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SOFTWARE TOOLS FOR STATISTICAL DISCLOSURE CONTROL

Herramientas software para el control de la confidencialidad y del output

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SEMINARIO SOBRE APLICACIONES Y DESARROLLO DE BIG DATA Y DATA SCIENCE EN LA BANCA CENTRAL

3 de junio de 2021

ESTADÍSTICA

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Data laboratory BELab

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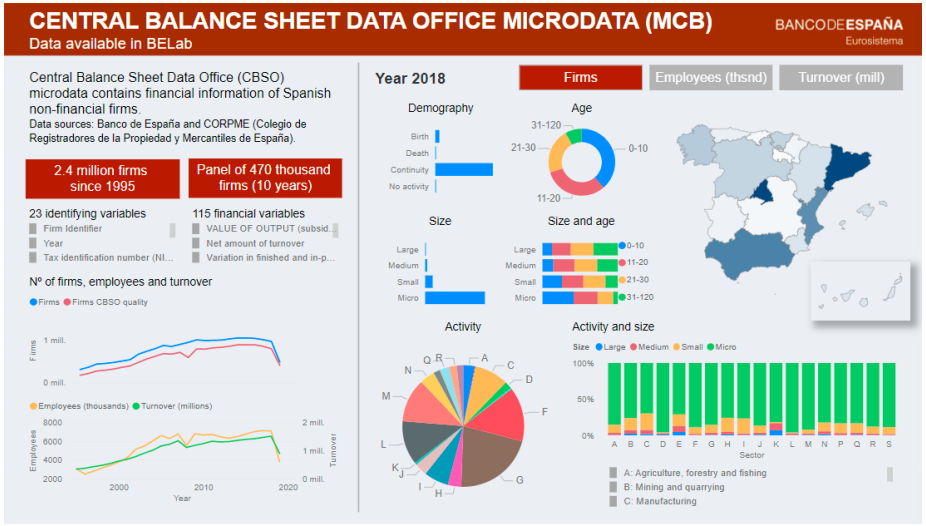
- https://www.bde.es/bde/es/areas/analisis-economi/otros/que-es-belab/
- Banco de España launched BELab in **July 2019** to provide access to the research community to high quality microdata, as part of its **strategic plan** (December 2019)
- **On-site and remote access**
- **Available datasets:**
  - Non-financial enterprises and corporate groups
  - Debt securities issuers
  - Households surveys
  - The German Federal Employment Agency
- Interactive **dashboards** for the exploration of available datasets
- Exploring **anonymization and output control tools** for future use



Introduction to Statistical Disclosure Control

- Due to **national laws on privacy**, micro-data cannot be distributed to the public or to researchers whenever re-identification of persons or establishments is possible.
- The goal of **anonymizing** micro-data and tabular data is to prevent confidential information from being assigned to a specific respondent.
- **Disclosure**, also known as "**re-identification**", occurs when an intruder uses some released data to reveal previously unknown information about an individual.
- **Types of disclosure**: identity disclosure, attribute disclosure, inferential disclosure.
- Confidentiality can be achieved by applying **statistical disclosure control** (SDC) methods to the data in order to **decrease the disclosure risk** [1].
- **Software** packages are fundamental for the anonymization of data sets.

[1] Templ, M., Kowarik, A., & Meindl, B. (2015). Statistical disclosure control for micro-data using the R package sdcMicro. Journal of Statistical Software, 67(1), 1-36.

[2] Templ, M., Meindl, B., & Kowarik, A. (2013). Introduction to statistical disclosure control (SDC).

Unsafe data that DOES allow re-identification of individual units

SDC tools

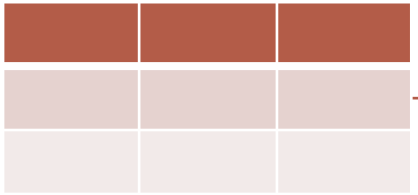
Safe data that DOES NOT allow re-identification of individual units

Unsafe microdata

mu-argus or sdcMicro

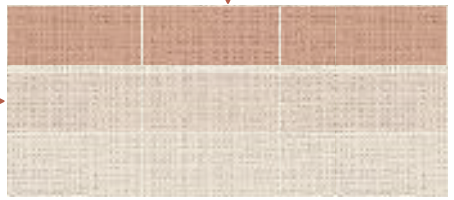
Safe microdata for research or publication

Output control



Unsafe tables

tau-argus or sdcTable



Safe tables for publication

Unsafe data that DOES allow re-identification of individual units

SDC tools

Safe data that DOES NOT allow re-identification of individual units

Company	Activity	Location	Turnover
Telefonica	Telecom	Madrid	**1 mill**
Taller Pérez	Motor	Patones	**100**

Unsafe microdata

mu-argus or sdcMicro

Company	Activity	Location	Turnover
?	Telecom	Madrid	>500 mil
?	Motor	Patones	-

Safe microdata for research or publication

Output control

Frequency table

	Madrid	Patones
Telecom	300	**2**
Motor	500	**1**

Average turnover (magnitude table)

