Preprocessing

K. Gibert

Dep. *Statistics and Operations Research*

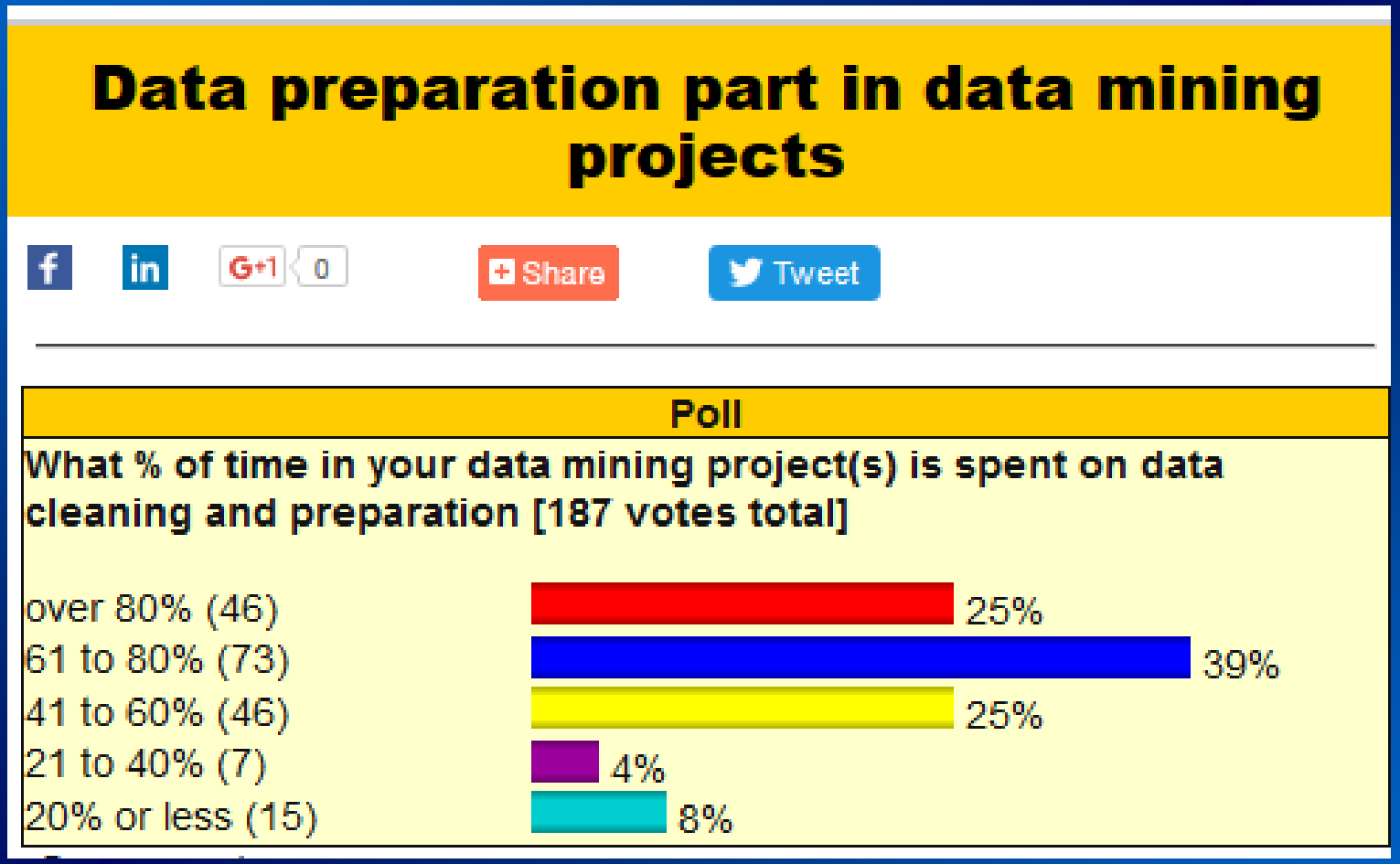
Knowledge Engineering and machine learning group at
Intelligent Data Science and Artificial Intelligence Research Center

University Research Institute on Science and Technology for Sustainability

Universitat Politècnica de Catalunya-BarcelonaTech

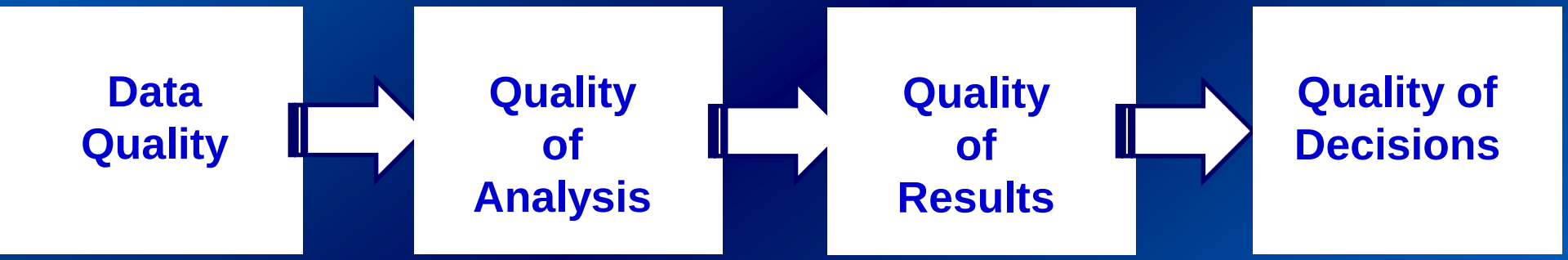
Apunts disponibles (histoIntrodesc)

Impact of Preprocessing in real Data Mining projects



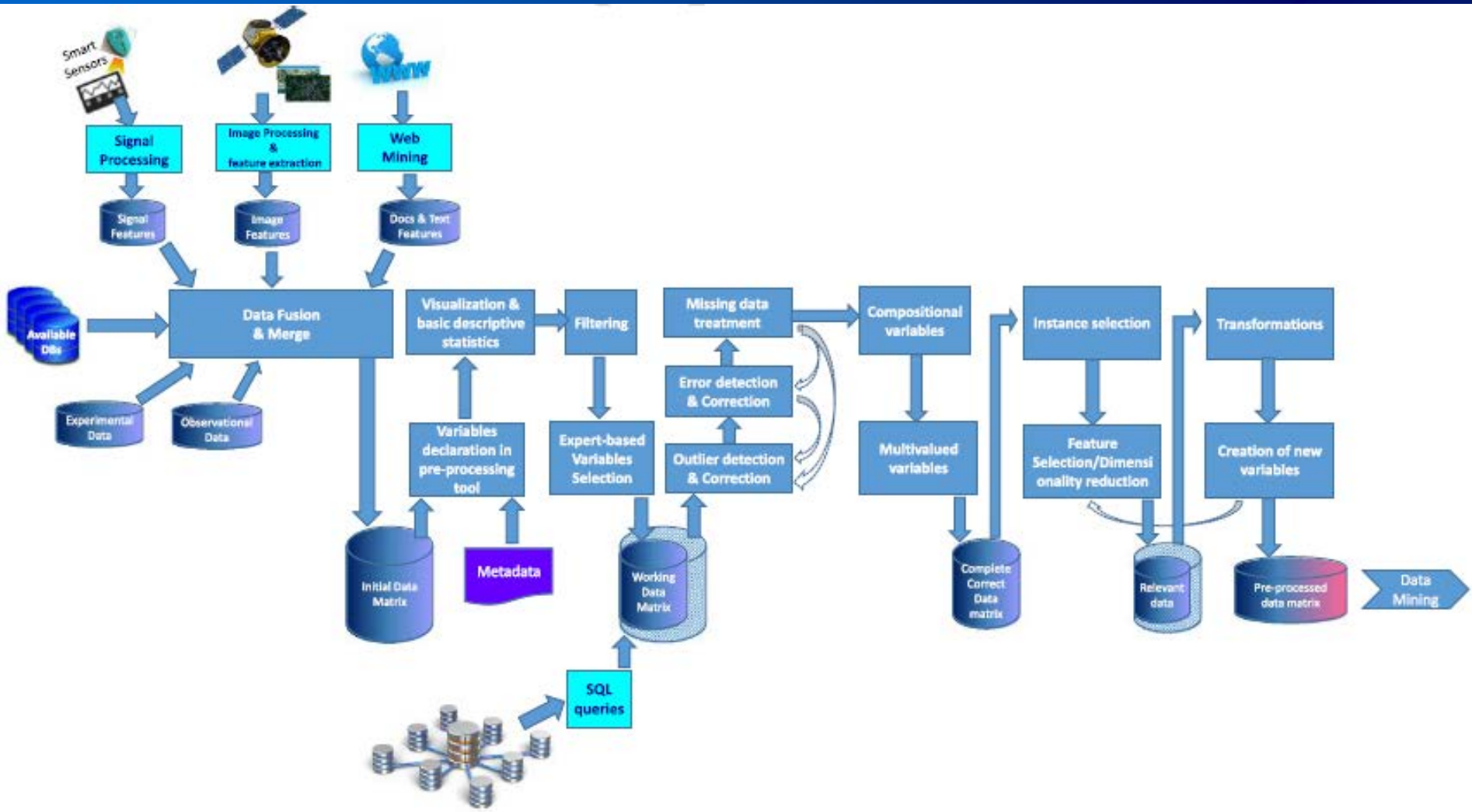
http://www.kdnuggets.com/polls/2003/data_preparation.htm

Preprocessing



Methodology

[Gibert Aicomm2016]



Gibert, K., M. Sànchez-Marrè, J. Izquierdo (2016) A Survey on Pre-processing Techniques in the Context of Environmental Data Mining. Artificial Intelligence in Communications, 29(6): 627-663, IOSPress DOI: 10.3233/AIC-160710

Preprocessing

Data cleaning
Data preparation
Data preprocessing

- Formatting issues, building software context
- Determining working matrix, Filtering
- Identification and treatment of missing data
- Identification and treatment of outliers
- Identification and treatment of errors *(correct when possible)*
- Feature selection/extraction, dimensionality reduction
- Instance selection
- Data transformation
- Derivation of new variables

Determine Data Matrix

Which data matrix rows?

Define target population

Objects selection

Which data matrix columns?

Determine objects descritpion

Variables selection

Objects Selection

Inclusion/Exclusion criteria
Filtering

Select from a data base or data warehouse or from real individuals (costs are different)

- Experimental data (experimental design)
- Observational data (sample theory)

REPORT IN FINAL DOC

Define the target population

Determines scope of conclusions

Goals' oriented Variables Selection

- Often expert-guided
  (highly related with goal of analysis)
  - Be maximalists
    - Eliminate irrelevant or redundant information is less risky than detect lack of relevant things to be added in a second wave
    - Technically, to complete a final submatrix is highly costly (in both time and resources)

Preprocessing

Data cleaning
Data preparation
Data preprocessing

- Formatting issues, building software context
- Determining working matrix, Filtering
- Identification and treatment of missing data
- Identification and treatment of outliers
- Identification and treatment of errors *(correct when possible)*
- Feature selection/extraction, dimensionality reduction
- Instance selection
- Data transformation
- Derivation of new variables

Missing data
(empty cells in data matrix)

- Types and diagnosis
- Little's test
- A simple descriptive alternative
- Some methods
  - Knn
  - The MIMMI method
  - MICE
  - Interpolation (for time series)

Missing data

(empty cells in data matrix)

- Randon missing
  - non problematic
  - casual
  - follow same distribution as present data
  - inputation is easy: mean, 0
- Non random missing: absence is informative
  - come from some particular part of population
  - probably correspond to special values
  - difficult to induce from the present data
  - inputation is much difficult
  - very critical
  - very dangerous to ignore those individuals
  - asking religion in israel (muslims do not answer)
  - Asking age to a lady over 45
  - Frequency of observations (microbio tests in water)
- Non applicable value (non-random, structural)
  - salary of a non-working person
  - number of pregnancies of a man
  - number of cigarretes of a non-smoker person
  - age of menopause

Missing data

Diagnoses

Little's MCAR test

H_0: Missings are completely at random (MCAR)
H_1: Missings are not random

$$d^2 = \sum_{j=1}^{J} n_j (\overline{X}_j - \overline{X}_j^*)^T \frac{1}{\hat{\sum}_j} (\overline{X}_j - \overline{X}_j^*) \sim \chi^2_{\sum r_j - K}$$

j=1:J missing patterns (subsets of missing variables in a case)
n_j cases in missing pattern j
$\overline{X}_j$ maximum likelihood estimates of the grand means
$\overline{X}_j^*$ means local to cases in missing pattern
$\hat{\sum}_j$ maximum likelihood estimate of the covariance matrix
rj number of complete variables for pattern j
K total number of variables

Searches signifficant differences in means conditioned to a certain subset of missing variables (pattern j)

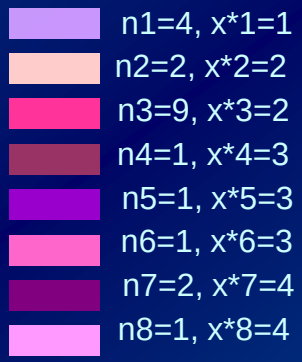
Dades UNICEF 2004 http://www.unicef.org/spanish/infobycountry/index.html missing patterns

