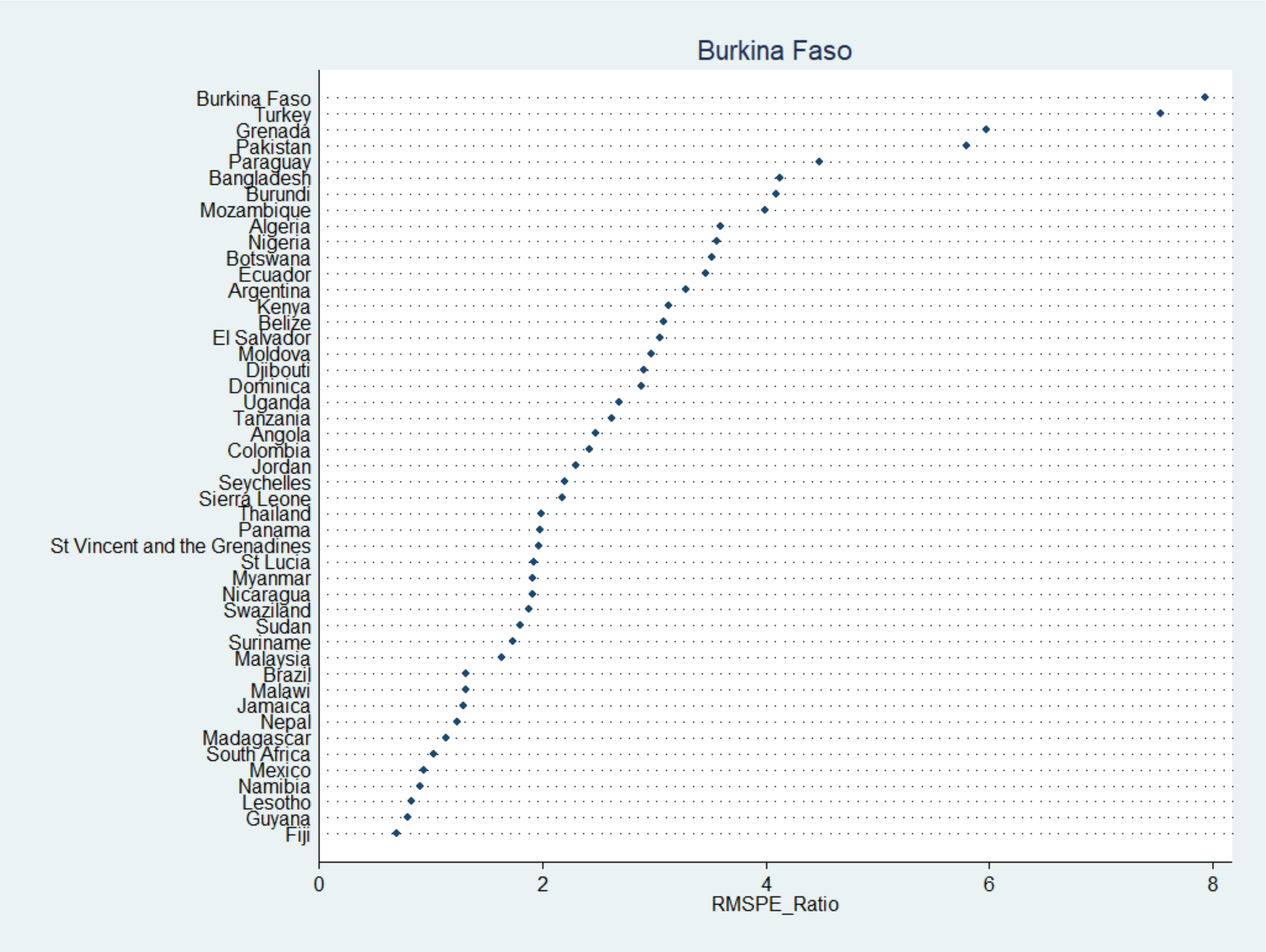
# UA on Secured Transactions: SCM – cont’d

- Significance of impact:
  - Computation and ranking of $MSPE\_Ratio_j$ for all countries in the donor pool
  - $MSPE\_Ratio_j$ should be small for countries with no reform
  - Burkina Faso ranks 1st out of 47 countries → p-value = 1/47 = 0.02