	Madrid	Patones
Telecom	**1.1 mill**	**50**
Motor	3 mill	**100**

Unsafe tables

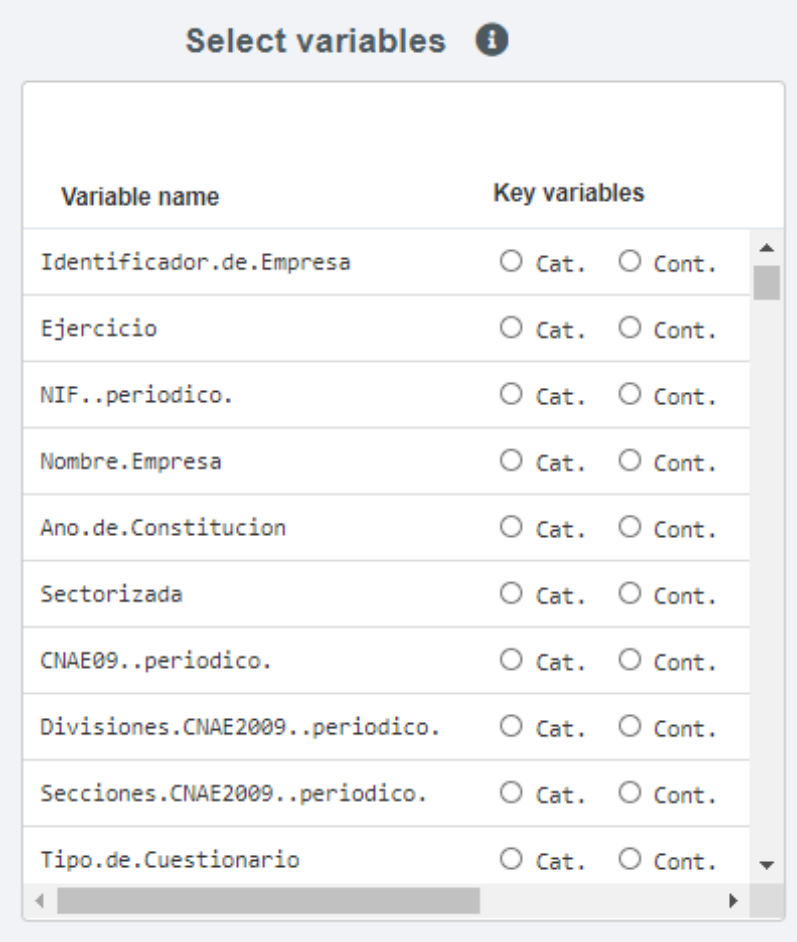
tau-argus or sdcTable

Average turnover (magnitude table)

	Madrid	Patones
Telecom	>1 mill, < 2mill	<100
Motor	> 2 mill	<500

Safe tables for publication

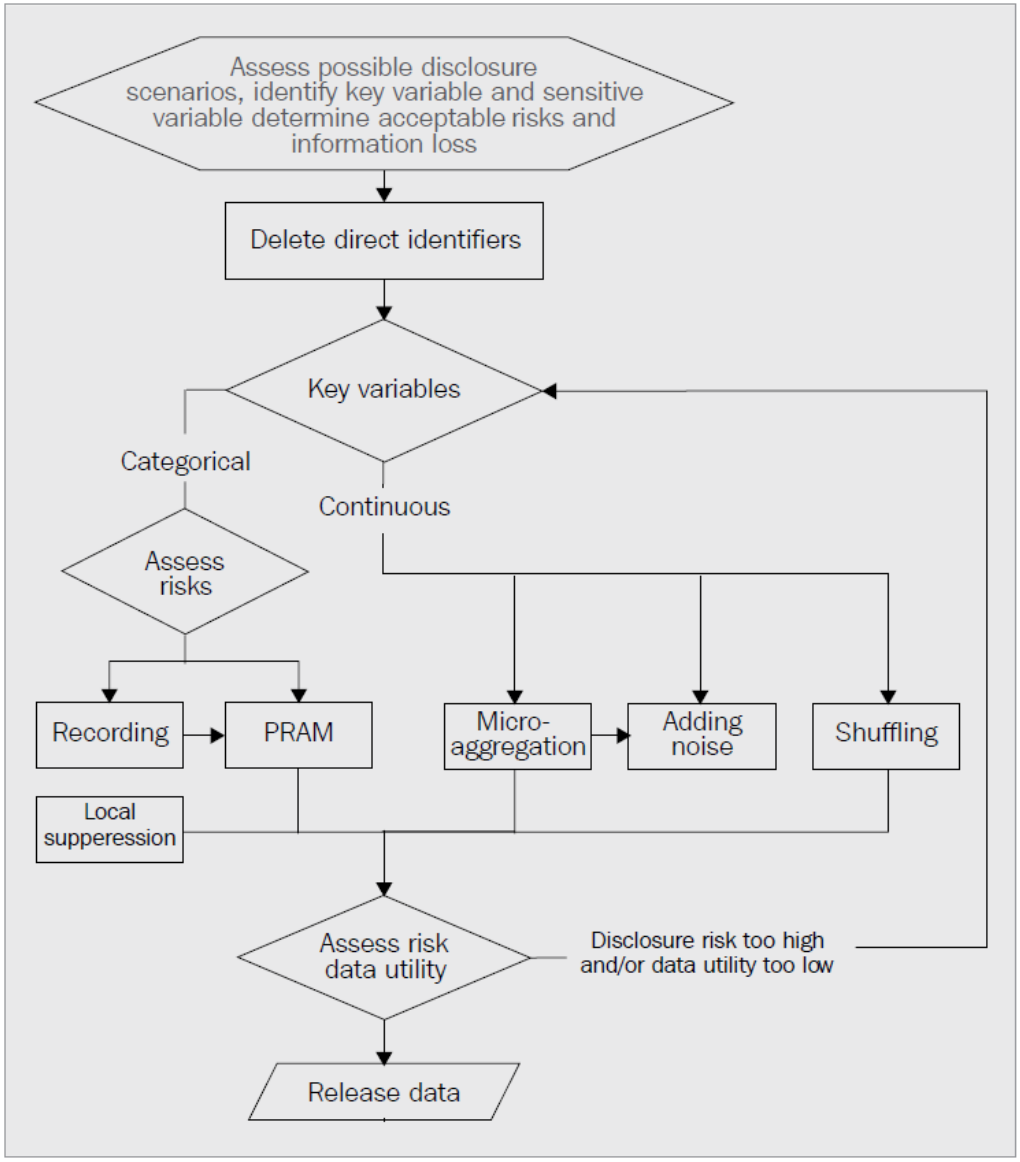
- ***Identifying* variables**, those whose values might lead to re-identification, must be determined:
  - **Direct identifiers** precisely identify statistical units (company name, CIF, address, etc).
  - **Key variables** (categorical or continuous), when considered together, can be used to identify individual units (region, activity, net turnover, total assets, total employment, etc).
  - **Sensitive variables** must not be discovered for any individual unit (insolvency status, etc).
- Determining **key variables** is a challenge and involves discussions with domain experts and interpretation of national laws.



