1 Data import and preparation

This part of the document deals with the data preparation of the provided cooper wire data before the data analysis.

1.1 Data import

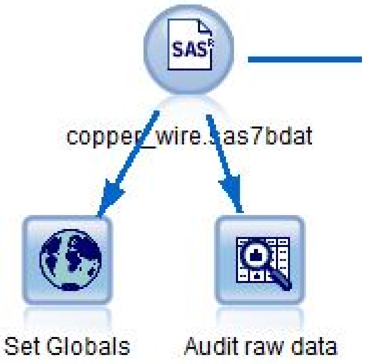
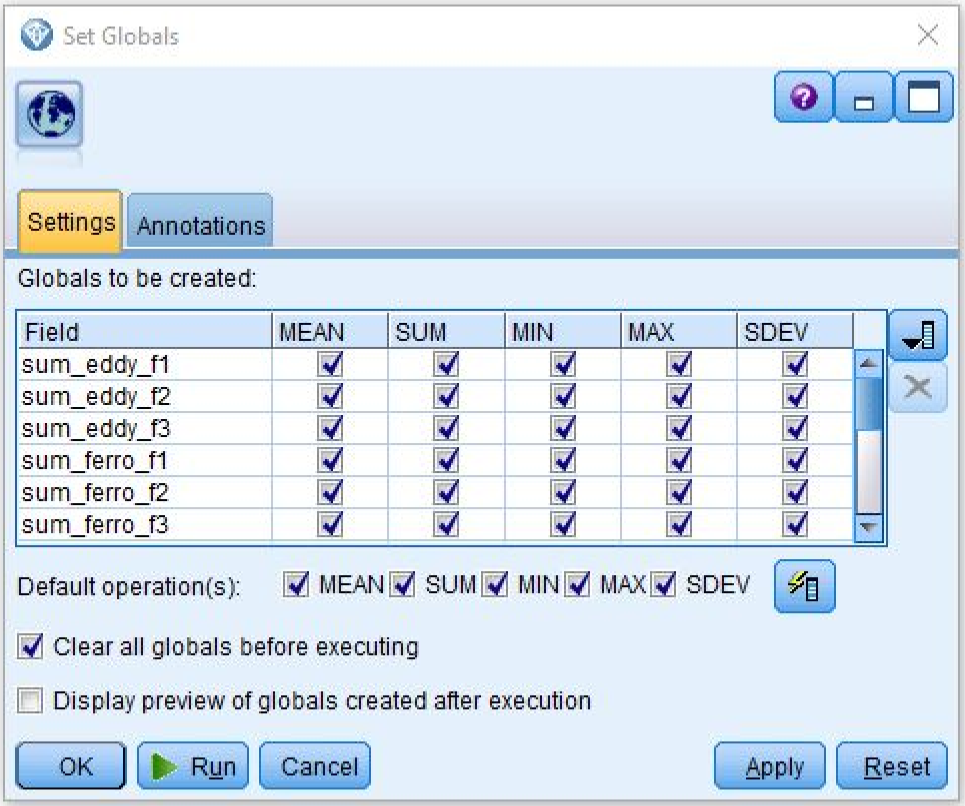


Abbildung 1: Data import in Stream

The data is imported via the node *SAS file*. The node *Set Globals* is used for setting the audited data results of the raw imported data as global values, which get used later on for the data preparation. The node *Data Audit* is used for analyzing the raw data.



Globals to be created:

Field	MEAN	SUM	MIN	MAX	SDEV
sum_eddy_f1	☑	☑	☑	☑	☑
sum_eddy_f2	☑	☑	☑	☑	☑
sum_eddy_f3	☑	☑	☑	☑	☑
sum_ferro_f1	☑	☑	☑	☑	☑
sum_ferro_f2	☑	☑	☑	☑	☑
sum_ferro_f3	☑	☑	☑	☑	☑