	Països	Zona	PobTotal	INBxcap	EsperVida	%NounatsBaixPes	UsInstalSaneja	VIH	%coneixPresHomes	$ConeixPresDones	AlfabetHomes	AlfabetDones	Mortalitat	Natalitat	Economia	despesaSalut/Defensa	Règim
2	CAMBOYA	AsiaOr+Pacific	13798	320	57	11	16	170		64	85	64	11	31	enDesenvolupament		Monarquia
3	COREA	AsiaOr+Pacific	22384		63	7	59						11	16	enDesenvolupament		Republica
4	FIJI	AsiaOr+Pacific	841	2690	68	10	98	0,6			94	91	6	23	enDesenvolupament	MMesDefensa	Republica
5	FILIPINES	AsiaOr+Pacific	81617	1170	71	20	73	9	59	44	93	93	5	25	enDesenvolupament	MesSalut	Republica
6	ILLES COOK	AsiaOr+Pacific	18			3	100								Subdesenvolupat		Monarquia
7	ILLES MARSHALL	AsiaOr+Pacific	60	2370		12	82								Subdesenvolupat		Republica
8	ILLES SALOMÓ	AsiaOr+Pacific	466	550	63	13	31						7	33	Subdesenvolupat		Monarquia
9	INDONÈSIA	AsiaOr+Pacific	220077	1140	67	9	52	110		23	92	83	7	21	enDesenvolupament	MesSalut	Republica
10	KIRIBATI	AsiaOr+Pacific	97	970		5	39								Subdesenvolupat		Republica
11	LAO, REPÚBLICA DEMOCRÀTICA	AsiaOr+Pacific	5792	390	55	14	24	1,7			77	61	12	35	enDesenvolupament		Republica
12	MALÀSIA	AsiaOr+Pacific	24894	4650	73	9		52			92	85	5	22	enDesenvolupament	MesSalut	Monarquia
13	MICRONÈSIA	AsiaOr+Pacific	110	1990	68	18	28						6	31	Subdesenvolupat		Republica
14	MONGÒLIA	AsiaOr+Pacific	2614	590	65	7	59	0,5		77	98	98	7	22	enDesenvolupament	MesSalut	Republica
15	MYANMAR	AsiaOr+Pacific	50004	220	61	15	73	330			94	86	10	20	enDesenvolupament	MesSalut	Dictadura
16	NAURU	AsiaOr+Pacific	13												Subdesenvolupat		Republica
17	NIUE	AsiaOr+Pacific	1			0	100								Subdesenvolupat		Monarquia
18	PALAU	AsiaOr+Pacific	20	6870		9	83								Subdesenvolupat		Republica
19	PAPUA NOVA GUINEA	AsiaOr+Pacific	5772	580	56	11	45	16			63	51	10	30	enDesenvolupament	MMesDefensa	Monarquia
20	SAMOA	AsiaOr+Pacific	184	1860	71	4	100				99	98	6	28	Subdesenvolupat		Monarquia
21	SINGAPUR	AsiaOr+Pacific	4273	24220	79	8		4,1			97	89	5	9	enDesenvolupament	MesSalut	Republica
22	TAILÀNDIA	AsiaOr+Pacific	63694	2540	70	9	99	0,2			95	91	7	16	enDesenvolupament	MMesDefensa	Monarquia
23	TIMOR-LESTE	AsiaOr+Pacific	887	550	56	12	33			6			12	50	Subdesenvolupat		Republica
24	TOKELAU	AsiaOr+Pacific													Subdesenvolupat		Monarquia
25	TONGA	AsiaOr+Pacific	102	1830	72	0	97				99	99	6	24	Subdesenvolupat		Monarquia
26	TUVALU	AsiaOr+Pacific	10			5	88								Subdesenvolupat		Monarquia
27	VANUATU	AsiaOr+Pacific	207	1340	69	6	50						6	31	enDesenvolupament		Republica
28	VIETNAM	AsiaOr+Pacific	83123	550	71	9	41	220		60	94	87	6	20	enDesenvolupament		Republica
29	XINA	AsiaOr+Pacific	1307989	1290	72	4	44	840			95	87	7	13	enDesenvolupament	MesSalut	Republica
30	ANGOLA	AfricaOr+Merid	15490	1030	41	12	30	240			82	54	22	48	enDesenvolupament	MesSalut	Republica
31	BOTSWANA	AfricaOr+Merid	1769	4340	35	10	41	350	90	93	76	82	27	26	enDesenvolupament	MesSalut	Republica
32	BURUNDI	AfricaOr+Merid	7282	90	44	16	36	250		47	67	52	19	45	enDesenvolupament	MesSalut	Republica
33	COMORAS	AfricaOr+Merid	777	530	64	25	23			41	63	49	7	36	enDesenvolupament		Republica
34	ERITREA	AfricaOr+Merid	4232	180	54	21	9	60		62			11	39	enDesenvolupament		Republica
35	ETIOPIA	AfricaOr+Merid	75600	110	48	15	6	1500			49	34	16	41	enDesenvolupament	MesSalut	Republica
36	KENYA	AfricaOr+Merid	33467	460	48	10	48	1200	68	59	78	70	15	39	enDesenvolupament	MMesDefensa	Republica
37	LESOTHO	AfricaOr+Merid	1798	740	35	14	37	320		58	74	90	25	28	enDesenvolupament	MMesDefensa	Monarquia
38	MADAGASCAR	AfricaOr+Merid	18113	300	56	17	33	140	54	49	76	65	12	39	enDesenvolupament	MMesDefensa	Republica

Dades UNICEF 2004 http://www.unicef.org/spanish/infobycountry/index.html

Missing pattern 1: (ConeixPresHomes)
Missing pattern 2: (ConeixPresHomes+DespesaSalut/Defensa)
Missing pattern 3: (ConeixPresHomes+ConeixPresDones)
Missing pattern 4: (ConeixPresHomes+ConeixPresDones+DespSal/Def)
Missing pattern 5: (ConeixPresHomes+AlfabetsDones+DespSal/Def)
Missing pattern 6: (VIH+ConeixPresHomes+ DespSal/Def)
Missing pattern 7: (VIH+ConeixPresHomes+ ConeixPresHomes+ConeixPresDones+DespSal/Def)
Missing pattern 8: (ConeixPresHomes+AlfabetHomes+AlfabetDones+DespSal/Def)

missing patterns



	Països	Zona	PobTotal	INBxcap	EsperVida	%NounatsBaixPes	UsInstalSaneja	VIH	%coneixPresHomes	$ConeixPresDones	AlfabetHomes	AlfabetDones	Mortalitat	Natalitat	Economia	despesaSalut/Defensa	Règim
2	CAMBOYA	AsiaOr+Pacific	13798	320	57	11	16	170		64	85	64	11	31	enDesenvolupament		Monarquia
3	COREA	AsiaOr+Pacific	22384		63	7	59						11	16	enDesenvolupament		Republica
4	FIJI	AsiaOr+Pacific	841	2690	68	10	98	0,6			94	91	6	23	enDesenvolupament	MMesDefensa	Republica
5	FILIPINES	AsiaOr+Pacific	81617	1170	71	20	73	9	59	44	93	93	5	25	enDesenvolupament	MesSalut	Republica
6	ILLES COOK	AsiaOr+Pacific	18			3	100								Subdesenvolupat		Monarquia
7	ILLES MARSHALL	AsiaOr+Pacific	60	2370		12	82								Subdesenvolupat		Republica
8	ILLES SALOMÓ	AsiaOr+Pacific	466	550	63	13	31						7	33	Subdesenvolupat		Monarquia
9	INDONÈSIA	AsiaOr+Pacific	220077	1140	67	9	52	110		23	92	83	7	21	enDesenvolupament	MesSalut	Republica
10	KIRIBATI	AsiaOr+Pacific	97	970		5	39								Subdesenvolupat		Republica
11	LAO, REPÚBLICA DEMOCRÀTICA	AsiaOr+Pacific	5792	390	55	14	24	1,7			77	61	12	35	enDesenvolupament		Republica
12	MALÀSIA	AsiaOr+Pacific	24894	4650	73	9		52			92	85	5	22	enDesenvolupament	MesSalut	Monarquia
13	MICRONÈSIA	AsiaOr+Pacific	110	1990	68	18	28						6	31	Subdesenvolupat		Republica
14	MONGÒLIA	AsiaOr+Pacific	2614	590	65	7	59	0,5		77	98	98	7	22	enDesenvolupament	MesSalut	Republica
15	MYANMAR	AsiaOr+Pacific	50004	220	61	15	73	330			94	86	10	20	enDesenvolupament	MesSalut	Dictadura
16	NAURU	AsiaOr+Pacific	13												Subdesenvolupat		Republica
17	NIUE	AsiaOr+Pacific	1			0	100								Subdesenvolupat		Monarquia
18	PALAU	AsiaOr+Pacific	20	6870		9	83								Subdesenvolupat		Republica
19	PAPUA NOVA GUINEA	AsiaOr+Pacific	5772	580	56	11	45	16			63	51	10	30	enDesenvolupament	MMesDefensa	Monarquia
20	SAMOA	AsiaOr+Pacific	184	1860	71	4	100				99	98	6	28	Subdesenvolupat		Monarquia
21	SINGAPUR	AsiaOr+Pacific	4273	24220	79	8		4,1			97	89	5	9	enDesenvolupament	MesSalut	Republica
22	TAILÀNDIA	AsiaOr+Pacific	63694	2540	70	9	99	0,2			95	91	7	16	enDesenvolupament	MMesDefensa	Monarquia
23	TIMOR-LESTE	AsiaOr+Pacific	887	550	56	12	33			6			12	50	Subdesenvolupat		Republica
24	TOKELAU	AsiaOr+Pacific													Subdesenvolupat		Monarquia
25	TONGA	AsiaOr+Pacific	102	1830	72	0	97				99	99	6	24	Subdesenvolupat		Monarquia
26	TUVALU	AsiaOr+Pacific	10			5	88								Subdesenvolupat		Monarquia
27	VANUATU	AsiaOr+Pacific	207	1340	69	6	50						6	31	enDesenvolupament		Republica
28	VIETNAM	AsiaOr+Pacific	83123	550	71	9	41	220		60	94	87	6	20	enDesenvolupament		Republica
29	XINA	AsiaOr+Pacific	1307989	1290	72	4	44	840			95	87	7	13	enDesenvolupament	MesSalut	Republica
30	ANGOLA	AfricaOr+Merid	15490	1030	41	12	30	240			82	54	22	48	enDesenvolupament	MesSalut	Republica
31	BOTSWANA	AfricaOr+Merid	1769	4340	35	10	41	350	90	93	76	82	27	26	enDesenvolupament	MesSalut	Republica
32	BURUNDI	AfricaOr+Merid	7282	90	44	16	36	250		47	67	52	19	45	enDesenvolupament	MesSalut	Republica
33	COMORAS	AfricaOr+Merid	777	530	64	25	23			41	63	49	7	36	enDesenvolupament		Republica
34	ERITREA	AfricaOr+Merid	4232	180	54	21	9	60		62			11	39	enDesenvolupament		Republica
35	ETIOPIA	AfricaOr+Merid	75600	110	48	15	6	1500			49	34	16	41	enDesenvolupament	MesSalut	Republica
36	KENYA	AfricaOr+Merid	33467	460	48	10	48	1200	68	59	78	70	15	39	enDesenvolupament	MMesDefensa	Republica
37	LESOTHO	AfricaOr+Merid	1798	740	35	14	37	320		58	74	90	25	28	enDesenvolupament	MMesDefensa	Monarquia
38	MADAGASCAR	AfricaOr+Merid	18113	300	56	17	33	140	54	49	76	65	12	39	enDesenvolupament	MMesDefensa	Republica

Dades UNICEF 2004 http://www.unicef.org/spanish/infobycountry/index.html

n1=4, x*1=1
n2=2, x*2=2
n3=9, x*3=2
n4=1, x*4=3
n5=1, x*5=3
n6=1, x*6=3
n7=2, x*7=4
n8=1, x*8=4

Missing pattern 9: (VIH+CPH+ CPD+AlfaH+AlfaD+DespSal/Def)
Missing pattern 10: (INB+VIH+CPH+ CPD+AlfaH+AlfaD+DespSal/Def))
Missing pattern 1: (EV+ VIH+CPH+ CPD+AlfaH+AlfaD+M+N+D/Def)
Missing pattern 12: (INB+ EV+ VIH+CPH+ CPD+AlfaH+AlfaD+M+N+D/Def)
Missing pattern 13: (INB+ EV+NBp+IS+ VIH+CPH+ CPD+AlfaH+AlfaD+M+N+D/Def)
Missing pattern 14: (Pob+INB+ EV+NBp+IS+ VIH+CPH+ CPD+AlfaH+AlfaD+M+N+D/Def)

missing patterns

n9=3, x*9=6
n10=1, x*10=7
n11=3, x*11=9
n12=3, x*12=10
n13=1, x*13=12
n14=1, x*14=13

	Països	Zona	PobTotal	INBxcap	EsperVida	%NounatsBaixPes	UsInstalSaneja	VIH	%coneixPresHomes	$ConeixPresDones	AlfabetHomes	AlfabetDones	Mortalitat	Natalitat	Economia	despesaSalut/Defensa	Règim
2	CAMBOYA	AsiaOr+Pacific	13798	320	57	11	16	170		64	85	64	11	31	enDesenvolupament		Monarquia
3	COREA	AsiaOr+Pacific	22384		63	7	59						11	16	enDesenvolupament		Republica
4	FIJI	AsiaOr+Pacific	841	2690	68	10	98	0,6			94	91	6	23	enDesenvolupament	MMesDefensa	Republica
5	FILIPINES	AsiaOr+Pacific	81617	1170	71	20	73	9	59	44	93	93	5	25	enDesenvolupament	MesSalut	Republica
6	ILLES COOK	AsiaOr+Pacific	18			3	100								Subdesenvolupat		Monarquia
7	ILLES MARSHALL	AsiaOr+Pacific	60	2370		12	82								Subdesenvolupat		Republica
8	ILLES SALOMÓ	AsiaOr+Pacific	466	550	63	13	31						7	33	Subdesenvolupat		Monarquia
9	INDONÈSIA	AsiaOr+Pacific	220077	1140	67	9	52	110		23	92	83	7	21	enDesenvolupament	MesSalut	Republica
10	KIRIBATI	AsiaOr+Pacific	97	970		5	39								Subdesenvolupat		Republica
11	LAO, REPÚBLICA DEMOCRÀTICA	AsiaOr+Pacific	5792	390	55	14	24	1,7			77	61	12	35	enDesenvolupament		Republica
12	MALÀSIA	AsiaOr+Pacific	24894	4650	73	9		52			92	85	5	22	enDesenvolupament	MesSalut	Monarquia
13	MICRONÈSIA	AsiaOr+Pacific	110	1990	68	18	28						6	31	Subdesenvolupat		Republica
14	MONGÒLIA	AsiaOr+Pacific	2614	590	65	7	59	0,5		77	98	98	7	22	enDesenvolupament	MesSalut	Republica
15	MYANMAR	AsiaOr+Pacific	50004	220	61	15	73	330			94	86	10	20	enDesenvolupament	MesSalut	Dictadura
16	NAURU	AsiaOr+Pacific	13												Subdesenvolupat		Republica
17	NIUE	AsiaOr+Pacific	1			0	100								Subdesenvolupat		Monarquia
18	PALAU	AsiaOr+Pacific	20	6870		9	83								Subdesenvolupat		Republica
19	PAPUA NOVA GUINEA	AsiaOr+Pacific	5772	580	56	11	45	16			63	51	10	30	enDesenvolupament	MMesDefensa	Monarquia
20	SAMOA	AsiaOr+Pacific	184	1860	71	4	100				99	98	6	28	Subdesenvolupat		Monarquia
21	SINGAPUR	AsiaOr+Pacific	4273	24220	79	8		4,1			97	89	5	9	enDesenvolupament	MesSalut	Republica
22	TAILÀNDIA	AsiaOr+Pacific	63694	2540	70	9	99	0,2			95	91	7	16	enDesenvolupament	MMesDefensa	Monarquia
23	TIMOR-LESTE	AsiaOr+Pacific	887	550	56	12	33			6			12	50	Subdesenvolupat		Republica
24	TOKELAU	AsiaOr+Pacific													Subdesenvolupat		Monarquia
25	TONGA	AsiaOr+Pacific	102	1830	72	0	97				99	99	6	24	Subdesenvolupat		Monarquia
26	TUVALU	AsiaOr+Pacific	10			5	88								Subdesenvolupat		Monarquia
27	VANUATU	AsiaOr+Pacific	207	1340	69	6	50						6	31	enDesenvolupament		Republica
28	VIETNAM	AsiaOr+Pacific	83123	550	71	9	41	220		60	94	87	6	20	enDesenvolupament		Republica
29	XINA	AsiaOr+Pacific	1307989	1290	72	4	44	840			95	87	7	13	enDesenvolupament	MesSalut	Republica
30	ANGOLA	AfricaOr+Merid	15490	1030	41	12	30	240			82	54	22	48	enDesenvolupament	MesSalut	Republica
31	BOTSWANA	AfricaOr+Merid	1769	4340	35	10	41	350	90	93	76	82	27	26	enDesenvolupament	MesSalut	Republica
32	BURUNDI	AfricaOr+Merid	7282	90	44	16	36	250		47	67	52	19	45	enDesenvolupament	MesSalut	Republica
33	COMORAS	AfricaOr+Merid	777	530	64	25	23			41	63	49	7	36	enDesenvolupament		Republica
34	ERITREA	AfricaOr+Merid	4232	180	54	21	9	60		62			11	39	enDesenvolupament		Republica
35	ETIOPIA	AfricaOr+Merid	75600	110	48	15	6	1500			49	34	16	41	enDesenvolupament	MesSalut	Republica
36	KENYA	AfricaOr+Merid	33467	460	48	10	48	1200	68	59	78	70	15	39	enDesenvolupament	MMesDefensa	Republica
37	LESOTHO	AfricaOr+Merid	1798	740	35	14	37	320		58	74	90	25	28	enDesenvolupament	MMesDefensa	Monarquia
38	MADAGASCAR	AfricaOr+Merid	18113	300	56	17	33	140	54	49	76	65	12	39	enDesenvolupament	MMesDefensa	Republica