SDC workflow for microdata protection

1. **Deletion of direct identifiers,** to guarantee primary confidentiality
2. **Key and sensitive variables identification**, to address secondary confidentiality
3. **Individual disclosure risks measurement** based on sample frequency counts (k-anonymity, l-diversity, etc).
4. **Application of SDC-methods** to modify high-risk observations.
5. **Disclosure risk and information loss** are recomputed comparing original and modified data.

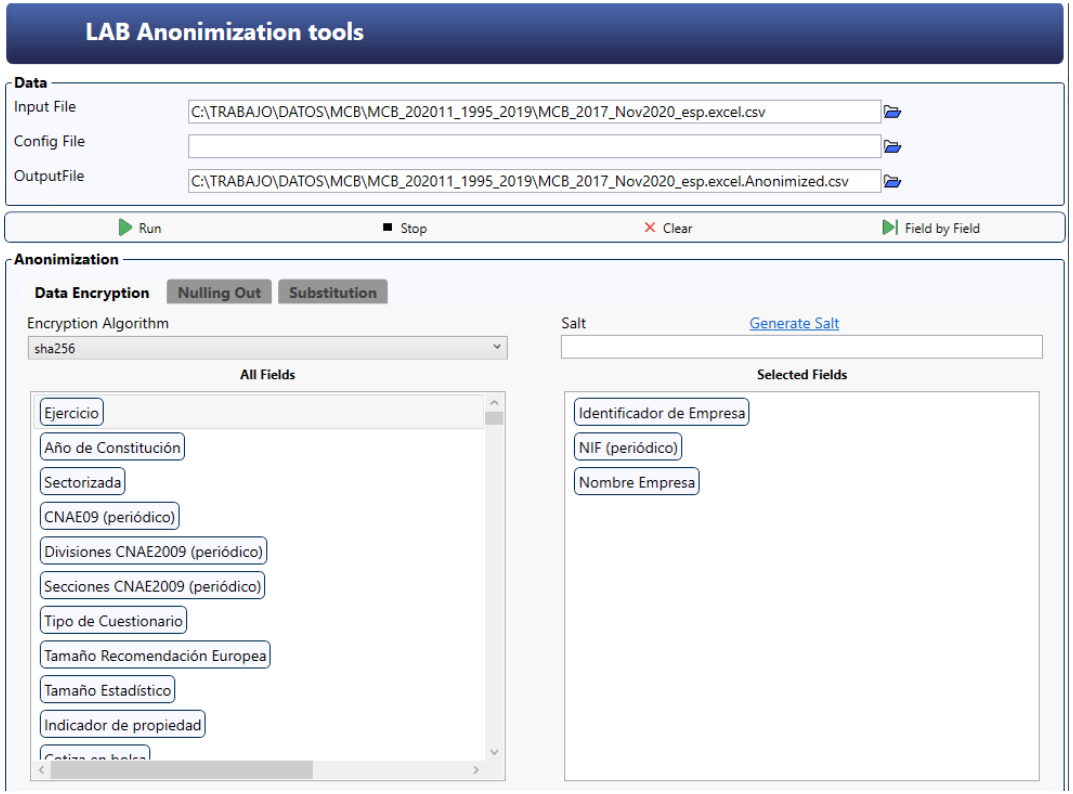
- The goal is to **release a safe data set** with low (individual) risks and high data utility.



- **Anonymization tool** developed by the IT Dept for BELab to guarantee **primary confidentiality**:
  - Replaces **direct identifiers** by anonymous unique identifiers (sha256, sha512 hashing algorithm)
  - Repeatable but irreversible process

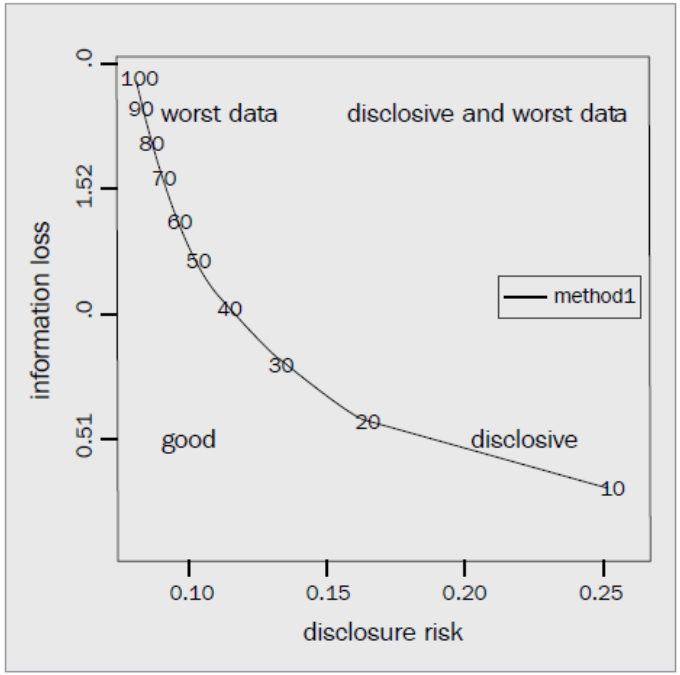
- **Steps**:
  - Select input file
  - Select configuration parameters (seed)
  - Select identifying variables
  - Run anonymization and save data