Default operation(s): ☑ MEAN ☑ SUM ☑ MIN ☑ MAX ☑ SDEV

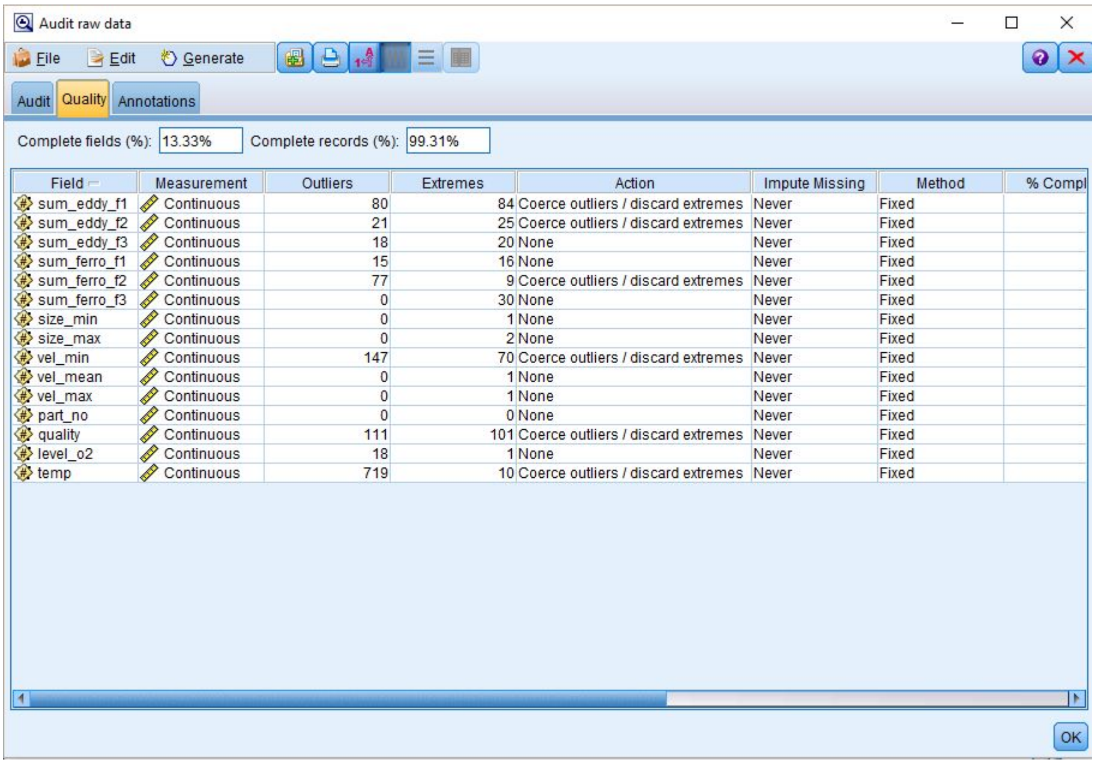
☑ Clear all globals before executing

□ Display preview of globals created after execution

Abbildung 2: Set audit results as global values in the stream

1.2 Data preparation

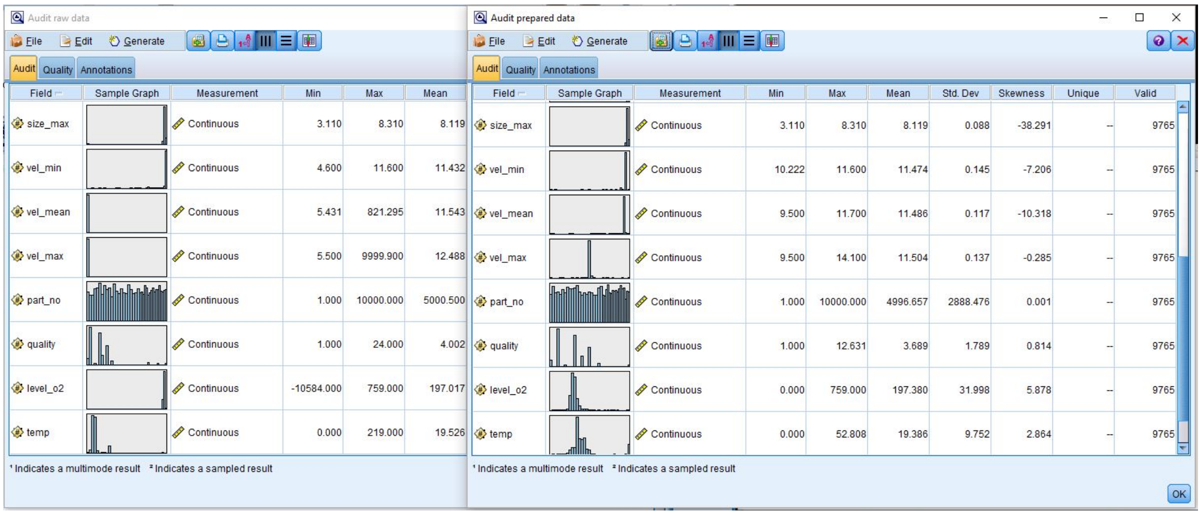
The outliers and extremes where determined during the audit of the raw data.



