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Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA
Consiglio Nazionale delle Ricerche IRCrES ISTITUTO di RICERCA sulla CRESCITA ECONOMICA SOSTENIBILE RESEARCH INSTITUTE on SUSTAINABLE ECONOMIC GROWTH

Missione 4
Istruzione e Ricerca

The Responsiveness Scores Model for Impact Driver Analysis

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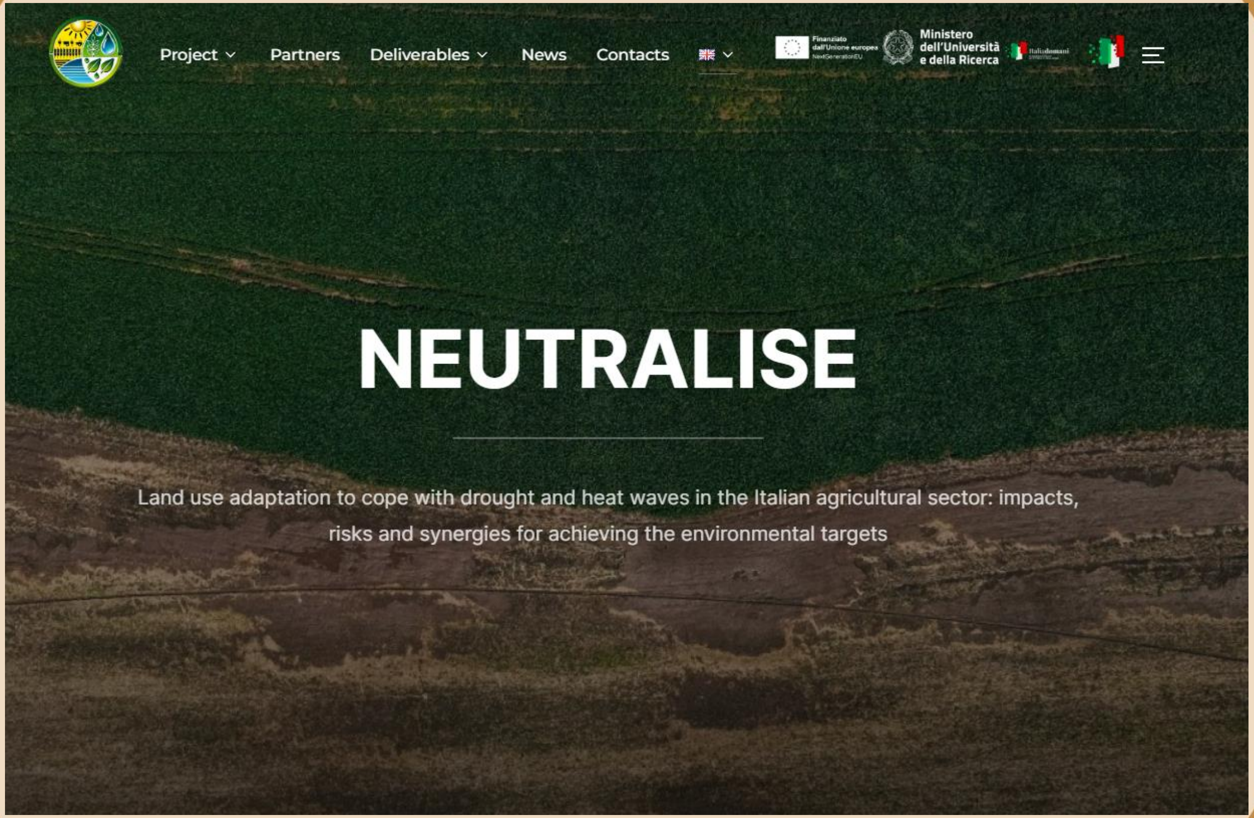

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Introduction

- **Risk mapping** of climate change effect on land use is a central task of **NEUTRALIZE** project
- In **WP3 "Statistical analysis and indicators"**, **CNR-IRCRES** wants to contribute by adopting a statistical methodology for building **resilience indicators** called **Responsiveness Scores (RSs)**
- Using RSs, we are able to **map resilience** of a target variable *y* on a series of determinants **x** of *y* using an ***iterated random-coefficient regression***

What we want to do?

- The AGRITALIM provides different datasets on the basis of different climate scenarios
- For each scenario (i.e., dataset) we run a **Responsiveness Scores (RSs)** model to analyze the **resilience** of farms with respect to specific outcome (Ys) determined by specific drivers (Xs)
- We study the change in the RSs within the different scenarios

$$Y_i = f(X_i)$$

i = Region / Altimetry Agricultural sector

What RSs are?