- **Future functionalities**: allow for string substitutions, etc



SDC workflow for microdata protection
Application of SDC methods

- A **trade-off** between information loss and disclosure risk must be achieved, based on the use case requirements.
- Very **sensitive data** requires more **aggressive anonymization** to guarantee low disclosure risk.
- The **access mode** (on-site vs remote access) also determines the degree of anonymization.
- The complexity of **output control** depends on the anonymization used and the affordable risk.
- Multiple **SDC methods** for microdata and tabular data protection are available:

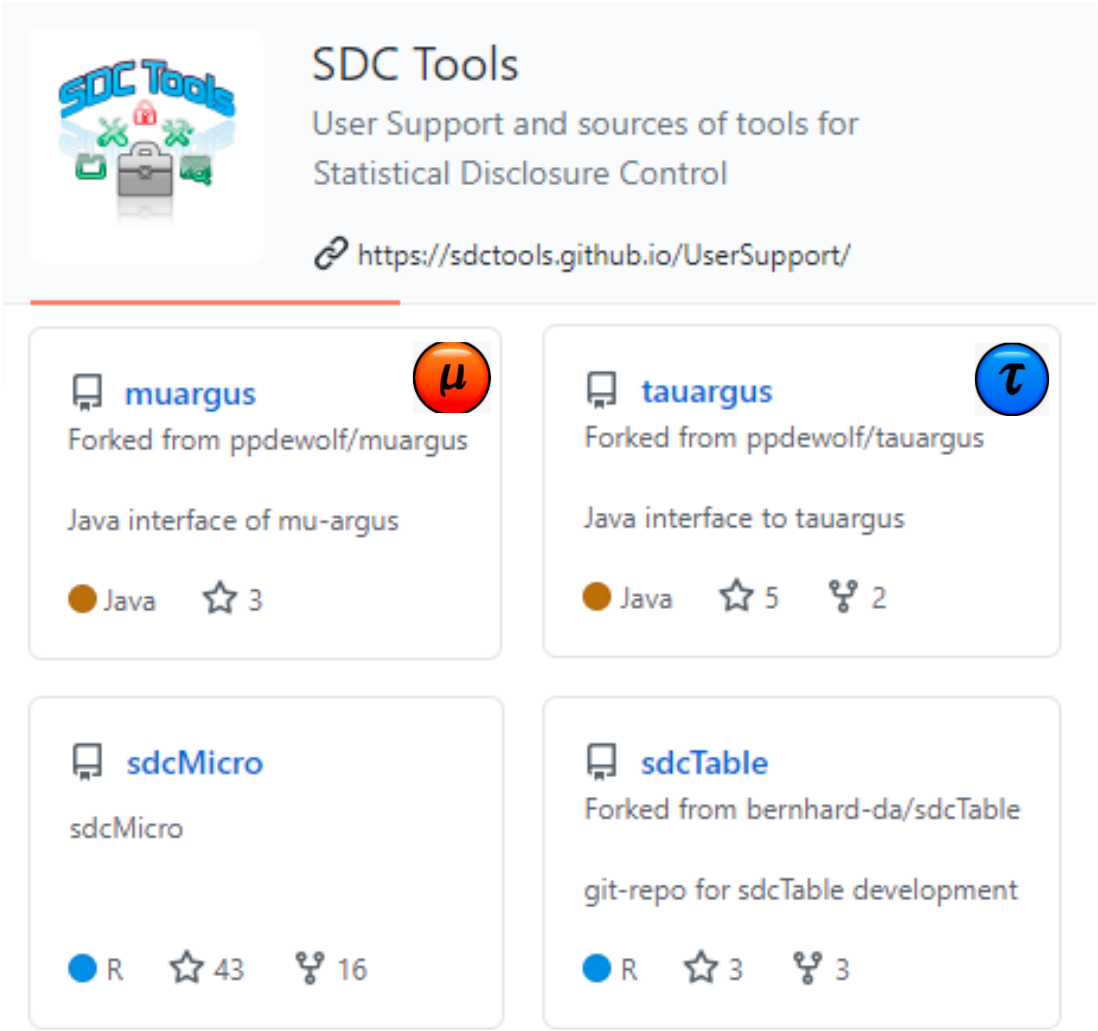


	Deterministic SDC methods	Probabilistic SDC methods
Categorical key variables	Recoding Local suppression	Swapping PRAM
Continuous key variables	Micro-aggregation	Adding correlated noise Shuffling

SDC tools for tabular data and microdata protection

- SDC software is used by **National Statistical Institutes, Eurostat, National Banks,** and other **public bodies**.
- **Eurostat** launched a Specific Grant for the user support and maintenance of SDC tools.
- **Git repository**:

  https://github.com/sdcTools
- Tools for **microdata protection**: mu-argus, sdcMicro
- Tools for **tabular data protection**: tau-argus, sdcTable



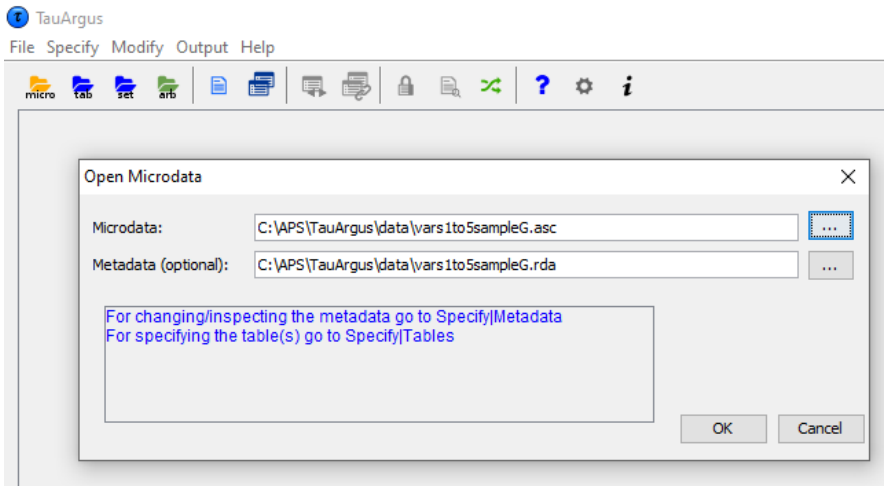
SDC tools for tabular data and microdata protection