Complete fields (%): 13.33%   Complete records (%): 99.31%

Field	Measurement	Outliers	Extremes	Action	Impute Missing	Method	% Compl
sum_eddy_f1	Continuous	80	84	Coerce outliers / discard extremes	Never	Fixed	
sum_eddy_f2	Continuous	21	25	Coerce outliers / discard extremes	Never	Fixed	
sum_eddy_f3	Continuous	18	20	None	Never	Fixed	
sum_ferro_f1	Continuous	15	16	None	Never	Fixed	
sum_ferro_f2	Continuous	77	9	Coerce outliers / discard extremes	Never	Fixed	
sum_ferro_f3	Continuous	0	30	None	Never	Fixed	
size_min	Continuous	0	1	None	Never	Fixed	
size_max	Continuous	0	2	None	Never	Fixed	
vel_min	Continuous	147	70	Coerce outliers / discard extremes	Never	Fixed	
vel_mean	Continuous	0	1	None	Never	Fixed	
vel_max	Continuous	0	1	None	Never	Fixed	
part_no	Continuous	0	0	None	Never	Fixed	
quality	Continuous	111	101	Coerce outliers / discard extremes	Never	Fixed	
level_o2	Continuous	18	1	None	Never	Fixed	
temp	Continuous	719	10	Coerce outliers / discard extremes	Never	Fixed	

Abbildung 3: Audit of the raw data



Field	Sample Graph	Measurement	Min	Max	Mean
size_max		Continuous	3.110	8.310	8.119
vel_min		Continuous	4.600	11.600	11.432
vel_mean		Continuous	5.431	821.295	11.543
vel_max		Continuous	5.500	9999.900	12.488
part_no		Continuous	1.000	10000.000	5000.500
quality		Continuous	1.000	24.000	4.002
level_o2		Continuous	-10584.000	759.000	197.017
temp		Continuous	0.000	219.000	19.526

[1] Indicates a multimode result [2] Indicates a sampled result

Field	Sample Graph	Measurement	Min	Max	Mean	Std. Dev	Skewness	Unique	Valid
size_max		Continuous	3.110	8.310	8.119	0.088	-38.291	--	9765
vel_min		Continuous	10.222	11.600	11.474	0.145	-7.206	--	9765
vel_mean		Continuous	9.500	11.700	11.486	0.117	-10.318	--	9765
vel_max		Continuous	9.500	14.100	11.504	0.137	-0.285	--	9765
part_no		Continuous	1.000	10000.000	4996.657	2888.476	0.001	--	9765
quality		Continuous	1.000	12.631	3.689	1.789	0.814	--	9765
level_o2		Continuous	0.000	759.000	197.380	31.998	5.878	--	9765
temp		Continuous	0.000	52.808	19.386	9.752	2.864	--	9765

[1] Indicates a multimode result [2] Indicates a sampled result

Abbildung 4: Audit of the raw data

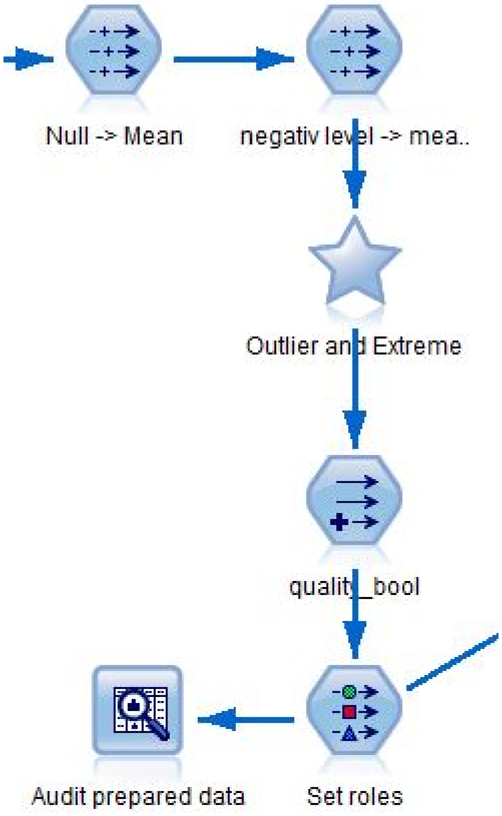


Abbildung 5: Flow of data preparation tasks

This flow prepares the data for the later analysis. The following tasks are performed:

- Null values will be replaced with the mean value set by the *Set Global* node
- The negative value of the field *temp* will be replaced with the global mean of this field
- The outliers and extremes will be handled as you can see in image 3
- A new filed will be created *quality_bool* which represents the quality state good or false
- The fields which are not considered to be relevant will be set as ignored and the field *quality_bool* will be set as the target field for the further analysis

1.3 Predictive Model

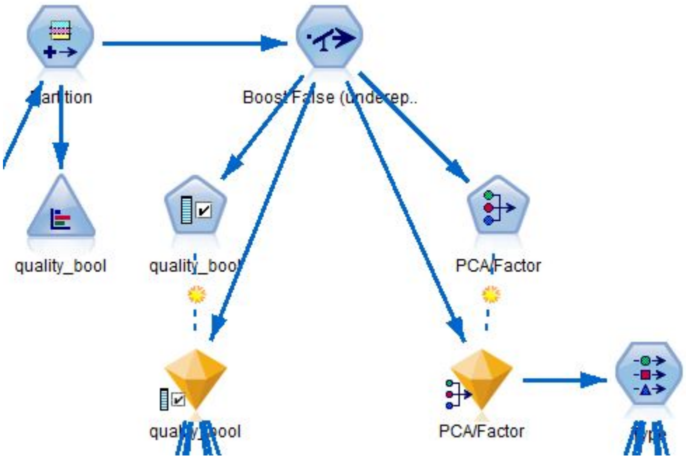
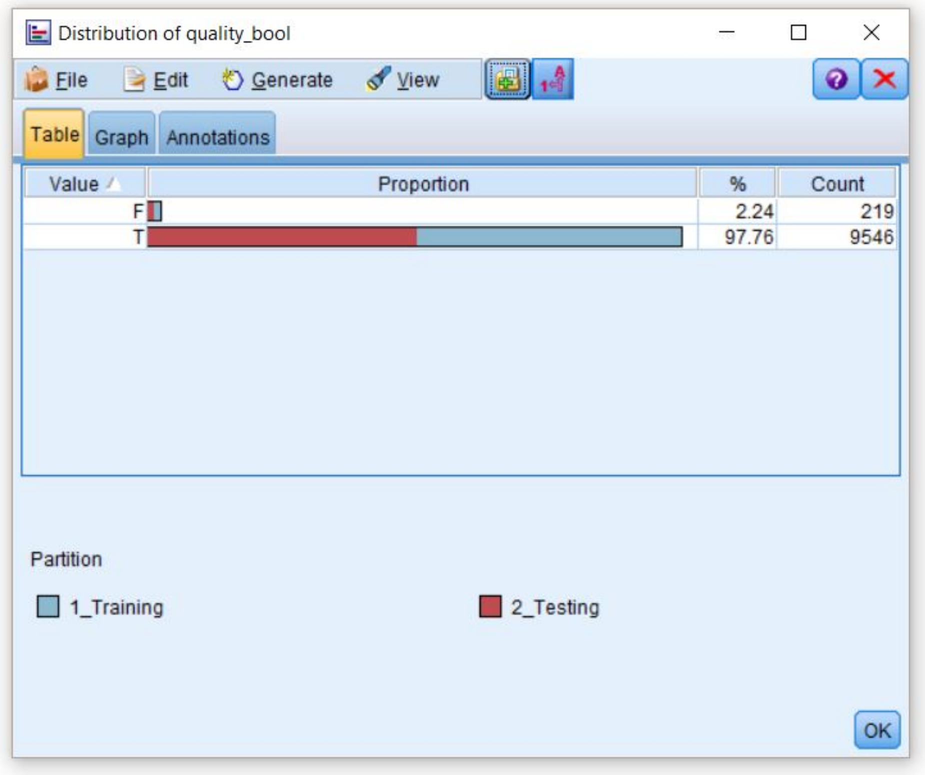


Abbildung 6: Flow of further data preparation

This part of the stream prepares the data by splitting it into test and training data, additionally the *False qualtity_bool* will be boost to increase their representation in the data. At last the data gets prepared on the one hand with a *Feature Selection* and on the other hand with a *PAC Factor*.