Dades UNICEF 2004 http://www.unicef.org/spanish/infobycountry/index.html

missing patterns

- n1=4, x*1=1
- n2=2, x*2=2
- n3=9, x*3=2
- n4=1, x*4=3
- n5=1, x*5=3
- n6=1, x*6=3
- n7=2, x*7=4
- n8=1, x*8=4
- n9=3, x*9=6
- n10=1, x*10=7
- n11=3, x*11=9
- n12=3, x*12=10
- n13=1, x*13=12
- n14=1, x*14=13

15 patterns

	Països	Zona	PobTotal	INBxcap	EsperVida	%NounatsBaixPes	UsInstalSaneja	VIH	%coneixPresHomes	$ConeixPresDones	AlfabetHomes	AlfabetDones	Mortalitat	Natalitat	Economia	despesaSalut/Defensa	Règim
2	CAMBOYA	AsiaOr+Pacific	13798	320	57	11	16	170		64	85	64	11	31	enDesenvolupament		Monarquia
3	COREA	AsiaOr+Pacific	22384		63	7	59						11	16	enDesenvolupament		Republica
4	FIJI	AsiaOr+Pacific	841	2690	68	10	98	0,6			94	91	6	23	enDesenvolupament	MMesDefensa	Republica
5	FILIPINES	AsiaOr+Pacific	81617	1170	71	20	73	9	59	44	93	93	5	25	enDesenvolupament	MesSalut	Republica
6	ILLES COOK	AsiaOr+Pacific	18			3	100								Subdesenvolupat		Monarquia
7	ILLES MARSHALL	AsiaOr+Pacific	60	2370		12	82								Subdesenvolupat		Republica
8	ILLES SALOMÓ	AsiaOr+Pacific	466	550	63	13	31						7	33	Subdesenvolupat		Monarquia
9	INDONÈSIA	AsiaOr+Pacific	220077	1140	67	9	52	110		23	92	83	7	21	enDesenvolupament	MesSalut	Republica
10	KIRIBATI	AsiaOr+Pacific	97	970		5	39								Subdesenvolupat		Republica
11	LAO, REPÚBLICA DEMOCRÀTICA	AsiaOr+Pacific	5792	390	55	14	24	1,7			77	61	12	35	enDesenvolupament		Republica
12	MALÀSIA	AsiaOr+Pacific	24894	4650	73	9		52			92	85	5	22	enDesenvolupament	MesSalut	Monarquia
13	MICRONÈSIA	AsiaOr+Pacific	110	1990	68	18	28						6	31	Subdesenvolupat		Republica
14	MONGÒLIA	AsiaOr+Pacific	2614	590	65	7	59	0,5		77	98	98	7	22	enDesenvolupament	MesSalut	Republica
15	MYANMAR	AsiaOr+Pacific	50004	220	61	15	73	330			94	86	10	20	enDesenvolupament	MesSalut	Dictadura
16	NAURU	AsiaOr+Pacific	13												Subdesenvolupat		Republica
17	NIUE	AsiaOr+Pacific	1			0	100								Subdesenvolupat		Monarquia
18	PALAU	AsiaOr+Pacific	20	6870		9	83								Subdesenvolupat		Republica
19	PAPUA NOVA GUINEA	AsiaOr+Pacific	5772	580	56	11	45	16			63	51	10	30	enDesenvolupament	MMesDefensa	Monarquia
20	SAMOA	AsiaOr+Pacific	184	1860	71	4	100				99	98	6	28	Subdesenvolupat		Monarquia
21	SINGAPUR	AsiaOr+Pacific	4273	24220	79	8		4,1			97	89	5	9	enDesenvolupament	MesSalut	Republica
22	TAILÀNDIA	AsiaOr+Pacific	63694	2540	70	9	99	0,2			95	91	7	16	enDesenvolupament	MMesDefensa	Monarquia
23	TIMOR-LESTE	AsiaOr+Pacific	887	550	56	12	33			6			12	50	Subdesenvolupat		Republica
24	TOKELAU	AsiaOr+Pacific													Subdesenvolupat		Monarquia
25	TONGA	AsiaOr+Pacific	102	1830	72	0	97				99	99	6	24	Subdesenvolupat		Monarquia
26	TUVALU	AsiaOr+Pacific	10			5	88								Subdesenvolupat		Monarquia
27	VANUATU	AsiaOr+Pacific	207	1340	69	6	50						6	31	enDesenvolupament		Republica
28	VIETNAM	AsiaOr+Pacific	83123	550	71	9	41	220		60	94	87	6	20	enDesenvolupament		Republica
29	XINA	AsiaOr+Pacific	1307989	1290	72	4	44	840			95	87	7	13	enDesenvolupament	MesSalut	Republica
30	ANGOLA	AfricaOr+Merid	15490	1030	41	12	30	240			82	54	22	48	enDesenvolupament	MesSalut	Republica
31	BOTSWANA	AfricaOr+Merid	1769	4340	35	10	41	350	90	93	76	82	27	26	enDesenvolupament	MesSalut	Republica
32	BURUNDI	AfricaOr+Merid	7282	90	44	16	36	250		47	67	52	19	45	enDesenvolupament	MesSalut	Republica
33	COMORAS	AfricaOr+Merid	777	530	64	25	23			41	63	49	7	36	enDesenvolupament		Republica
34	ERITREA	AfricaOr+Merid	4232	180	54	21	9	60		62			11	39	enDesenvolupament		Republica
35	ETIOPIA	AfricaOr+Merid	75600	110	48	15	6	1500			49	34	16	41	enDesenvolupament	MesSalut	Republica
36	KENYA	AfricaOr+Merid	33467	460	48	10	48	1200	68	59	78	70	15	39	enDesenvolupament	MMesDefensa	Republica
37	LESOTHO	AfricaOr+Merid	1798	740	35	14	37	320		58	74	90	25	28	enDesenvolupament	MMesDefensa	Monarquia
38	MADAGASCAR	AfricaOr+Merid	18113	300	56	17	33	140	54	49	76	65	12	39	enDesenvolupament	MMesDefensa	Republica

Dades UNICEF 2004 http://www.unicef.org/spanish/infobycountry/index.html missing patterns

n3=9, x*3=2, r3= 13-2=11

$$\overline{X}_3 = [\overline{X}_{Pob}, \overline{X}_{INB}, \overline{X}_{EV}, \overline{X}_{\%NbP}, \overline{X}_{AlfaH}, \overline{X}_{AlfaD}, \overline{X}_M, \overline{X}_N]$$

$$\bar{X}_3^* = [\bar{X}_{Pob}^*, \bar{X}_{INB}^*, \bar{X}_{EV}^*,]$$

$\hat{\sum}_3$ = *Variances and covariances of full variables*

$\overline{X}_{Pob} = 38120$

$\overline{X}^*_{Pob} = 172062$

$$d^2 = \sum_{j=1}^{J} n_j (\overline{X}_j - \overline{X}_j^*)^T \frac{1}{\hat{\sum}_j} (\overline{X}_j - \overline{X}_j^*) \sim \chi^2_{\sum r_j - K}$$

Type equation here.

	Països		PobTotal	INBxcap	EsperVida	%NounatsBaixPes	UsInstalSaneja	VIH	%coneixPresHomes	$ConeixPresDones	AlfabetHomes	AlfabetDones	Mortalitat	Natalitat	Economia	despesaSalut/Defensa	Règim
2	CAMBOYA	AsiaOr+Pacific	13798	320	57	11	16	170		64	85	64	11	31	enDesenvolupament		Monarquia
3	COREA	AsiaOr+Pacific	22384		63	7	59						11	16	enDesenvolupament		Republica
4	FIJI	AsiaOr+Pacific	841	2690	68	10	98	0,6			94	91	6	23	enDesenvolupament	MMesDefensa	Republica
5	FILIPINES	AsiaOr+Pacific	81617	1170	71	20	73	9	59	44	93	93	5	25	enDesenvolupament	MesSalut	Republica
6	ILLES COOK	AsiaOr+Pacific	18			3	100								Subdesenvolupat		Monarquia
7	ILLES MARSHALL	AsiaOr+Pacific	60	2370		12	82								Subdesenvolupat		Republica
8	ILLES SALOMÓ	AsiaOr+Pacific	466	550	63	13	31						7	33	Subdesenvolupat		Monarquia
9	INDONÈSIA	AsiaOr+Pacific	220077	1140	67	9	52	110		23	92	83	7	21	enDesenvolupament	MesSalut	Republica
10	KIRIBATI	AsiaOr+Pacific	97	970		5	39								Subdesenvolupat		Republica
11	LAO, REPÚBLICA DEMOCRÀTICA	AsiaOr+Pacific	5792	390	55	14	24	1,7			77	61	12	35	enDesenvolupament		Republica
12	MALÀSIA	AsiaOr+Pacific	24894	4650	73	9		52			92	85	5	22	enDesenvolupament	MesSalut	Monarquia
13	MICRONÈSIA	AsiaOr+Pacific	110	1990	68	18	28						6	31	Subdesenvolupat		Republica
14	MONGÒLIA	AsiaOr+Pacific	2614	590	65	7	59	0,5		77	98	98	7	22	enDesenvolupament	MesSalut	Republica
15	MYANMAR	AsiaOr+Pacific	50004	220	61	15	73	330			94	86	10	20	enDesenvolupament	MesSalut	Dictadura
16	NAURU	AsiaOr+Pacific	13												Subdesenvolupat		Republica
17	NIUE	AsiaOr+Pacific	1			0	100								Subdesenvolupat		Monarquia
18	PALAU	AsiaOr+Pacific	20	6870		9	83								Subdesenvolupat		Republica
19	PAPUA NOVA GUINEA	AsiaOr+Pacific	5772	580	56	11	45	16			63	51	10	30	enDesenvolupament	MMesDefensa	Monarquia
20	SAMOA	AsiaOr+Pacific	184	1860	71	4	100				99	98	6	28	Subdesenvolupat		Monarquia
21	SINGAPUR	AsiaOr+Pacific	4273	24220	79	8		4,1			97	89	5	9	enDesenvolupament	MesSalut	Republica
22	TAILÀNDIA	AsiaOr+Pacific	63694	2540	70	9	99	0,2			95	91	7	16	enDesenvolupament	MMesDefensa	Monarquia
23	TIMOR-LESTE	AsiaOr+Pacific	887	550	56	12	33			6			12	50	Subdesenvolupat		Republica
24	TOKELAU	AsiaOr+Pacific													Subdesenvolupat		Monarquia
25	TONGA	AsiaOr+Pacific	102	1830	72	0	97				99	99	6	24	Subdesenvolupat		Monarquia
26	TUVALU	AsiaOr+Pacific	10			5	88								Subdesenvolupat		Monarquia
27	VANUATU	AsiaOr+Pacific	207	1340	69	6	50						6	31	enDesenvolupament		Republica
28	VIETNAM	AsiaOr+Pacific	83123	550	71	9	41	220		60	94	87	6	20	enDesenvolupament		Republica
29	XINA	AsiaOr+Pacific	1307989	1290	72	4	44	840			95	87	7	13	enDesenvolupament	MesSalut	Republica
30	ANGOLA	AfricaOr+Merid	15490	1030	41	12	30	240			82	54	22	48	enDesenvolupament	MesSalut	Republica
31	BOTSWANA	AfricaOr+Merid	1769	4340	35	10	41	350	90	93	76	82	27	26	enDesenvolupament	MesSalut	Republica
32	BURUNDI	AfricaOr+Merid	7282	90	44	16	36	250		47	67	52	19	45	enDesenvolupament	MesSalut	Republica
33	COMORAS	AfricaOr+Merid	777	530	64	25	23			41	63	49	7	36	enDesenvolupament		Republica
34	ERITREA	AfricaOr+Merid	4232	180	54	21	9	60		62			11	39	enDesenvolupament		Republica
35	ETIOPIA	AfricaOr+Merid	75600	110	48	15	6	1500			49	34	16	41	enDesenvolupament	MesSalut	Republica
36	KENYA	AfricaOr+Merid	33467	460	48	10	48	1200	68	59	78	70	15	39	enDesenvolupament	MMesDefensa	Republica
37	LESOTHO	AfricaOr+Merid	1798	740	35	14	37	320		58	74	90	25	28	enDesenvolupament	MMesDefensa	Monarquia
38	MADAGASCAR	AfricaOr+Merid	18113	300	56	17	33	140	54	49	76	65	12	39	enDesenvolupament	MMesDefensa	Republica

The Little test in R

- LittleMCAR {BaylorEdPsych}
- **USAGE:** LittleMCAR(x)

  x: dataframe, matrix less than 50 variables

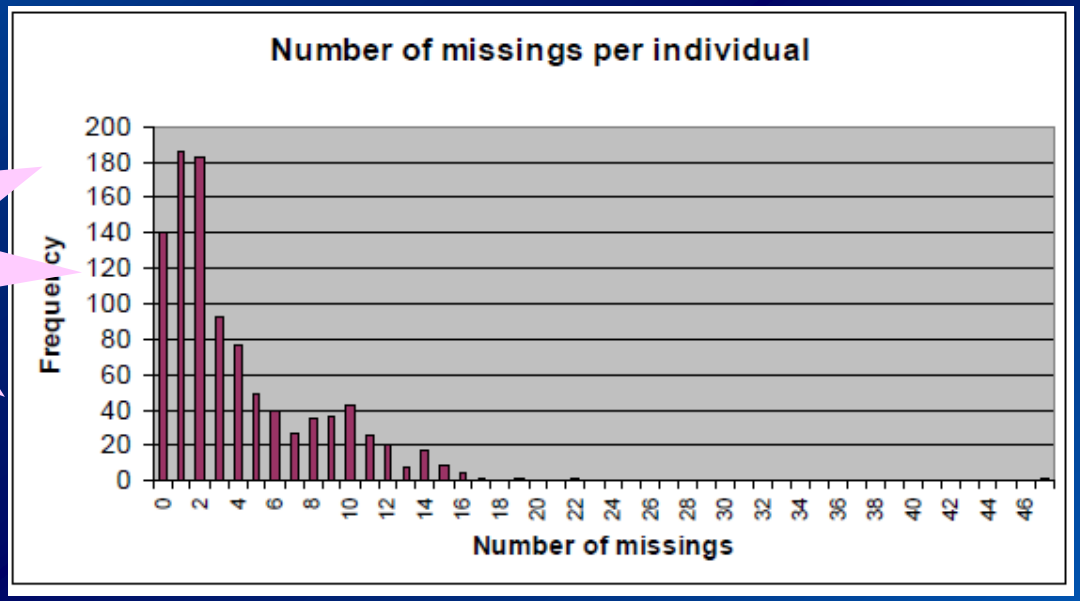
- **Returns:**

chi.square	Chi-square value
df	Degrees of freedom used for chi-square
missing.patterns	Number of missing data patterns
amount.missing	Amount and percent of mssing data
data	The data, organized my missing data patterns