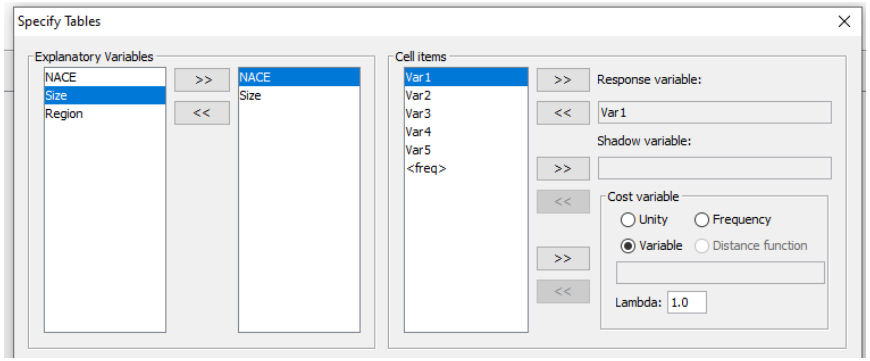
- **Tabular data protection:** tau-argus vs sdcTable:
  - Tau-argus has a **GUI**, sdcTable is command line and requires programming
  - We will use **tau-argus** in BELab
- **Microdata protection:** mu-argus vs sdcMicro:
  - Both libraries have a **GUI**, no programming required
  - Mu-argus is similar to tau-argus, learning can be easier
  - sdcMicro incorporates more algorithms
  - sdcMicro claims to be better optimized for **large datasets**.
  - We will probably use **sdcMicro** in BELab
- Tau-argus and mu-argus are implemented in **Java**, sdcTable and sdcMicro in **R**.

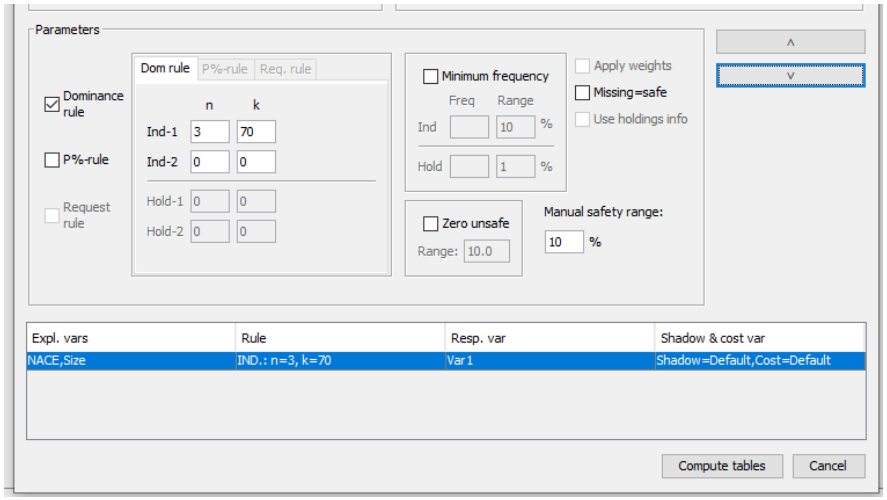
Method \ Software	μ-Argus 4.2	sdcMicroGUI > 1.1.0
Frequency counts	✔	✔
Individual risk	✔	✔
Individual risk on households	✔	✔
l-diversity		✔
SUDA2		
Global risk	✔	✔
Global risk with log-lin mod.		
Recoding	✔	✔
Local suppression	(✔)	✔
Swapping	(✔)	
PRAM	✔	✔
Adding correlated noise		✔
Micro-aggregation	✔	✔
Shuffling		✔
Utility measures	(✔)	✔
GUI	(✔)	✔
CLI		
Missing values	✔	✔
Cluster designs	✔	✔
Large data		✔
Reporting	✔	✔
Platform independent		✔
Free and open-source		✔

Protecting tabular data with tau-argus
Example with a sample dataset

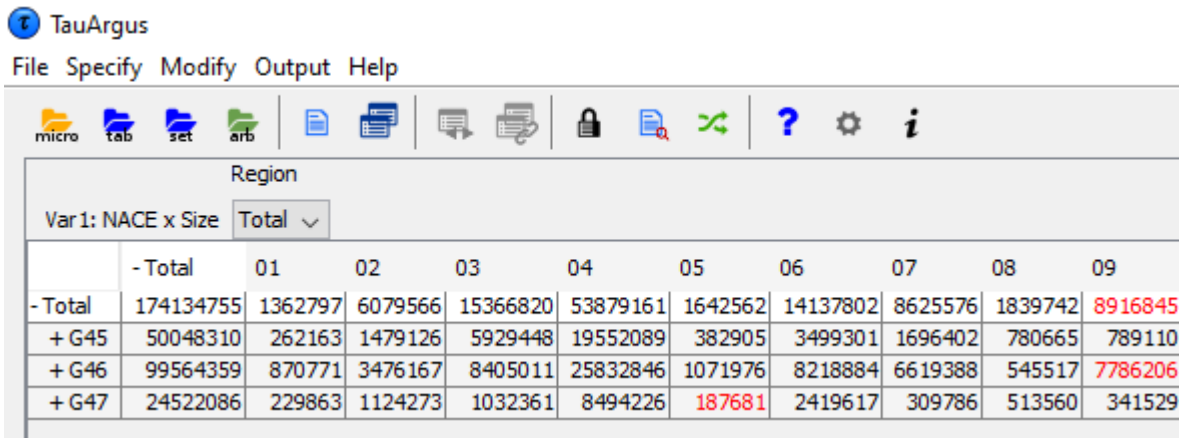
1. **Open microdata** (or table)
2. Select variables and **specify tables**
3. Set **anonymization parameters** (dominance rule, P% rule, weights, etc)