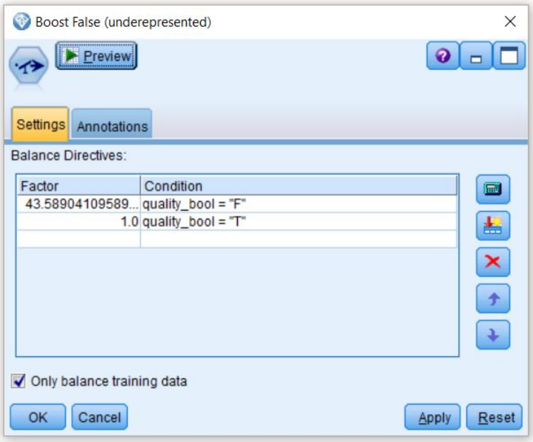
Value	Proportion	%	Count
F		2.24	219
T		97.76	9546

Partition

🟦 1_Training 🟥 2_Testing

Abbildung 7: Badly distributed *quality_bool*

As we can see that the *False* quality is underrepresented compared to the *True* quality.



Boost False (underrepresented)

Balance Directives:

Factor	Condition
43.58904109589...	quality_bool = "F"
1.0	quality_bool = "T"

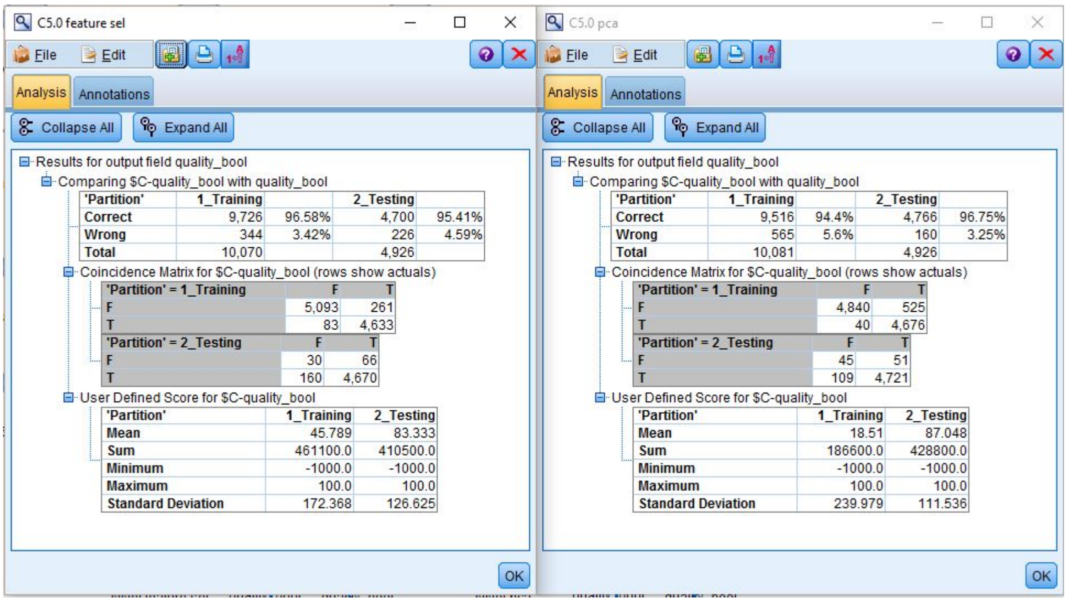
☑ Only balance training data

Abbildung 8: Boost of quality *False*

The node *Balance* has been generated by the node *Distribution* and boost the representation of the *False* quality. After this nodes follows the node *Field selection* which removes fields which are not related to the *target*.

The node *Field selection* has reduced the count of fields from *15* down to *10*, therefore has removed *5* fields.