Missing data

(Simple alternative)

- Build new variable counting number of missings per individuals.
- Describe this variable



Reliability of individual

- Count nr of missing per variable and rank variables
  Provides reliability

- Create indicator of missing/non-missing per variable
  and compare both groups of cases

Missing data

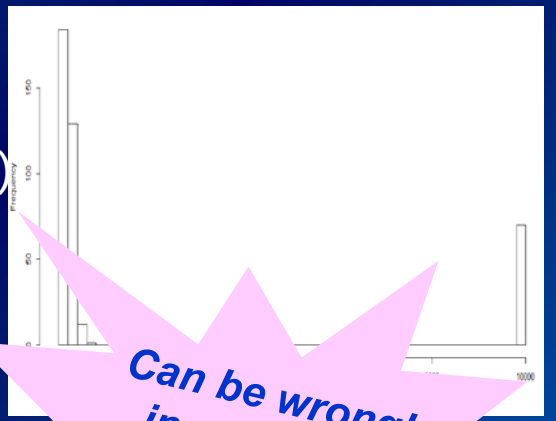
(empty cells in data matrix)

- Representation:
  - *,?, “ “, depending on software
  - numerical variables: sometimes codified (0, 99999, -1…)
  - categorical variables: special modality (Ns/Nc, …)

- Standardize missing representation

- Causes of missing data:
  - *voluntary hidden (religion in israel) (always non-random)*
  - *data non-provided*
  - *data non-achieveable*
    - *technical limitations (example anemometers IKE hurrican)*
    - *accessibility (no privileges, sensitive information)*
  - *data lost*
  - *data forced to missing (as a result of correction)*

- *Identification:*
  - *Numerical indicators (stdev…)*



Can be wrongly incorporated in analysis

Missing data treatment

Depends on analysis goals!!!!!

- keep it as a missing: only eventually
  - Can signifficantly reduce the treated observations
- Inputing: Substituting by a useful value (open problem, difficult)
  - Qualitative variable: Substitute by “Unkown<varName>”
  - Stardard way, expert knowledge required
    - use 0
    - use global mean
    - use conditional mean for local groups
    - inputation models (complex)
    - Nearest neighbor (R)
    - Intelligent inputation
    - MIMMI
  - non parametric aproach (montecarlo methods, multiple inputation)
    - special software required
    - technical hypothesis about variable distributions required
    - Final models integration required
      - *Example: French survey, global incomes of household*

Missing data treatment

- Missing values frequent in real data
- Imputation before analysis CRITICAL
- Most statistical packages:
  - simple inputation by global mean
  - listwise deletion (dangerous)
- Specific softwares:
  - dedicated to sophisticated inputation methods
  - highly time consuming
  - non-exportable complete data matrices
- Find a trade-of between precision and simplicity

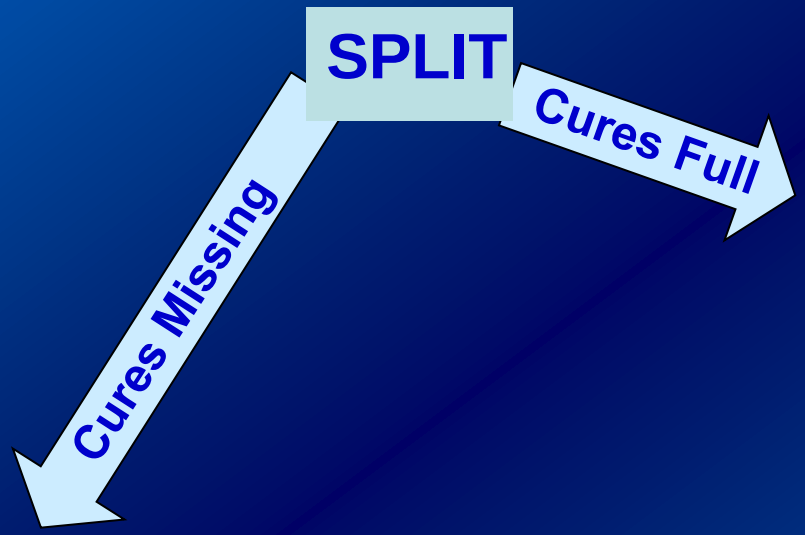
Knn method

C_HISTORI	C_TRACTAI	DATA	Alimentació	Cures d'aparença	Higiene	Vestit: part superior	Vestit: part inferior	Utilització del bany	Bufeta	Intestí	Llit, cadira, cadira de rod
1569,0	84585,0	09/07/2003 0:00	7	7	6	7	7	6	5	5	7
1642,0	74011,0	20/06/2002 0:00	7	7	7	7	7	7	7	7	7
1645,0	84990,0	21/07/2003 0:00	7		6	6	2	6	6	6	3
1666,0	91980,0	09/03/2004 0:00	7	7	7	7	7	6	6	5	7
1694,0	83561,0	03/06/2003 0:00	7	7	7	7	7	7	6	6	7
1754,0	114451,0	03/02/2006 0:00	7	7	6	7	6	6	6	6	7
1858,0	76281,0	26/09/2002 0:00	7		5	7	7	6	5	5	7
1900,0	84368,0	01/07/2003 0:00	6	6	4	4	3	1	6	4	7
1904,0	82443,0	30/04/2003 0:00	4	7	4	6	5	3	2	3	4
1919,0	74098,0	20/06/2002 0:00	7	7	7	7	7	7	6	6	4
1976,0	80110,0	13/02/2003 0:00	7	5	3	4	3	3	5	5	3
2052,0	81175,0	20/03/2003 0:00	7	7	6	7	6	6	6	6	7
2059,0	82951,0	15/05/2003 0:00	1	1	1	1	1	1	1	1	1
2251,0	76399,0	01/10/2002 0:00	5	5	1	1	1	1	6	5	1
2267,0	86796,0	01/10/2003 0:00	7		7	7	7	7	6	6	7
2524,0	76436,0	02/10/2002 0:00	7	7	6	7	6	6	6	6	7
2533,0	81445,0	28/03/2003 0:00	7	7	7	7	7	7	6	6	7
2604,0	75742,0	06/09/2002 0:00	7	7	6	7	7	7	5	6	7
2646,0	84112,0	20/06/2003 0:00	7	7	7	7	7	7	6	6	7
2685,0	79191,0	15/01/2003 0:00	7	7	7	7	7	7	6	6	7
2694,0	78901,0	02/01/2003 0:00	7	7	7	7	7	7	6	6	7
2726,0	74218,0	27/06/2002 0:00	6	6	4	6	6	5	3	5	6
2765,0	79837,0	05/02/2003 0:00	5	5	2	5	2	1	5	5	4

Knn method

Original uncomplete data

C_HISTORI	C_TRACTAI	DATA	Alimentació	Cures d'aparença	Higiene	Vestit: part superior	Vestit: part inferior	Utilització del bany	Bufeta	Intestí	Llit, cadira, cadira de roc
1569,0	84585,0	09/07/2003 0:00	7	7	6	7	7	6	5	5	7
1642,0	74011,0	20/06/2002 0:00	7	7	7	7	7	7	7	7	7
1645,0	84990,0	21/07/2003 0:00	7		6	6	2	6	6	6	3
1666,0	91980,0	09/03/2004 0:00	7	7	7	7	7	6	6	5	7
1694,0	83561,0	03/06/2003 0:00	7	7	7	7	7	7	6	6	7
1754,0	114451,0	03/02/2006 0:00	7	7	6	7	6	6	6	6	7
1858,0	76281,0	26/09/2002 0:00	7		5	7	7	6	5	5	7
1900,0	84368,0	01/07/2003 0:00	6	6	4	4	3	1	6	4	7
1904,0	82443,0	30/04/2003 0:00	4	7	4	6	5	3	2	3	4
1919,0	74098,0	20/06/2002 0:00	7	7	7	7	7	7	6	6	4
1976,0	80110,0	13/02/2003 0:00	7	5	3	4	3	3	5	5	3
2052,0	81175,0	20/03/2003 0:00	7	7	6	7	6	6	6	6	7
2059,0	82951,0	15/05/2003 0:00	1	1	1	1	1	1	1	1	1
2251,0	76399,0	01/10/2002 0:00	5	5	1	1	1	1	6	5	1
2267,0	86796,0	01/10/2003 0:00	7		7	7	7	7	6	6	7
2524,0	76436,0	02/10/2002 0:00	7	7	6	7	6	6	6	6	7
2533,0	81445,0	28/03/2003 0:00	7	7	7	7	7	7	6	6	7
2604,0	75742,0	06/09/2002 0:00	7	7	6	7	7	7	5	6	7
2646,0	84112,0	20/06/2003 0:00	7	7	7	7	7	7	6	6	7
2685,0	79191,0	15/01/2003 0:00	7	7	7	7	7	7	6	6	7
2694,0	78901,0	02/01/2003 0:00	7	7	7	7	7	7	6	6	7
2726,0	74218,0	27/06/2002 0:00	6	6	4	6	6	5	3	5	6
2765,0	79837,0	05/02/2003 0:00	5	5	2	5	2	1	5	5	4

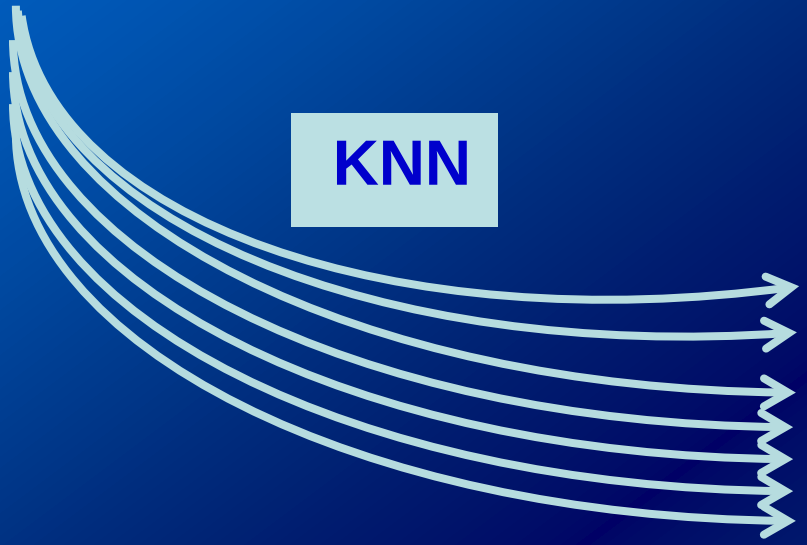


C_HISTORI	C_TRACTAI	DATA	Alimentació	Cures d'aparença	Higiene	Vestit: part superior	Vestit: part inferior	Utilització del bany	Bufeta	Intestí	Llit, cadira, cadira de roc
1569,0	84585,0	09/07/2003 0:00	7	7	6	7	7	6	5	5	7
1642,0	74011,0	20/06/2002 0:00	7	7	7	7	7	7	7	7	7
1666,0	91980,0	09/03/2004 0:00	7	7	7	7	7	6	6	5	7
1694,0	83561,0	03/06/2003 0:00	7	7	7	7	7	7	6	6	7
1754,0	114451,0	03/02/2006 0:00	7	7	6	7	6	6	6	6	7
1900,0	84368,0	01/07/2003 0:00	6	6	4	4	3	1	6	4	7
1904,0	82443,0	30/04/2003 0:00	4	7	4	6	5	3	2	3	4
1919,0	74098,0	20/06/2002 0:00	7	7	7	7	7	7	6	6	4
1976,0	80110,0	13/02/2003 0:00	7	5	3	4	3	3	5	5	3
2052,0	81175,0	20/03/2003 0:00	7	7	6	7	6	6	6	6	7
2059,0	82951,0	15/05/2003 0:00	1	1	1	1	1	1	1	1	1
2251,0	76399,0	01/10/2002 0:00	5	5	1	1	1	1	6	5	1
2524,0	76436,0	02/10/2002 0:00	7	7	6	7	6	6	6	6	7
2533,0	81445,0	28/03/2003 0:00	7	7	7	7	7	7	6	6	7
2604,0	75742,0	06/09/2002 0:00	7	7	6	7	7	7	5	6	7
2646,0	84112,0	20/06/2003 0:00	7	7	7	7	7	7	6	6	7
2685,0	79191,0	15/01/2003 0:00	7	7	7	7	7	7	6	6	7
2694,0	78901,0	02/01/2003 0:00	7	7	7	7	7	7	6	6	7
2726,0	74218,0	27/06/2002 0:00	6	6	4	6	6	5	3	5	6
2765,0	79837,0	05/02/2003 0:00	5	5	2	5	2	1	5	5	4

C_HISTORI	C_TRACTAI	DATA	Alimentació	Cures d'aparença	Higiene	Vestit: part superior	Vestit: part inferior	Utilització del bany	Bufeta	Intestí	Llit, cadira, cadira de rod
1645.0	84990.0	21/07/2003 0:00	7		6	6	2	6	6	6	3
1858.0	76281.0	26/09/2002 0:00	7		5	7	7	6	5	5	7
2267,0	86796,0	01/10/2003 0:00	7		7	7	7	7	6	6	7