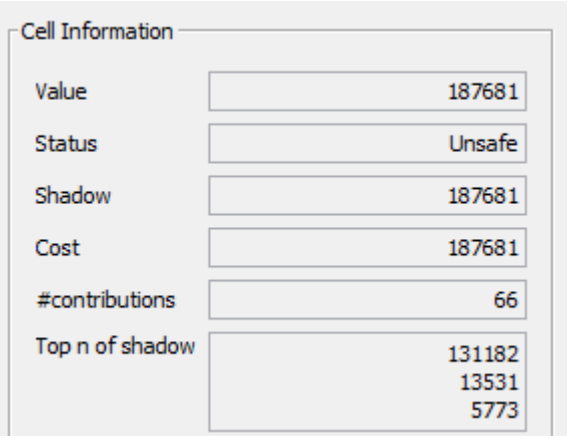




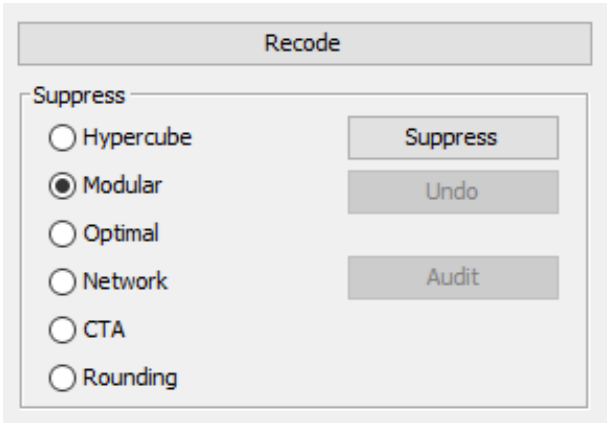
4. Tau-argus identifies table cells with high **risk of re-identification**.

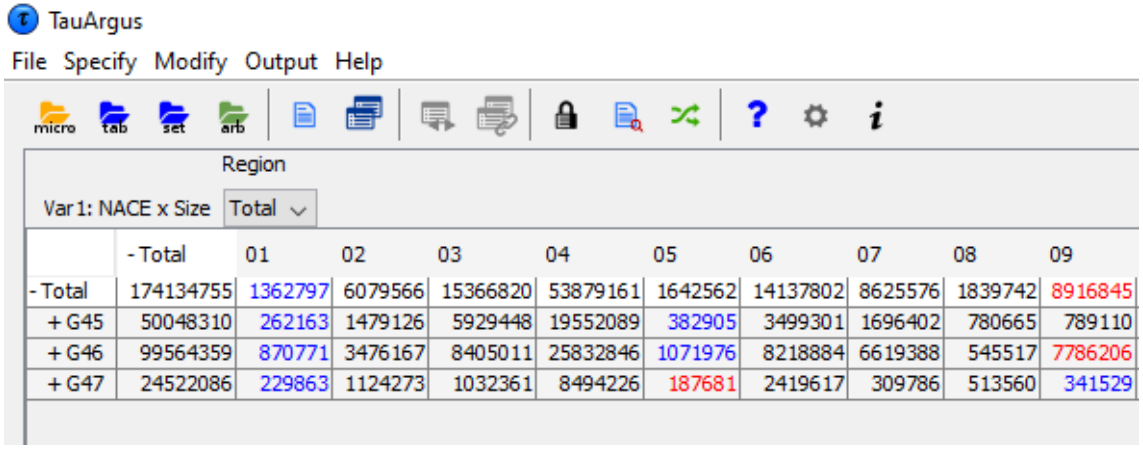


	- Total	01	02	03	04	05	06	07	08	09
- Total	174134755	1362797	6079566	15366820	53879161	1642562	14137802	8625576	1839742	8916845
+ G45	50048310	262163	1479126	5929448	19552089	382905	3499301	1696402	780665	789110
+ G46	99564359	870771	3476167	8405011	25832846	1071976	8218884	6619388	545517	7786206
+ G47	24522086	229863	1124273	1032361	8494226	187681	2419617	309786	513560	341529



5. Select and run **SDC algorithm** (primary and secondary suppression, recoding, etc)





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6. Generate an anonymization **report** summarizing the process and results.

τ-ARGUS Report

Fri May 28 13:46:24 CEST 2021

Original file:	*C:\APS\TauArgus\data\vars1to5sampleG.asc*
Meta file:	*C:\APS\TauArgus\data\vars1to5sampleG.rda*
Table file:	*C:\APS\TauArgus\data\cosa.txt*

Sensitivity Rule:

Dominance rule (Individual level) with n = 3 and k = 70%
Manual safety margin: 10%
Missing codes have been considered unsafe

Modular (HITAS) Salazar solution

Solver used: SCIP

libTauHITaS version is 4.2.4.1

Using SCIP
SCIP version is 3.110000
using SoPlex 2.0.1

Max time per subtable: 1 minutes

Additional Singleton/Singleton option has been used
Additional Singleton/Multiple option has been used
Additional Min. Frequency option has been used