ECOPA

# UA on Secured Transactions: SCM – cont'd

**Figure 7: Placebo in Space: Burkina Faso (RMSPE Ratio)**



# UA on Secured Transactions: SCM – cont'd

- Robustness of results:
  - Check whether results were driven by a particular control country. Are results robust to the removal of this country?
  - "leave-one-out" test: SCM runned iteratively, omitting at each iteration one of the countries receiving a positive weight in the respective synthetic countries

ECOPA

# UA on Secured Transactions: SCM – cont'd

**Table A1.4: Leave-One-Out RMSPE-Post/RMSPE-Pre Ratios**

| Removed Country | Burkina Faso | Central African Republic | Cameroon | Comoros | Mali | Senegal | Togo |
|---|---|---|---|---|---|---|---|
| **None** | **7.93** | **5.79** | **6.16** | **6.76** | **5.41** | **9.32** | **6.26** |
| **Algeria** | | | 7.24 | | | | |
| **Angola** | | | | | | | 6.13 |
| **Argentina** | | | | | 5.00 | | |
| **Botswana** | | | | | | | |
| **Burundi** | | | 3.99 | | 4.84 | | |
| **Djibouti** | | | | 5.29 | | | 5.12 |
| **Ecuador** | 8.04 | | | | | 5.72 | |
| **El Salvador** | 7.88 | | | | | | |
| **Fiji** | | | | | | 4.31 | |
| **Guyana** | 8.01 | | | | 4.79 | 9.17 | |
| **Jamaica** | | | | | | 8.29 | 6.16 |
| **Kenya** | | | | 6.57 | | | |
| **Lesotho** | | | | 6.41 | | | 6.27 |
| **Madagascar** | | | 5.47 | 6.89 | | | |
| **Malawi** | | | 5.31 | | 5.76 | | 6.09 |
| **Malaysia** | | | | | 5.84 | | |
| **Mexico** | | | | 6.68 | | | 6.30 |
| **Moldova** | | | | | | | |
| **Mozambique** | | | | 6.92 | | 9.16 | |
| **Myanmar** | | 6.64 | 7.80 | | 6.10 | | |
| **Nepal** | 7.35 | | | | | | |
| **Nicaragua** | 8.31 | | | | | | |
| **Nigeria** | | | | | | | |
| **Pakistan** | | | | | | | |
| **Sierra Leone** | 6.14 | 1.86 | 3.44 | 4.81 | 3.02 | 6.93 | 6.30 |
| **Sudan** | 6.73 | 5.09 | | | 5.01 | 9.53 | |
| **Suriname** | 8.08 | | | | 6.06 | | |
| **Swaziland** | | | | | | | 5.62 |
| **Syria** | 7.95 | 5.58 | 6.15 | | | 7.94 | |
| **Tanzania** | | 6.51 | 6.32 | | | | |
| **Turkey** | | | | | | 10.96 | 6.51 |
| **Uganda** | | | 6.22 | | | | |

- Results robust for Burkina Faso
- For CAR however, much dependent on the inclusion of Sierra Leone in the donor pool → check carefully whether SL is a "valid" control country

ECOPA

# More on pricing

# Discrete Choice Model

- Berry (1994)
- Allows for the estimation of elasticities at the product level: own- and cross-price
- Consumer makes his choice within a category of $J$ substitutable products

# Discrete Choice Model – cont'd

- Utility of individual $i$ from buying product $j$ in period $t$:

$$U_{ijt} = cons + \alpha P_{jt} + \boldsymbol{\beta X_{jt}} + \mu_j + \gamma_t + \xi_{jt} + \varepsilon_{ijt}$$

with

  - $P_{jt}$ the price of product $j$ in period $t$
  - $\boldsymbol{X_{jt}}$ a set of (observable) covariates
  - $\mu_j$ and $\gamma_t$ product and time fixed effects
  - $\xi_{jt}$ <u>unobserved</u> characteristics of product $j$ in period $t$
  - $\varepsilon_{ijt}$ idiosyncratic preferences