Knn method

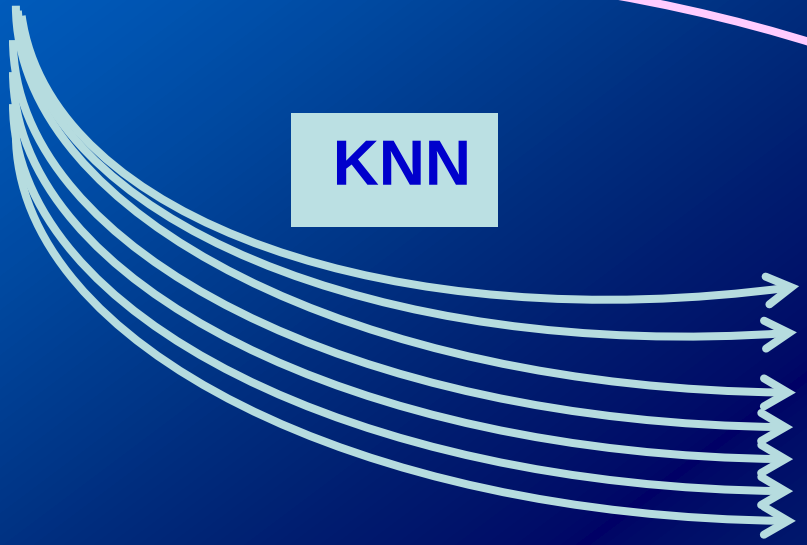
C_HISTORI	C_TRACTAI	DATA	Alimentació	Cures d'aparença	Higiene	Vestit: part superior	Vestit: part inferior	Utilització del bany	Bufeta	Intestí	Llit, cadira, cadira de rod
1645,0	84990,0	21/07/2003 0:00	7			6	2	6	6	6	3
1858,0	76281,0	26/09/2002 0:00	7			7	7	6	5	5	7
2267,0	86796,0	01/10/2003 0:00	7			7	7	7	6	6	7



C_HISTORI	C_TRACTAI	DATA	Alimentació	Cures d'aparença	Higiene	Vestit: part superior	Vestit: part inferior	Utilització del bany	Bufeta	Intestí	Llit, cadira, cadira de roc
1569,0	84585,0	09/07/2003 0:00	7		6	7	7	6	5	5	7
1642,0	74011,0	20/06/2002 0:00	7		7	7	7	7	7	7	7
1666,0	91980,0	09/03/2004 0:00	7		7	7	7	7	6	5	7
1694,0	83561,0	03/06/2003 0:00	7		7	7	7	7	6	6	7
1754,0	114451,0	03/02/2006 0:00	7		6	7	6	6	6	6	7
1900,0	84368,0	01/07/2003 0:00	6		4	4	3	1	6	4	7
1904,0	82443,0	30/04/2003 0:00	4		4	6	5	3	2	3	4
1919,0	74098,0	20/06/2002 0:00	7		7	7	7	7	6	6	4
1976,0	80110,0	13/02/2003 0:00	7		3	4	3	3	5	5	3
2052,0	81175,0	20/03/2003 0:00	7		6	7	6	6	6	6	7
2059,0	82951,0	15/05/2003 0:00	1		1	1	1	1	1	1	1
2251,0	76399,0	01/10/2002 0:00	5		1	1	1	1	6	5	1
2524,0	76436,0	02/10/2002 0:00	7		6	7	6	6	6	6	7
2533,0	81445,0	28/03/2003 0:00	7		7	7	7	7	6	6	7
2604,0	75742,0	06/09/2002 0:00	7		6	7	7	7	5	6	7
2646,0	84112,0	20/06/2003 0:00	7		7	7	7	7	6	6	7
2685,0	79191,0	15/01/2003 0:00	7		7	7	7	7	6	6	7
2694,0	78901,0	02/01/2003 0:00	7		7	7	7	7	6	6	7
2726,0	74218,0	27/06/2002 0:00	6		4	6	6	5	3	5	6
2765,0	79837,0	05/02/2003 0:00	5		2	5	2	1	5	5	4

Knn method

C_HISTORI	C_TRACTAI	DATA	Alimentació	Cures d'aparença	Higiene	Vestit: part superior	Vestit: part inferior	Utilització del bany	Bufeta	Intestí	Llit, cadira, cadira de rod
1645,0	84990,0	21/07/2003 0:00	7			6	2	6	6	6	3
1858,0	76281,0	26/09/2002 0:00	7			7	7	6	5	5	7
2267,0	86796,0	01/10/2003 0:00	7		7	7	7	7	6	6	7



KNN

C_HISTORI	C_TRACTAI	DATA	Alimentació	Cures d'aparença	Higiene	Vestit: part superior	Vestit: part inferior	Utilització del bany	Bufeta	Intestí	Llit, cadira, cadira de roc
1569,0	84585,0	09/07/2003 0:00	7		6	7	7	6	5	5	7
1642,0	74011,0	20/06/2002 0:00	7		7	7	7	7	7	7	7
1666,0	91980,0	09/03/2004 0:00	7		7	7	7	7	6	6	5	7
1694,0	83561,0	03/06/2003 0:0	7		7	7	7	7	7	6	6	7
1754,0	114451,0	03/02/2006 0:00	7		6	7	6	6	6	6	7
1900,0	84368,0	01/07/2003 0:00	6		4	4	3	1	6	4	7
1904,0	82443,0	30/04/2003 0:00	4		4	6	5	3	2	3	4
1919,0	74098,0	20/06/2002 0:00	7		7	7	7	7	6	6	4
1976,0	80110,0	13/02/2003 0:00	7		3	4	3	3	5	5	3
2052,0	81175,0	20/03/2003 0:00	7		6	7	6	6	6	6	7
2059,0	82951,0	15/05/2003 0:00	1		1	1	1	1	1	1	1
2251,0	76399,0	01/10/2002 0:00	5		1	1	1	1	6	5	1
2524,0	76436,0	02/10/2002 0:00	7		6	7	6	6	6	6	7
2533,0	81445,0	28/03/2003 0:00	7		7	7	7	7	6	6	7
2604,0	75742,0	06/09/2002 0:00	7		6	7	7	7	5	6	7
2646,0	84112,0	20/06/2003 0:00	7		7	7	7	7	6	6	7
2685,0	79191,0	15/01/2003 0:00	7		7	7	7	7	6	6	7
2694,0	78901,0	02/01/2003 0:00	7		7	7	7	7	6	6	7
2726,0	74218,0	27/06/2002 0:00	6		4	6	6	5	3	5	6
2765,0	79837,0	05/02/2003 0:00	5		2	5	2	1	5	5	4

MIMMI method *[Gibert 2013]*

- Select a small number of relevant variables
  (whith small ratio of missing data)
- Use intelligent inputation on that reduced data matrix
  (expert-based inputation, vertical or horitzontal)
- Multivariate clustering using the imputed variables
- Determine a partition of the data
- Inpute the missing data of the remaining variables
  (use mean local to the group of every individual (conditional means)
- Good TRADE-OFF between quality improvement vs extra effort

Example OMS

MIMMI *Method* *[IJCM Gibert 2013]*

Complex process
highly time consuming
rarely applicable in real projects

- Horizontal inputation:
  use the value of other variables of the same individual as predictors of the missing value.

  inputing 0 in the income of 4th person if the household has only 1,2 or 3 persons

- Vertical inputation:
  use the value of the same variable in other similar individuals

  use the mean of the salary of 4rt persons over 18 years old if the household hasmore than 4per

MICE method

[vanBuuren1999]

multiple imputation by chained equations

Context:
Multiple regression
In general

Multiple imputation (MI):

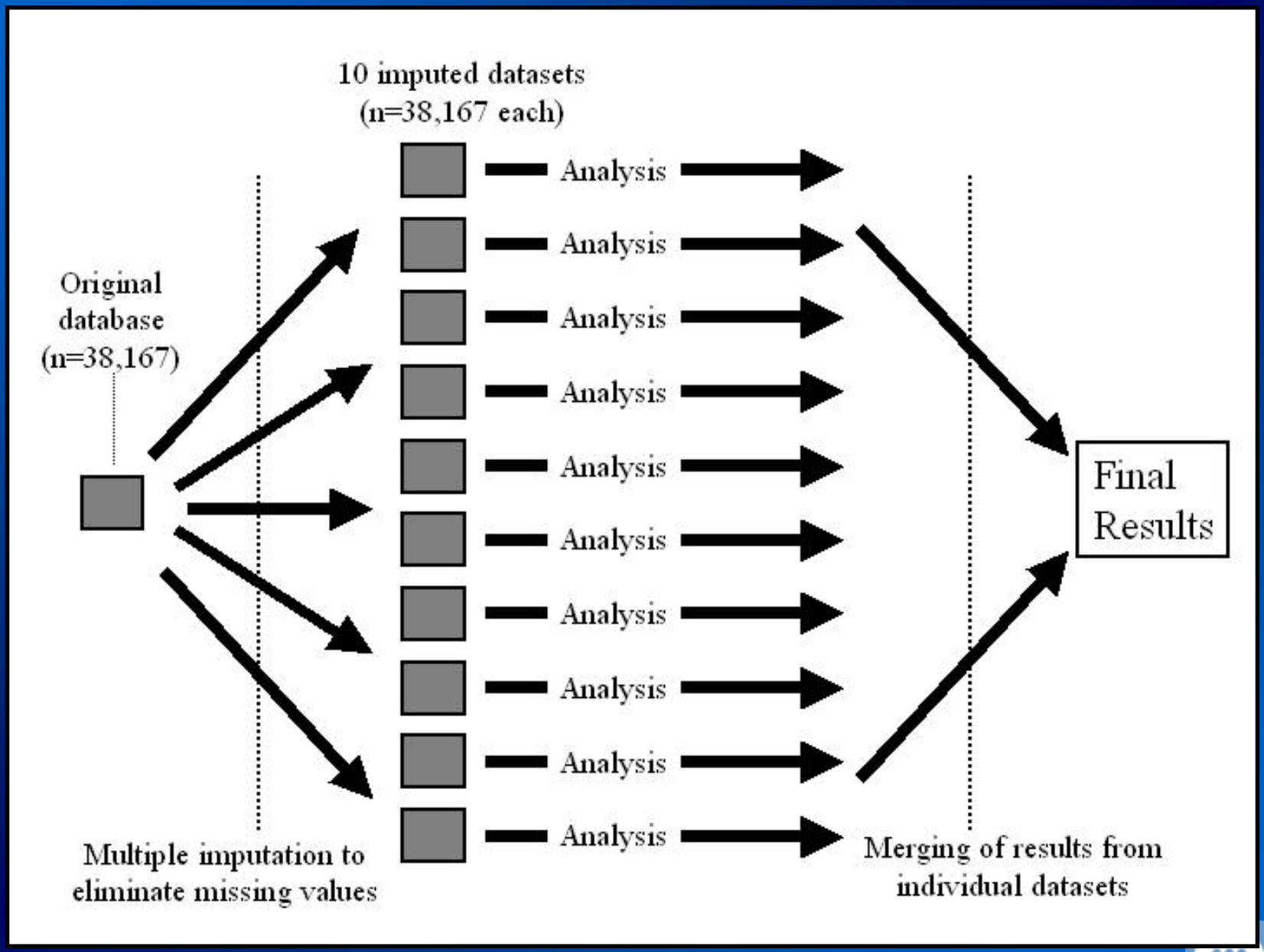
- Replace missing values with *plausible* substitutes
  - Distribution-based
    maximum-likelihood based Markov-chain Monte Carlo (MCMC)
  - Inject *the right amount of randomness* to reflect uncertainty
- Repeat *m* > 1 times to procude m imputed datasets
- Analyse datasets individually, but identically
- Combine the models, get confidence intervals using Rubin's rules (`micombine`)

The MICE approach has three components:

- Univariate – implemented in `uvis`
- Multivariate – implemented in `ice`
- Multiple – implemented in `ice`

- `ice` = imputation by chained equations

MICE



MICE

The overall *estimate of your parameter* (Q-bar) is its mean across the m imputations

$$\bar{Q} = m^{-1} \sum \hat{Q}^{(\ell)}$$

The *within-imputation variance* (U-bar) of the Q parameter is the mean of the variances across the m imputations

$$\bar{U} = m^{-1} \sum U^{(\ell)}$$

The *between-imputation variance* (B) of the Q parameter is standard deviation of Q across the m imputations

$$B = (m-1)^{-1} \sum (\hat{Q}^{(\ell)} - \bar{Q})^2$$

The *total variance* of Q is a function of U-bar and B. This total variance is used to calculate the standard error used for test statistics

$$T = (1 + m^{-1})B + \bar{U}$$

$$(\bar{Q} - Q)/\sqrt{T} \sim t_\nu$$

The *degrees of freedom* (v) are adjusted for the amount of information lost to missing data

$$\nu = (m-1)\left[1 + \frac{\bar{U}}{(1+m^{-1})B}\right]^2$$

MICE

- MICE method is very flexible – but demands thought when creating the imputation model
- Strongly recommend mastering the `eq()`, `passive()` and `substitute()` options
- Can deal with interactions using `passive()`
- Choice of *m* is important
  - may need to be (much) larger than 5
  - See Royston (2004, SJ 4:227-41) for discussion
- available in MICE Rpackage

Interpolation

- Usefull for time-series

- Consider constant between two effective measurements whenever we can assume that the variable evolve with a very slow dynamics

Preprocessing

Data cleaning
Data preparation
Data preprocessing

- Formatting issues, building software context
- Determining working matrix, Filtering
- Identification and treatment of missing data
- Identification and treatment of outliers
- Identification and treatment of errors *(correct when possible)*
- Feature selection/extraction, dimensionality reduction
- Instance selection
- Data transformation
- Derivation of new variables

Outlier

- Rare observation (presumed out of range)
- Multivariate vs univariate outlier

BIAS

Types of outliers:

- Mistake (Transcription Error or Measurement Error)
  - A person 560 years old
  - FIRST VERIFY *If possible correct*.
    If not, substitute by missing
- Informative point
  - A single informative point of a missing part of the population
  - *Complete the sample*
    when impossible, restrict scope of analysis
- Extreme value of the population
  - Very old person, 99 years old
  - *Keep*
- Value of another population
  - One swedish in the middle of cannibal tribu, measuring height
  - *Treat apart. CLEARLY REPORT ABOUT IT*
- Missing code
  - *Substitute by missing or inpute*

Care with suppressions

The danger of suppressions

- *In 1985 British scientists reported a hole in the ozone layer of the earth's atmosphere over the South Pole. This is disturbing, since ozone protects us from cancer-causing ultraviolet radiation. The British report was at first disredarded, since it was based on ground instruments looking up. More comprehensive observations from satellite instruments looking down had shown nothing unusual. Then examination of the satellite data revealed that the South Pole ozone readings were so low that the computer software used o analyze the data had automatically syppressed these values as erroneous outliers. Readings dating back to 1979 were reanalized and showed a large and growing hole in the ozone layer that is unexplained and possibily dangerous Computers analyzing large volumnes of data are often programmed to suppress outliers as protection againts errors in the data. As the example of the hole in the ozone layer illustrated, suppressing an outliers without inv estigating it can kleep valuable information out of the sight*

Moore, McCabe, Introduction to the practice of Statistics, 5th Edition, Freeman

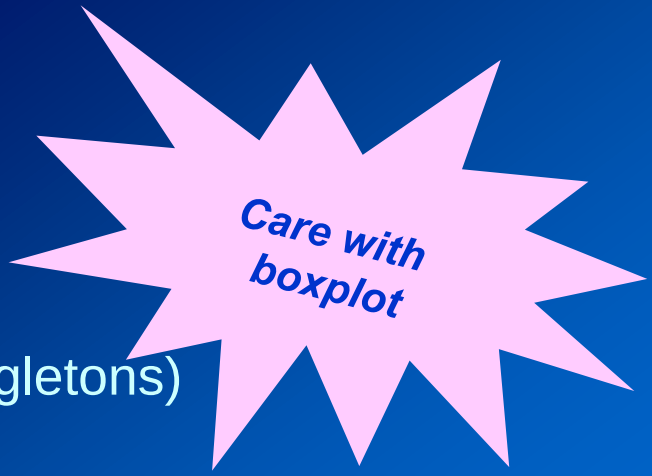
From the paper of John Gleick in New York Times, July 1985

http://www.nytimes.com/1986/07/29/science/hole-in-ozone-over-south-pole-worries-scientists.html?pagewanted=all