Time used to protect the table: 10 min 48 sec

Table generated from microdata

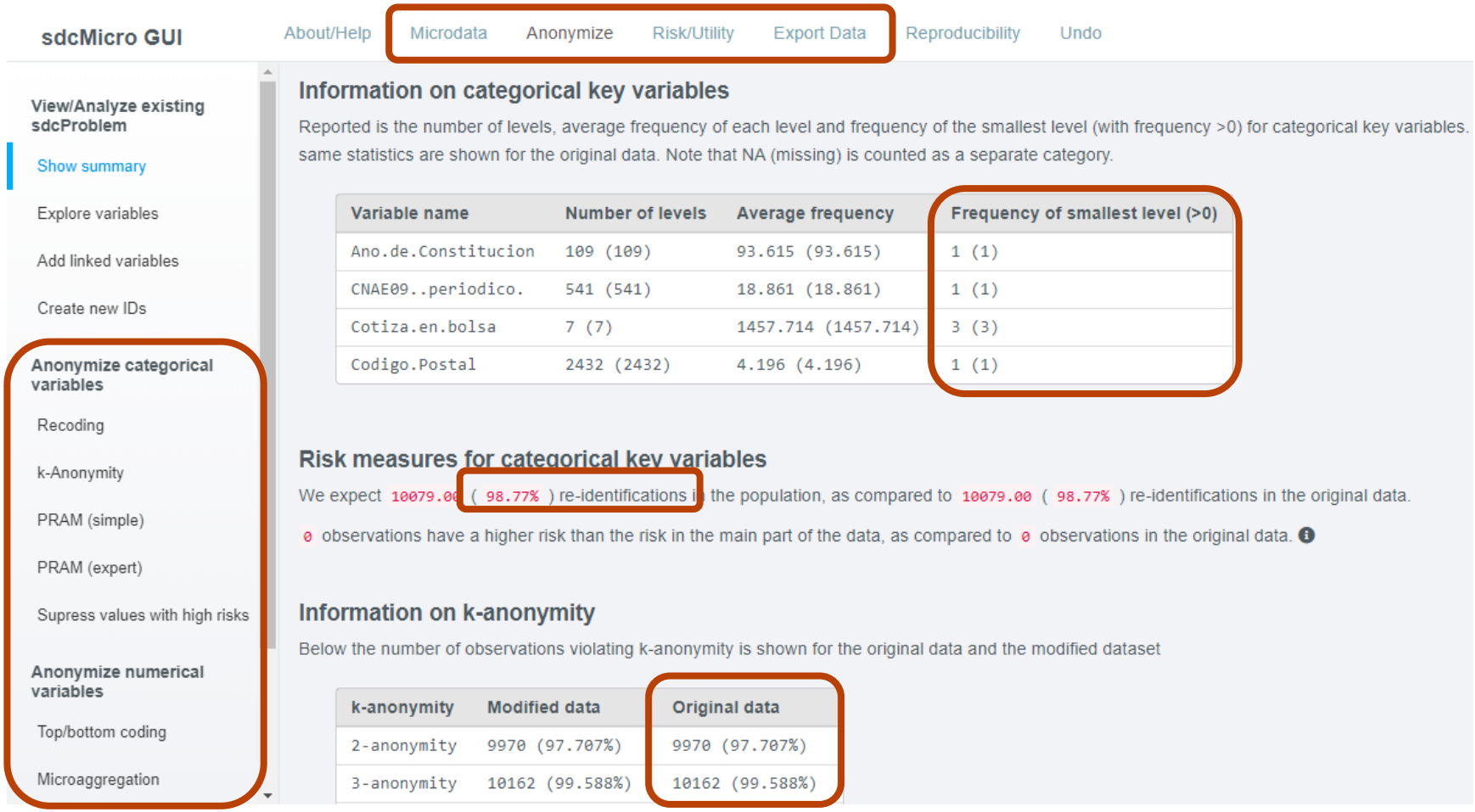
Table structure

Type	Var	# codes
Response var:	*Var1*	
Explanatory var1:	*NACE*	*248*
Explanatory var2:	*Size*	*17*
Explanatory var3:	*Region*	*12*

Summary of the table

	Status	Number of cells	Number of respondents	Response value	Cost value
1	*Safe*	*5152*	*1472848*	*2988357328*	*2988357328*
2	*Safe (manual)*	*0*	*0*	*0*	*0*
3	*Unsafe*	*17061*	*152983*	*1252095455*	*1252095455*
4	*Unsafe (request)*	*0*	*0*	*0*	*0*

- **Key variables** (categorical and continuous) are manually identified by the domain expert. High risk samples are identified and SDC methods applied to minimize risk.



Protecting microdata with sdcMicro
Example with a BELab dataset (MCB)