- Covariates may include prices of competitors, traffic, promotions, …

ECOPA

# Discrete Choice Model – cont'd

- Individual $i$ buys product $j$ if:

$$U_{ijt} > U_{ij't} \quad \forall j' \neq j$$

- Possibility of buying nothing (outside good $j = 0$): $U_{i0t} = \varepsilon_{i0t}$
- Logit assumption: $\varepsilon_{ijt}$ iid according to type I extreme value distribution:

$$pdf\colon f(\varepsilon) = e^{-\varepsilon} e^{-e^{-\varepsilon}}$$
$$cdf\colon F(\varepsilon) = e^{-e^{-\varepsilon}}$$

- The market share of product $j$ is then (exercise):

$$s_{jt} = \frac{e^{\delta_{jt}}}{\sum_{k=0}^{J} e^{\delta_{kt}}},$$

where $\delta_{jt} = cons + \alpha P_{jt} + \boldsymbol{\beta X_{jt}} + \mu_j + \gamma_t + \xi_{jt}$.

ECOPA

# Discrete Choice Model – cont'd

- Demonstration (suppress time indices):
  - Probability that an individual with type $\varepsilon_{ij}$ buys product $j$:

$$P_{ij}\middle|\varepsilon_{ij} = prob\left(\delta_j + \varepsilon_{ij} > \delta_{j'} + \varepsilon_{ij'} \quad \forall j' \neq j\right)$$
$$= \prod_{j' \neq j} e^{-e^{-(\varepsilon_{ij}+\delta_j-\delta_{j'})}}$$

  - "Summing" over all possible individual types:

$$s_j = \int_{-\infty}^{+\infty} P_{ij}\middle|\varepsilon_{ij}\, f(\varepsilon_{ij}) d\varepsilon_{ij}$$
$$= \frac{e^{\delta_j}}{\sum_{k=0}^{J} e^{\delta_k}}$$

  - See book by Kenneth Train (Discrete choice models - section 3.10) for intermediate computations

ECOPA

# Discrete Choice Model – cont'd

- Recognizing that $s_{0t} = \frac{1}{\sum_{k=0}^{J} e^{\delta_{kt}}}$ and taking the logs of $s_{jt}$ and $s_{0t}$:

$$\ln s_{jt} - \ln s_{0t} = \delta_{jt}$$

$$\Leftrightarrow \ln q_{jt} - \ln q_{0t} = cons + \alpha P_{jt} + \boldsymbol{\beta X_{jt}} + \mu_j + \gamma_t + \xi_{jt}$$

- <u>This is the equation to be estimated</u>, with:
  - $\xi_{jt}$ the error term;
  - $s_{jt} = q_{jt}/M$ where $q_{jt}$ is the quantity sold and M the market size (number of potential consumers)
  - $q_{0t} = M - \sum_{j=1}^{J} q_{jt}$
- If not known, the value of $M$ should be assumed

ECOPA

# Discrete Choice Model – cont’d

- Instrumentation
  - Error term $\xi_{jt}$ (unobserved products characteristics varying with time) may be correlated with prices
  - Exple: Hotel raises its price because of a public event nearby, not taken into account in the model
  - “Solution”: instrumental variables = unit costs or lag of prices

ECOPA

# Discrete Choice Model – cont'd

- Price elasticities of demand:
  - Own-price:

$$e_j = \frac{\partial q_j}{\partial P_j}\frac{P_j}{q_j}$$
$$= \alpha P_j(1 - s_j)$$

    - ✓ Depends on the disutility of price ($\alpha < 0$)
    - ✓ Absolute value increasing in prices and decreasing in market shares
  - Cross-price:

$$e_{jl} = \frac{\partial q_j}{\partial P_l}\frac{P_l}{q_j}$$
$$= -\alpha P_j s_l$$

ECOPA

# Discrete Choice Model – cont'd

- Price optimization:
  - Ojective:

    Turnover

$$CA(\boldsymbol{P}) = \sum_{j=1}^{J} P_j \, q_j$$

    Total margin

$$\Pi(\boldsymbol{P}) = \sum_{j=1}^{J} (P_j - c_j) q_j$$

    where $\boldsymbol{P} = (P_1, \dots, P_J)$ and $c_j$ is the unit cost

  - Possibility to add constraints (business rules) with respect to competitors' prices, margin rates, …