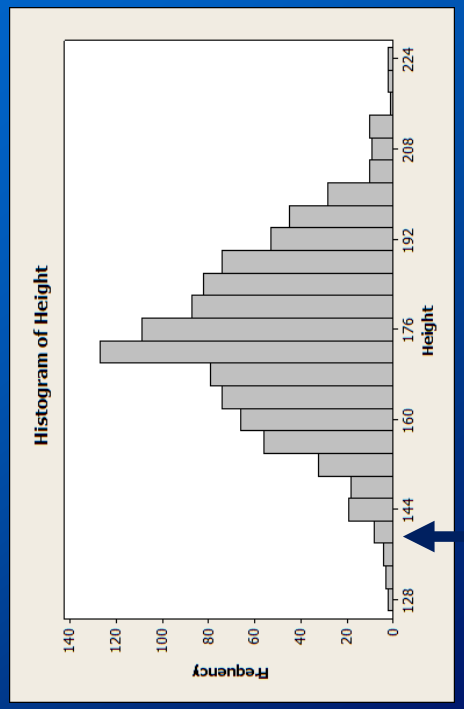
Outlier detection

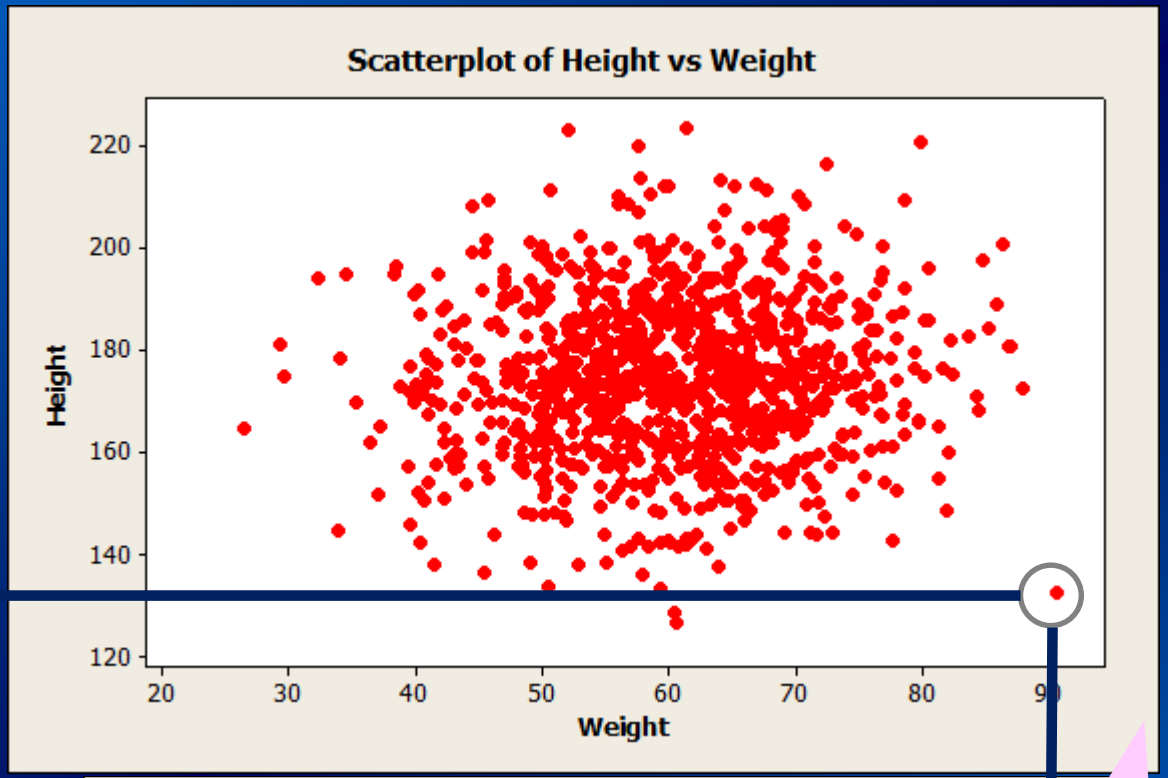
- Specific statistical Tests:
  - Depend on the software
  - Usually for specific distributions

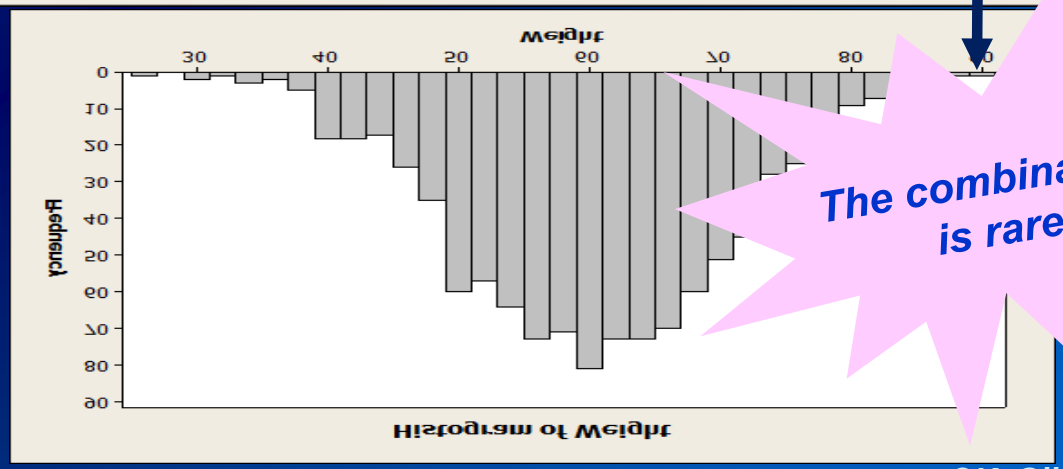
- Graphical representation of the distribution of data
  - Univariate (histogram or boxplot)
  - Bivariate (plots)
  - Clustering for multivariate outliers (singletons)



Dimensionality of outliers: Bivariate Outlier



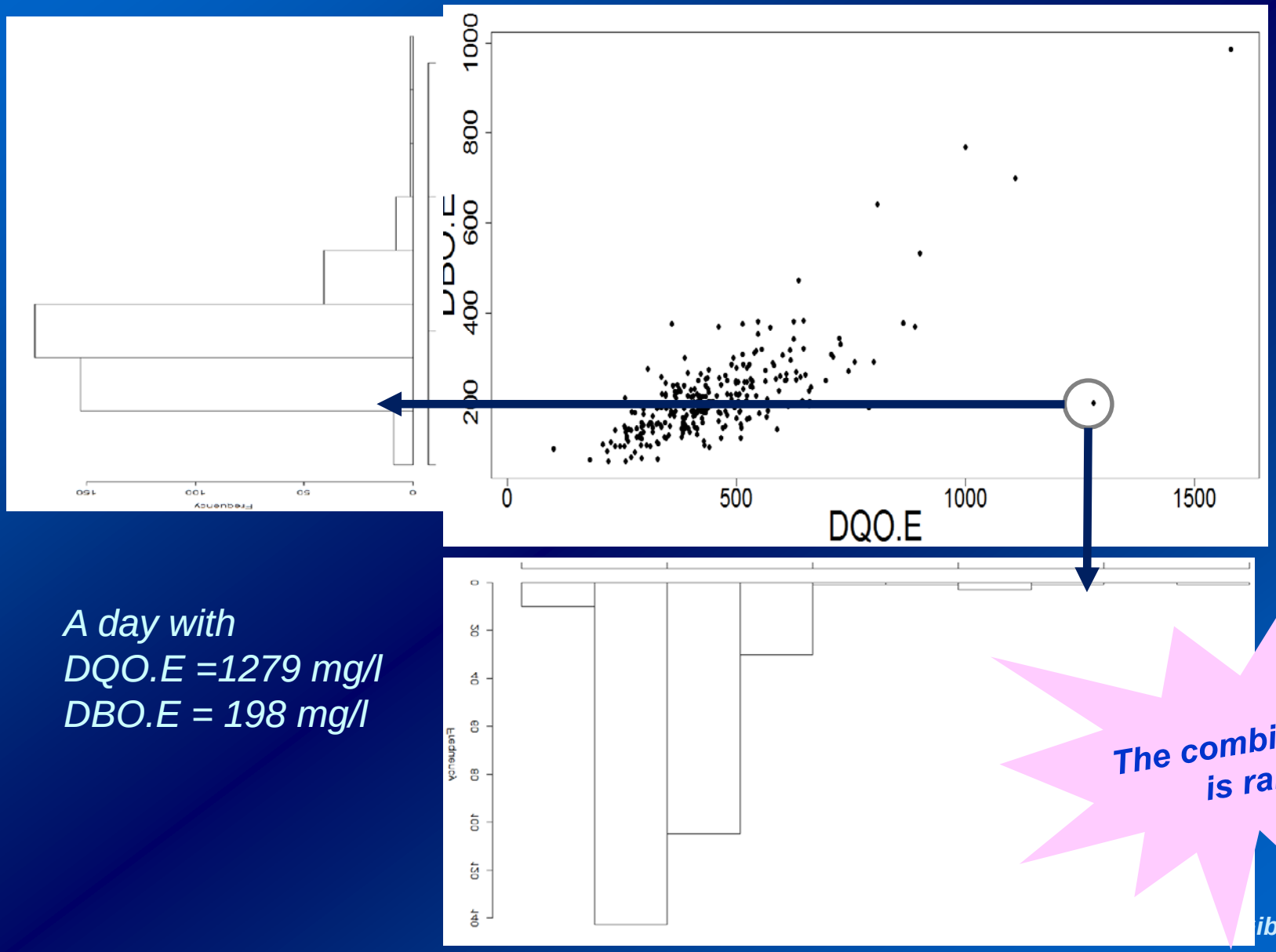




A person with 90Kg and 1,32 m

The combination is rare

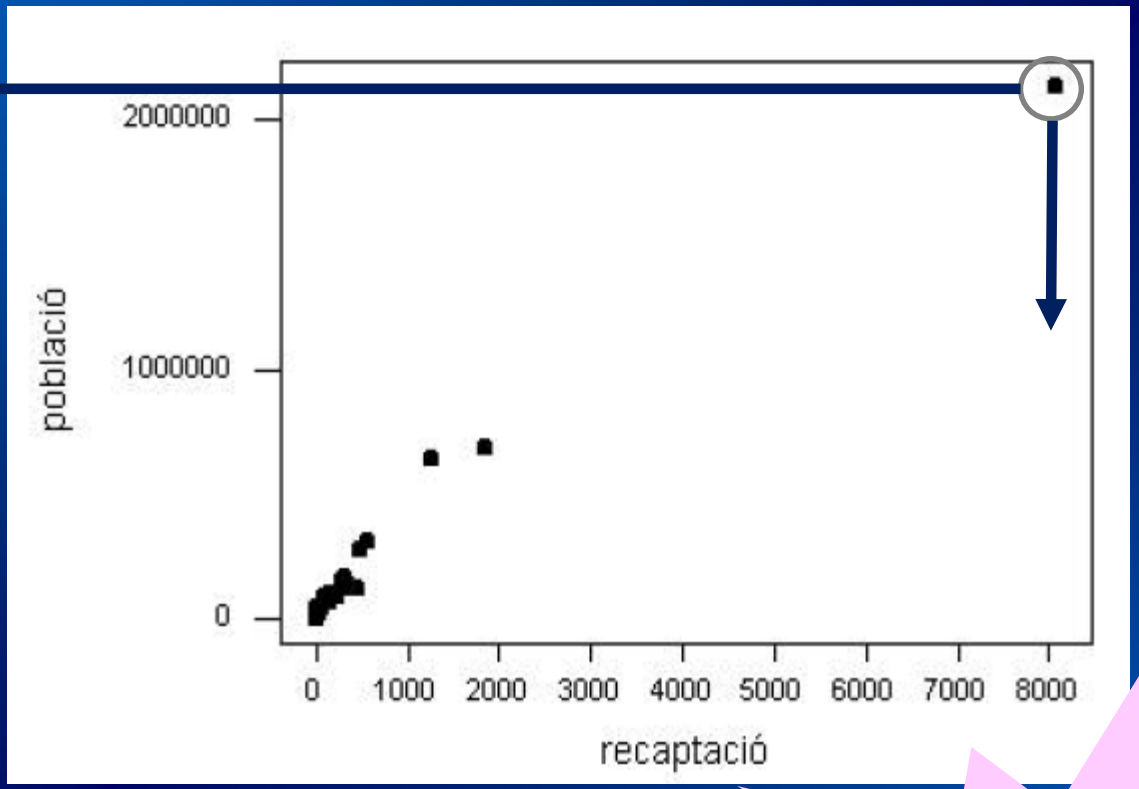
Dimensionality of outliers: Bivariate Outlier