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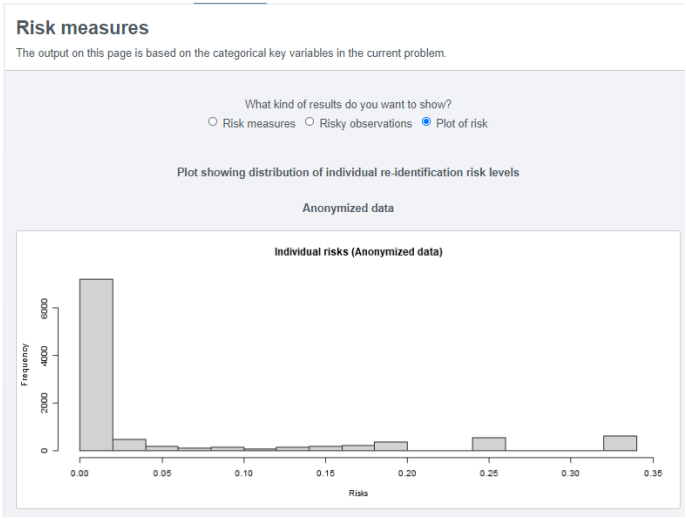
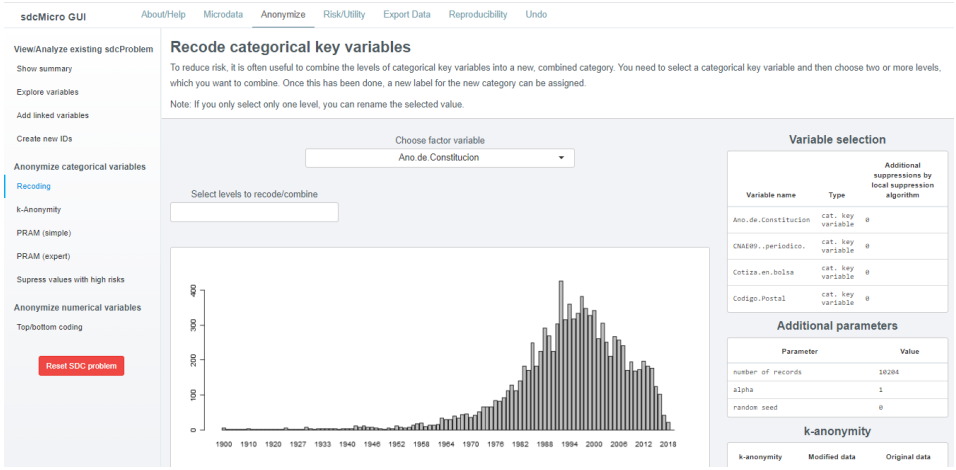
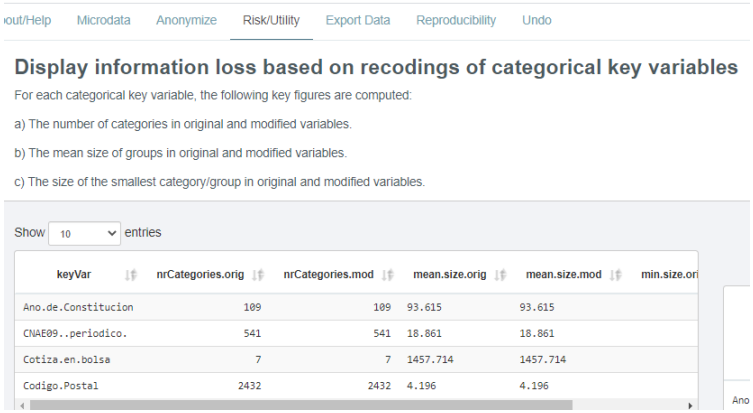
❑ Disclosure risk assessment



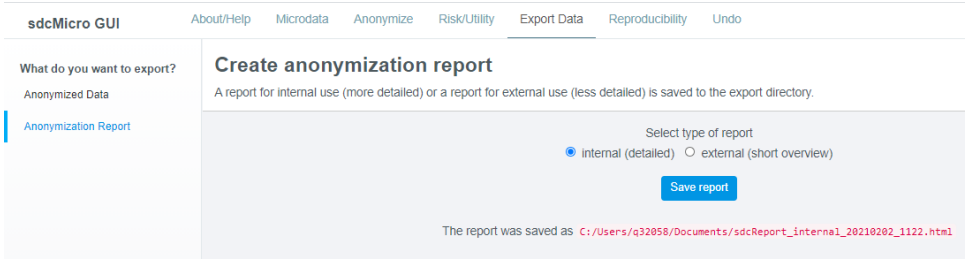
❑ Anonymization methods to reduce risk



❑ Information loss and data utility assessment

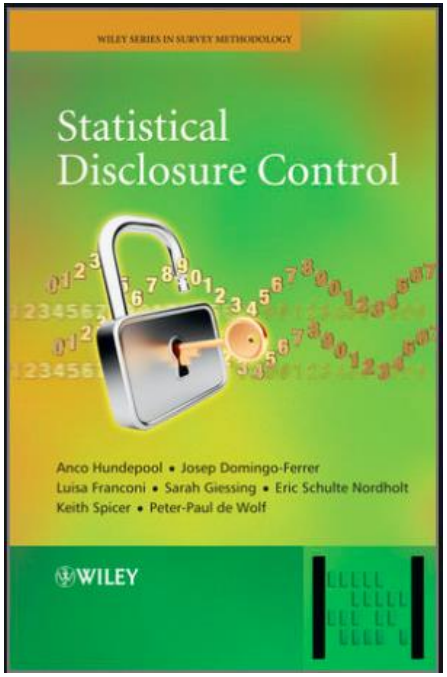


❑ Report generation



Resources

- **Git repository**: https://github.com/sdcTools
- **User support**: https://sdctools.github.io/UserSupport/
- **SDC book**: Hundepool, A., Domingo-Ferrer, J., Franconi, L., Giessing, S., Nordholt, E. S., Spicer, K., & De Wolf, P. P. (2012). ***Statistical disclosure control***. John Wiley & Sons.
- **Eurostat courses**: https://ec.europa.eu/eurostat/cros/content/estp-training-offer_en



DATE	COURSE TITLE	VENUE	COURSE ORGANISER	APPLICATION DEADLINE
23-26 March 2021 4 days	Statistical Disclosure Control	ONLINE	EUROSTAT	**25.01.2021**
21-22 October 2021 2 days	Output checking in research data centres	Eurostat, Luxembourg	EUROSTAT	**23.08.2021**
05-10-2021 12-10-2021 19-10-2021 26-10-2021 4 sessions	Big Data tools for data scientists	ONLINE	ICON-INSTITUT Public Sector GmbH	**09.08.2021**

Summary and conclusions

- The goal of **Statistical Disclosure Control** is to minimize disclosure risk while maximizing information utility when releasing microdata or tabular data.
- Powerful and reliable **software tools** for SDC are available, including mu-argus, tau-argus, sdcMicro and sdcTable.
- Multiple **public institutions** use them (Central Banks, Data Centers, Statistical Institutes, etc).
- The identification of **key variables** is a challenge and requires expert knowledge of the data.
- Eurostat **courses** and other learning **resources** are available.
- **Output control** is still a highly manual process. **Eurostat** is about to release a Stata tool to support output control.
- **BELab** staff has recently explored existing SDC tools and plans to use them in the near future when sensitive datasets are incorporated to the laboratory.

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Thank you for your attention!