Responsiveness Scores measure the change of a given outcome y when a given factor x_j changes, conditional on all other factors $\mathbf{x}_{-j}$.

It is the *derivative* of y on x_j, given $\mathbf{x}_{-j}$ (*regression coefficient*), but allowing each observation to get its own **responsiveness score** (*random coefficient regression*).

RSCORES: definition and estimation

Responsiveness Scores (RS) are obtained by an *iterated* ***Random Coefficient Regression*** **(RCR)**. The basic econometrics of this model can be found in Wooldridge (2002, pp. 638-642). The calculation of RS follows this simple protocol:

1. Define y, the outcome (or *response*) variable.
2. Define a set of Q factors thought of as affecting y, and indicate the generic factor with x_j.
3. Define a RCR model linking y to the various x_j, and extract a unit-specific *responsiveness effect* of y to the all set of factors x_j, with j=1, ... , Q.
4. For the generic unit i and factor j, indicate this effect as b_{ij} and collect all of them in a matrix B. Finally, aggregate by unit (row) and by factor (column) the b_{ij} getting synthetic unit and factor responsiveness measures.

Analytically, an RS is defined as the "**partial effect**" of an RCR (Wooldridge, 1997; 2002; 2005). Define a RCR model of this kind:

$$\begin{cases} y_i = a_{ij} + b_{ij} x_{ij} + e_i \\ a_{ij} = \gamma_0 + \mathbf{x}_{i,-j}\gamma + u_{ij} \\ b_{ij} = \delta_0 + \mathbf{x}_{i,-j}\boldsymbol{\delta} + v_{ij} \end{cases}$$

where e_i, u_{ij} and v_{ij} are error terms with $E(e_i \mid x_{ij}) = E(u_{ij} \mid x_{ij}) = E(v_{ij} \mid x_{ij}) = 0$.

According to this model, we can define the **regression line** as:

$$E(y_i \mid x_{ij},a_{ij},b_{ij}) = a_{ij} + b_{ij}x_{ij}$$

From this, we define the **RS** of of x_{ij} on y_i as the *derivative* of y_i respect to x_{ij}, that is:

$$\frac{\partial}{\partial x_{ij}}\left[E(y_i \mid x_{ij},a_{ij},b_{ij})\right] = b_{ij}$$

where: b_{ij} is called the ***partial effect*** of x_{ij} on y_i.

We can repeat the same procedure for each x_{ij} (j=1, ..., Q) so that it is possible eventually to define, for each unit i =1 ..., N and factor j=1, ..., Q, the N x Q matrix **B** of "partial effects" as follows:

$$\mathbf{B} = \begin{pmatrix} b_{11} & \cdots & b_{1Q} \\ \vdots & b_{ij} & \vdots \\ b_{N1} & \cdots & b_{NQ} \end{pmatrix}$$