A day with
DQO.E =1279 mg/l
DBO.E = 198 mg/l

The combination is rare

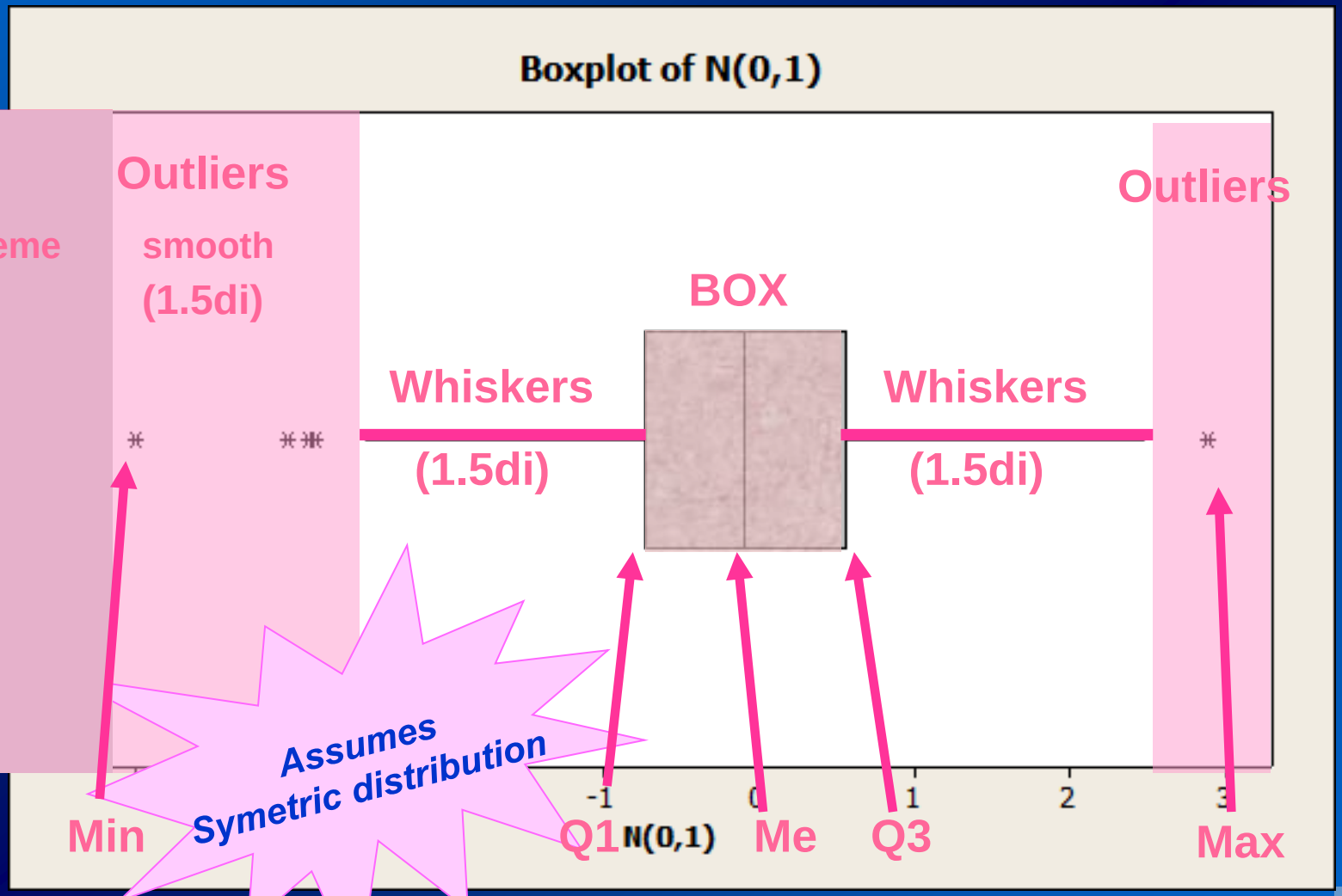
Dimensionality of outliers: Univariate Outlier



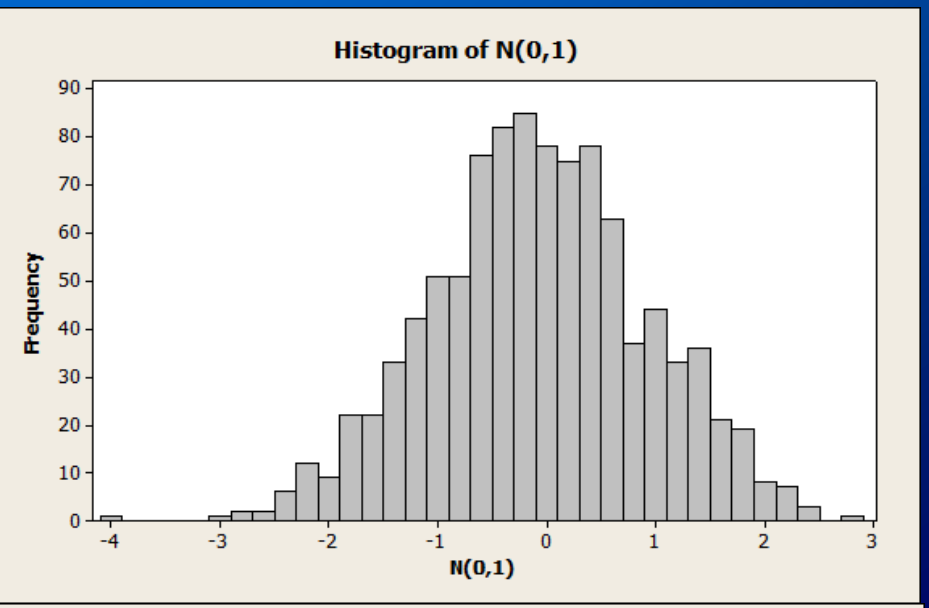
Aligned with global model!!!!

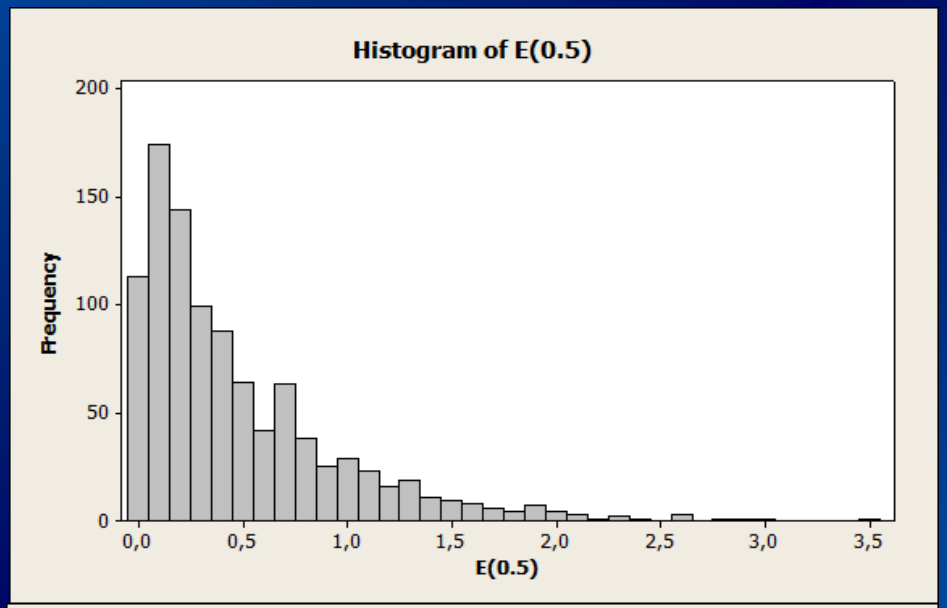
Boxplot *[Tukey 1956]*

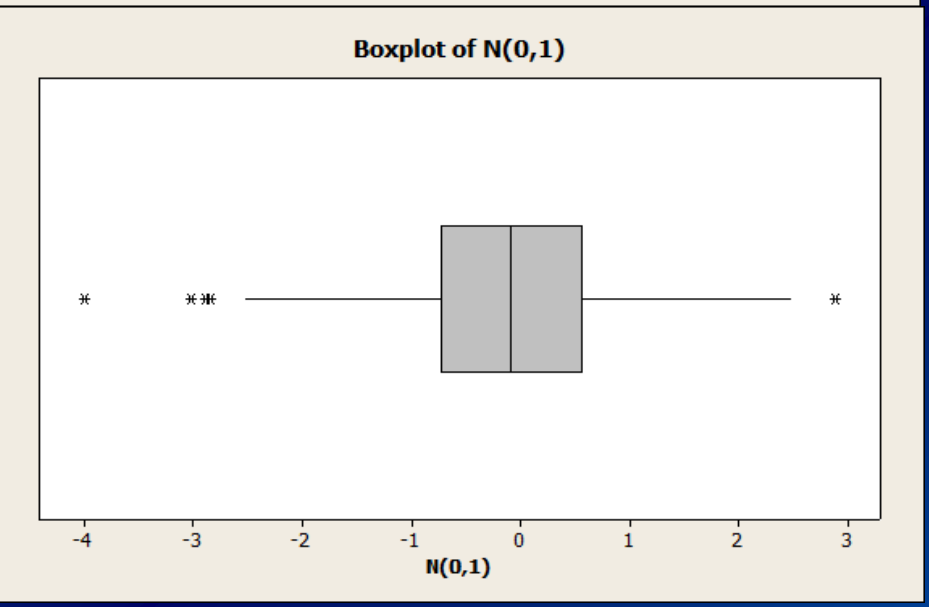
Symbolic representation of empirical distribution

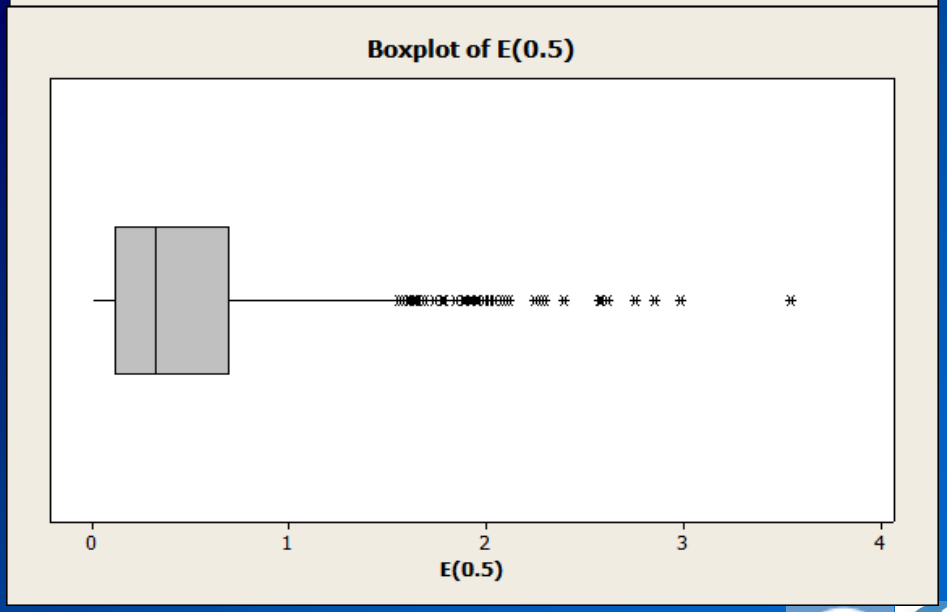


Boxplot [Tukey 1956]









Preprocessing

Data cleaning
Data preparation
Data preprocessing

- Formatting issues, building software context
- Determining working matrix, Filtering
- Identification and treatment of missing data
- Identification and treatment of outliers
- Identification and treatment of errors *(correct when possible)*
- Feature selection/extraction, dimensionality reduction
- Instance selection
- Data transformation
- Derivation of new variables

Instance selection

Evaluation of representative instances in a dataset

- Elimination of irrelevant instances
- Sampling
- Resampling

Reparing unbalanced datasets when required

- oversampling
- undersampling

Preprocessing

Data cleaning
Data preparation
Data preprocessing

- Formatting issues, building software context
- Determining working matrix, Filtering
- Identification and treatment of missing data
- Identification and treatment of outliers
- Identification and treatment of errors *(correct when possible)*
- Feature selection/extraction, dimensionality reduction
- Instance selection
- Data transformation
- Derivation of new variables

Feature selection

Evaluation of relevant variables in a dataset

- Priorization and ranking under different criteria
  - Feature weighting (determine weights of variables in the analysis)
- Elimination of irrelevant variables
  - Feature selection

Feature selection

- IA methods
- Statistical Feature selection: use statistical test for ranking
- Sometimes just use threshold on feature weighting ranks

Feature selection

- Goal: discard non-interesting variables
- Reduce data dimensionality
- Eliminate noise and redundancies
- Improve performance of algorithms
- Avoid spurious relationships in models
- Reduce curse of dimensionality
- Requires a response variable to be explained Y

- Rank relevance degree of Y wrt all other variables
- Discard less relevant

Statistical Feature selection

Guyon, I. (2008). Practical feature selection: from correlation to causality. NATO science for peace and security, 19, 27-43.

Hypothesis test:

H_0 : There is no relation between the y and x

H_1 : There is a relation

Get p-values for the dependence between Y and X

Lower p-values imply strongest dependence

Rank variables by ascending p-values

Discard irrelevant variables (threshold over p-values)

Specific tests depends on type of variables analyzed

Statistical Feature selection

Hypothesis test:

Y numerical

- X numerical: Correlations test / Sheffer generalized coefficient
- X qualitative: F test /Kruskal-Wallis

Y qualitative

- X numerical: F test/Kruskal-Wallis
- X qualitative: chi-2 test

Feature selection

Evaluation of relevant variables in a dataset

- Priorization and ranking under different criteria
  - Feature weighting (determine weights of variables in the analysis)
- Elimination of irrelevant variables
  - Feature selection

Feature selection

- IA methods (based on information theory)
- Statistical methods (based on statistical tests)
- Sometimes just use threshold on feature weighting ranks

Preprocessing

Data cleaning
Data preparation
Data preprocessing

- Formatting issues, building software context
- Determining working matrix, Filtering
- Identification and treatment of missing data
- Identification and treatment of outliers
- Identification and treatment of errors *(correct when possible)*
- Feature selection/extraction, dimensionality reduction
- Instance selection
- Data transformation
- Derivation of new variables

Variables Transformation

- Homogeneization
- Approaching to methods hypothesis
- Getting more interpretability

Variables Transformation

- Data cleaning reasons
  - Measurement units of Thyroids hormones from different laboratories

1993
Collaboration UPC, Barcelona, Spain
Andrija Stampar School of Public Health, Zagreb, Croatia
Setre Milordsnice Clinical Hospital, Zagreb, Croatia

Find patterns of thyroids dysfunctions 1002 patients, 12 measurements

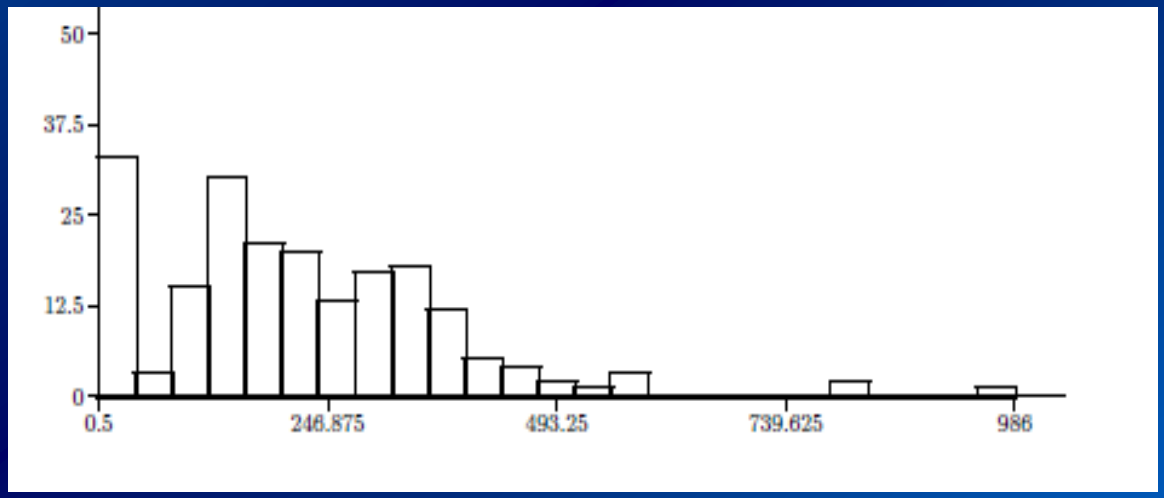
2013
Collaboration UPC, Atención Primaria ICS
http://www.sidiap.org/