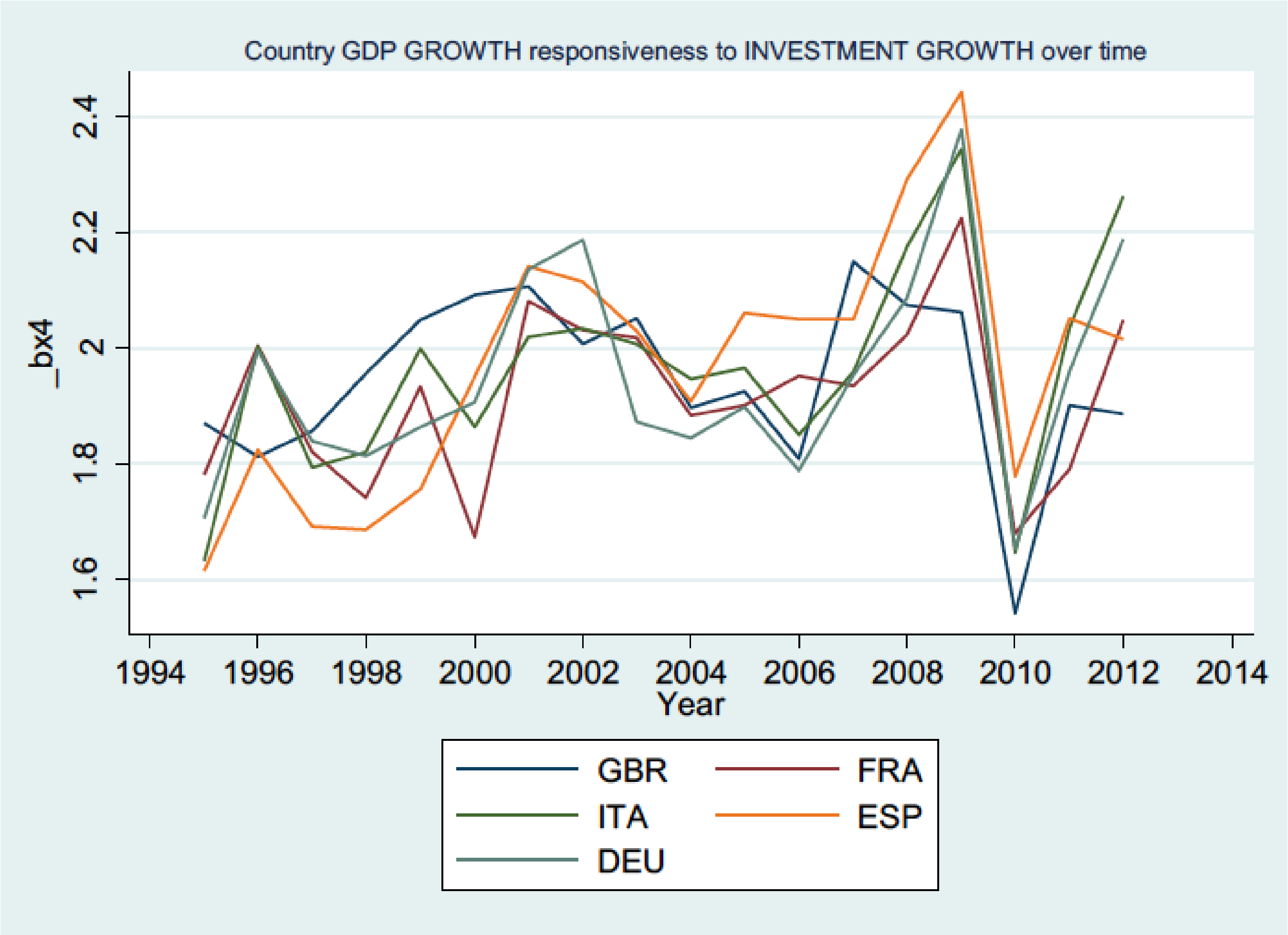
If all variables are standardized, partial effects are **beta coefficients** so that they are independent of the unit of measurement and can be compared and summed.

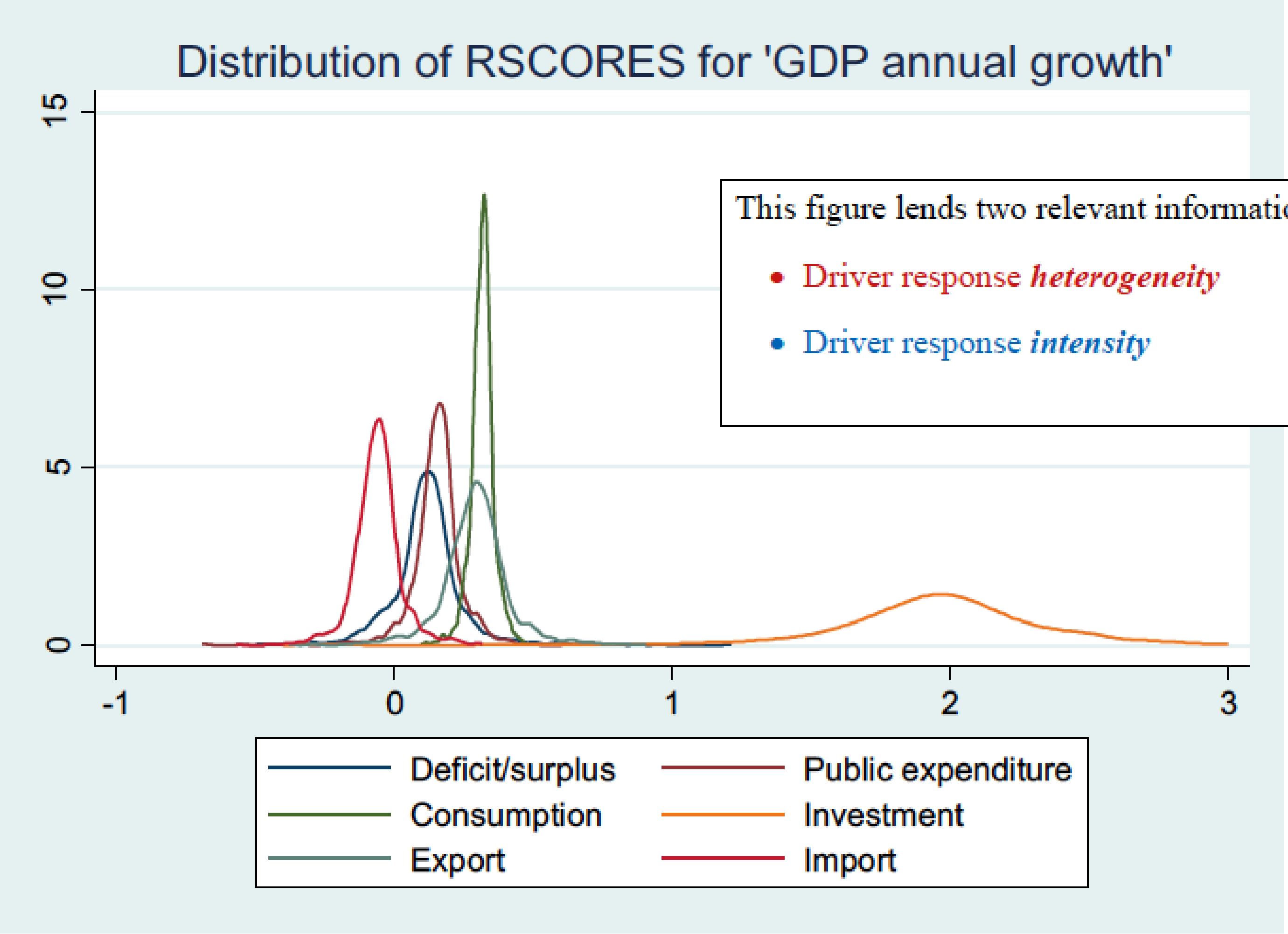
Once matrix **B** is known, we can define for each unit *i* the Total Unit Responsiveness (TUR) and the Mean Unit Responsiveness (MUR) as:

$$\mathrm{TUR}_i = \sum_{j=1}^{Q} b_{ij} \quad \text{and} \quad \mathrm{MUR}_i = \frac{1}{Q}\sum_{j=1}^{Q} b_{ij}$$

and for each factor *j*, the Total (or Mean) Responsiveness of *y* to factor *j*'s unit change (TFR and MFR) as:

$$\mathrm{TFR}_j = \sum_{i=1}^{N} b_{ij} \quad \text{and} \quad \mathrm{MFR}_j = \frac{1}{N}\sum_{i=1}^{N} b_{ij}$$


Country GDP GROWTH responsiveness to INVESTMENT GROWTH over time
_bx4
1.6
1.8
2
2.2
2.4
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
Year
GBR
FRA
ITA
ESP
DEU



This figure lends two relevant information:

- Driver response ***heterogeneity***
- Driver response ***intensity***

Unit responsiveness rank

```
set more off
sort _bx4
list countryname year _bx4 if _bx4>=3 & _bx4!=.
```

```
      +-----------------------------------------+
      |          countryname   year        _bx4 |
      |-----------------------------------------|
1864. |              Belarus   1992    3.230418 |
1865. |           Azerbaijan   1999    3.232215 |
1866. |                 Mali   2006    3.271389 |
1867. |          Congo, Rep.   2008    3.311152 |
1868. |           Seychelles   2008    3.314989 |
      |-----------------------------------------|
1869. |              Nigeria   2012    3.334117 |
1870. |     Macao SAR, China   2009    3.413818 |
1871. |  Trinidad and Tobago   2007     3.46852 |
1872. |            Indonesia   1999    3.514539 |
1873. |            Argentina   2002    3.515946 |
      |-----------------------------------------|
1874. |             Bulgaria   1991    3.667125 |
1875. |   Iran, Islamic Rep.   1994    3.690769 |
1876. |             Bulgaria   1990     4.40006 |
1877. |              Nigeria   2004    5.845391 |
      +-----------------------------------------+
```

Conclusions

`rscore` can be useful to detect both *factor importance* and *factor heterogeneous response*

`rscore` allows to *fixed-effect* estimation to mitigate potential factor *endogeneity*

`rscore` allows to rank both factors and observations, thus providing more detailed idiosyncratic information