Laboratory measuments in TSH

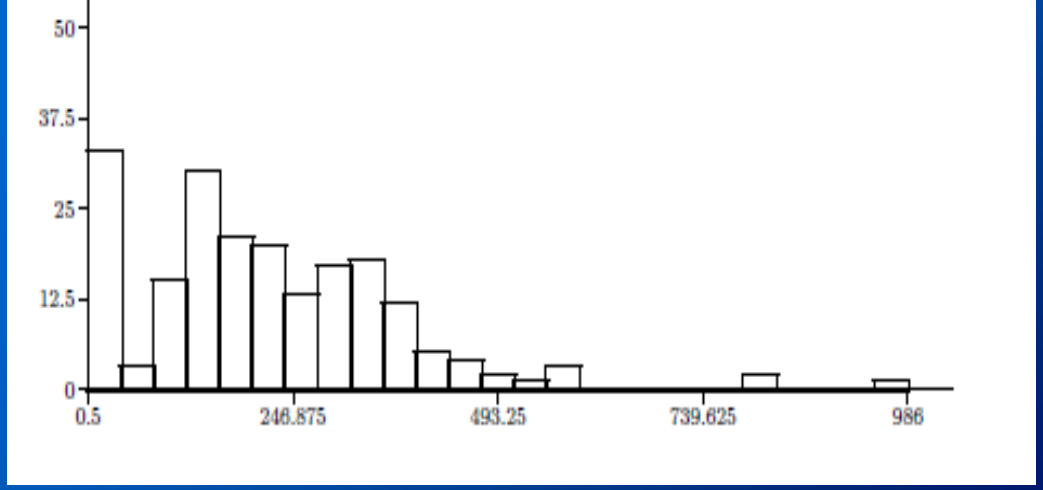
Laboratory Tests measurements

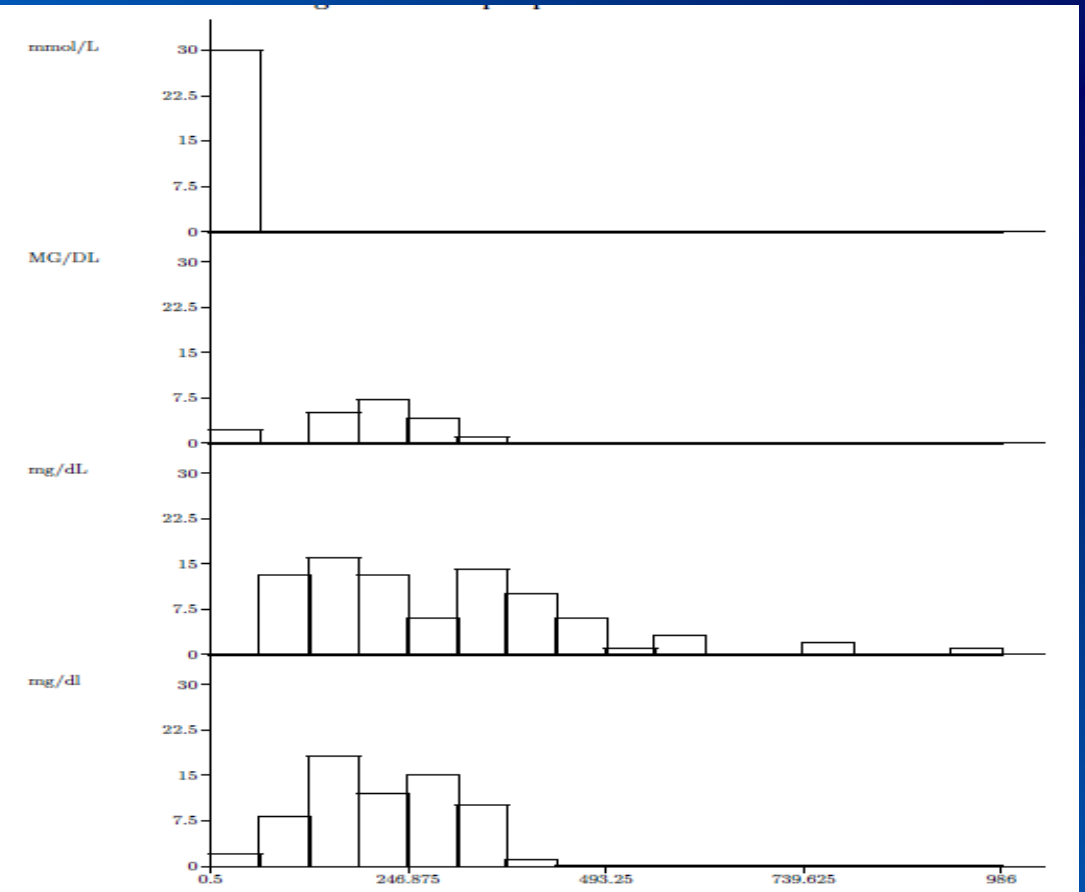
Measurement of Total Cholesterol from 200 pacs from Catalan Public Health System in 2013 (Primary Care)

Summary Statistics	
Number of objecs	200
Number of missing values	0
Number of useful values	200
Mean	213.2037
Median	193.9
First Quartile (Q1)	115.8
Third Quartile (Q3)	306.2
Minimum	0.5
Maximum	986
Quasi-standard deviation	156.4218
Variation Coeficient	0.7318



Frequency Table		
Modalities	Freq. absol.	Freq. relat.
mg/dl	66	0.33
mg/dL	85	0.425
MG/DL	19	0.095
mmol/L	30	0.15
missing data	0	0





Unitat	Count
(mg/dL)	12
0.0 - 240.0	1
55519	1
G/L	4
mg/dl	50
mg/dL	50
MG/DL	50
mg/dl^MMOL/L.	50
mmol/L	50
Mmol/L	1
MMOL/l	1
MMOL/L	1
mmol/L^mg/dL	50
N=	321

mmol/l = 38,669 mg/dl

Variables Transformation

- Data cleaning reasons
  - Measurement units of Thyroids hormones from different laboratories
  - Refer the whole set of variables to comparable units
    all concentration variables in mg/l
    proportions instead of absolute numbers, ...
  - Coertions: Information loss.
    - Discretization (h/week working)
    - Categorization (Thiroids levels)
    - Recategorizations (professions)

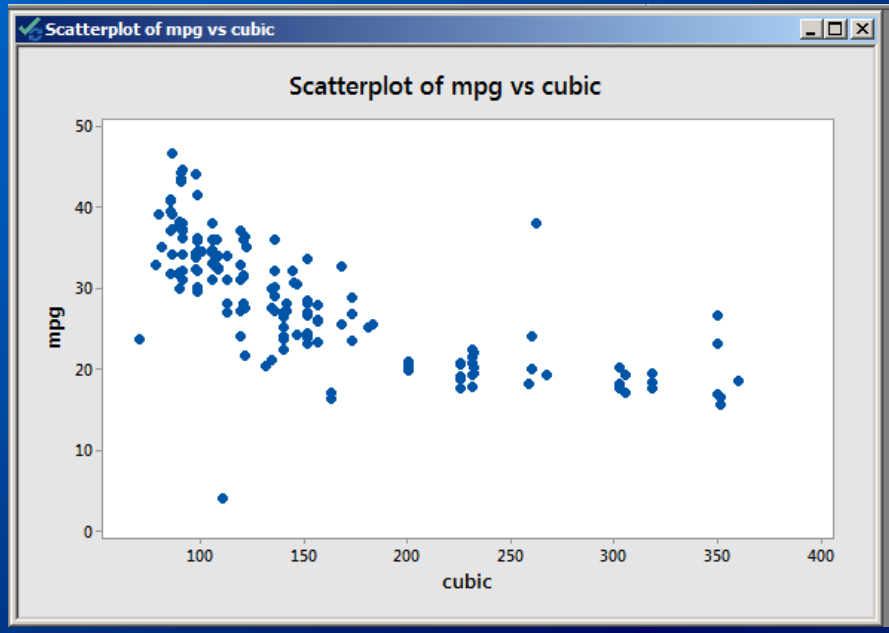
Better avoid

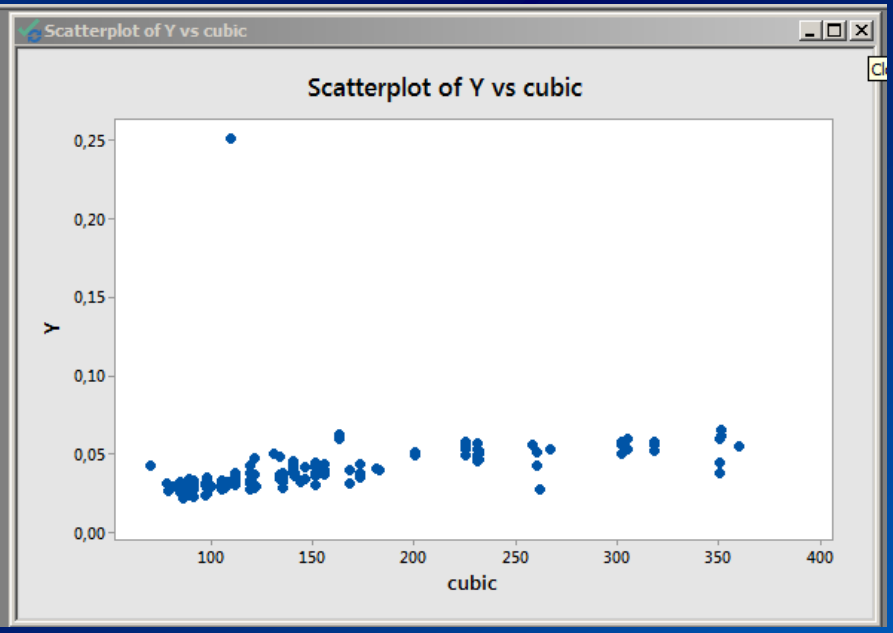
- Technical questions:
  - Estandarditzation, normalitzation o linealirization
  - Eventual logaritmic transformation
  - Required by data mining technique to apply

Select a technique respectfull with original data

Exceptional situations

where transforms make sense





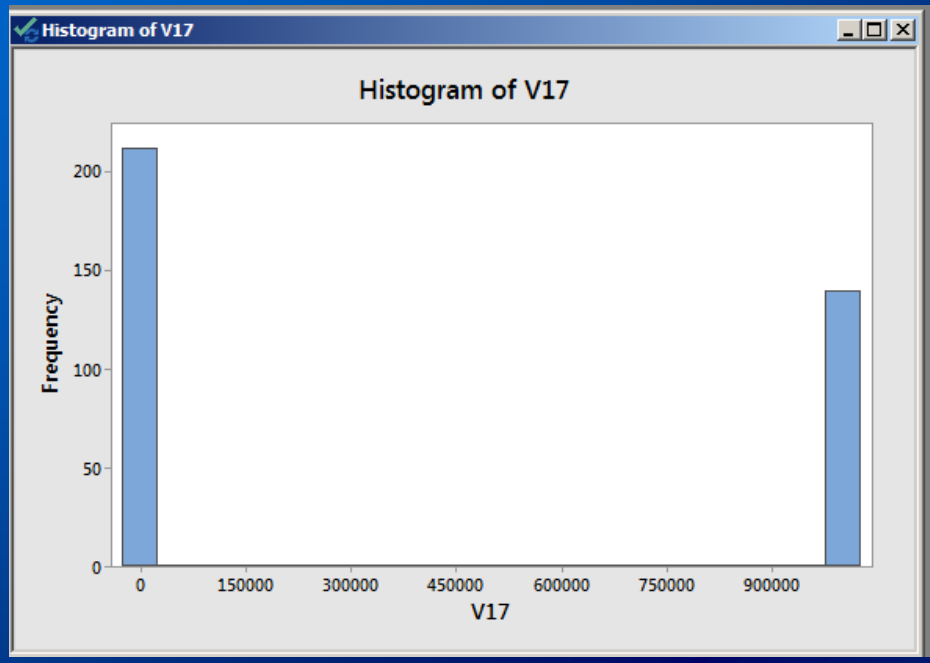
- Mpg: miles per gallon of a car
- Cubic: cubic capacity of the car engine
  Non linear relationship (regression non suitable)

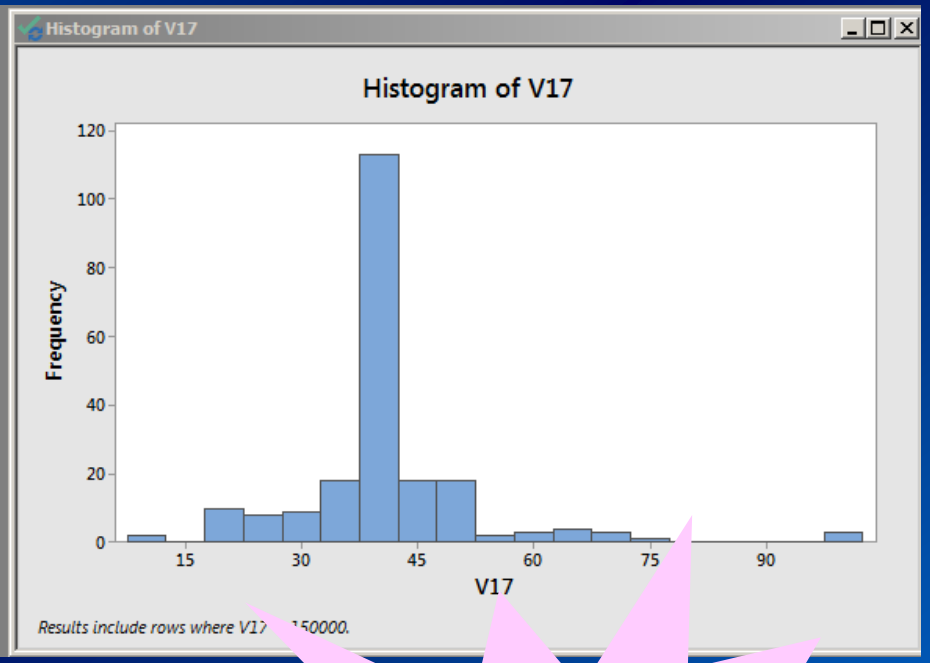
- Y = 1/mgp : Linearizes the relationship

Y is car Consumption!!!!

Exceptional situations

where transforms make sense





- Hours working per week
- 3-modal:
  - Arround 20 h/w
  - Arround 40 h/w
  - Arround 65 h/w

- Correspondence with part-time, full-time, extra turns w rks

Build a qualitative variable: Type of work (part-time, full, turn)

Preprocessing

Data cleaning
Data preparation
Data preprocessing

- Formatting issues, building software context
- Determining working matrix, Filtering
- Identification and treatment of missing data
- Identification and treatment of outliers
- Identification and treatment of errors *(correct when possible)*
- Feature selection/extraction, dimensionality reduction
- Instance selection
- Data transformation
- Derivation of new variables

Derivation of new variables

- Aggregates (additions of other variables)
  - Total household income
- Synthetic indicators
  - Classical generation of global score in psychometric scales
  - Indicators

  (Lund parameter =external contacts/days hospital
  indicator of "development of a health system")
  Case Credit Scoring (saving capacity)

Input missingsPreviously
According to operation

- Binary indicators
  - *If condition regarding a combination of values then indicatior=1, else the indicator=0*
- *Dimensionality reduction techniques*