1.3.1 What are results of the use of *Feature Selection* and *PCA Factor* with defaults ?



C5.0 feature sel

Results for output field quality_bool

Comparing $C-quality_bool with quality_bool

'Partition'	1_Training		2_Testing	
Correct	9,726	96.58%	4,700	95.41%
Wrong	344	3.42%	226	4.59%
Total	10,070		4,926	

Coincidence Matrix for $C-quality_bool (rows show actuals)

'Partition' = 1_Training	F	T
F	5,093	261
T	83	4,633
'Partition' = 2_Testing	**F**	**T**
F	30	66
T	160	4,670

User Defined Score for $C-quality_bool

'Partition'	1_Training	2_Testing
Mean	45.789	83.333
Sum	461100.0	410500.0
Minimum	-1000.0	-1000.0
Maximum	100.0	100.0
Standard Deviation	172.368	126.625

C5.0 pca

Results for output field quality_bool

Comparing $C-quality_bool with quality_bool

'Partition'	1_Training		2_Testing	
Correct	9,516	94.4%	4,766	96.75%
Wrong	565	5.6%	160	3.25%
Total	10,081		4,926	

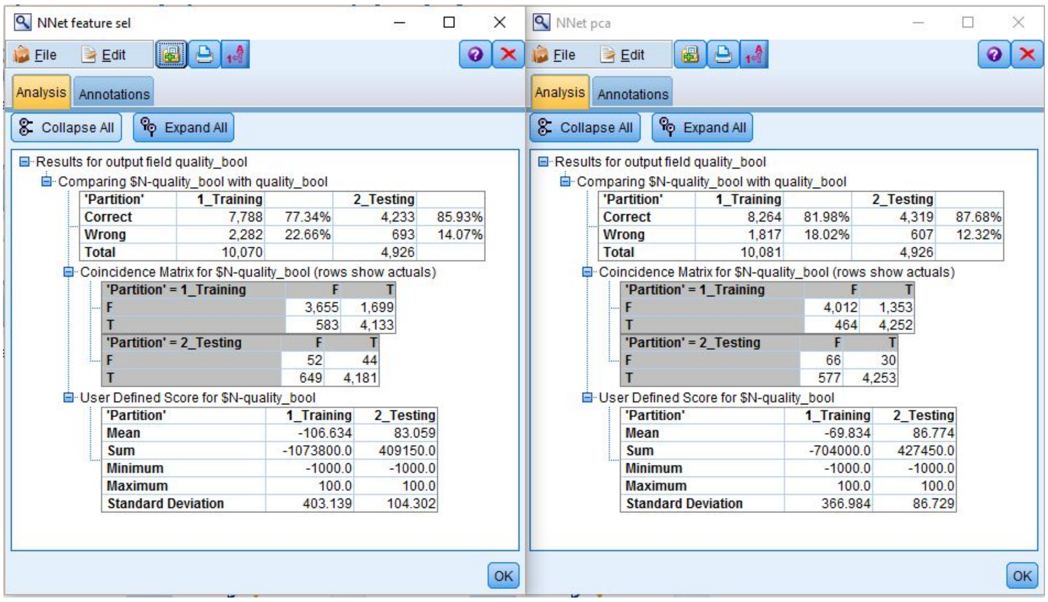
Coincidence Matrix for $C-quality_bool (rows show actuals)

'Partition' = 1_Training	F	T
F	4,840	525
T	40	4,676
'Partition' = 2_Testing	**F**	**T**
F	45	51
T	109	4,721

User Defined Score for $C-quality_bool

'Partition'	1_Training	2_Testing
Mean	18.51	87.048
Sum	186600.0	428800.0
Minimum	-1000.0	-1000.0
Maximum	100.0	100.0
Standard Deviation	239.979	111.536

Abbildung 9: C5.0 with *Feature Selection* compared to *PAC*



NNet feature sel

Results for output field quality_bool

Comparing $N-quality_bool with quality_bool

'Partition'	1_Training		2_Testing	
Correct	7,788	77.34%	4,233	85.93%
Wrong	2,282	22.66%	693	14.07%
Total	10,070		4,926	

Coincidence Matrix for $N-quality_bool (rows show actuals)

'Partition' = 1_Training	F	T
F	3,655	1,699
T	583	4,133
'Partition' = 2_Testing	F	T
F	52	44
T	649	4,181

User Defined Score for $N-quality_bool

'Partition'	1_Training	2_Testing
Mean	-106.634	83.059
Sum	-1073800.0	409150.0
Minimum	-1000.0	-1000.0
Maximum	100.0	100.0
Standard Deviation	403.139	104.302

NNet pca

Results for output field quality_bool

Comparing $N-quality_bool with quality_bool

'Partition'	1_Training		2_Testing	
Correct	8,264	81.98%	4,319	87.68%
Wrong	1,817	18.02%	607	12.32%
Total	10,081		4,926	

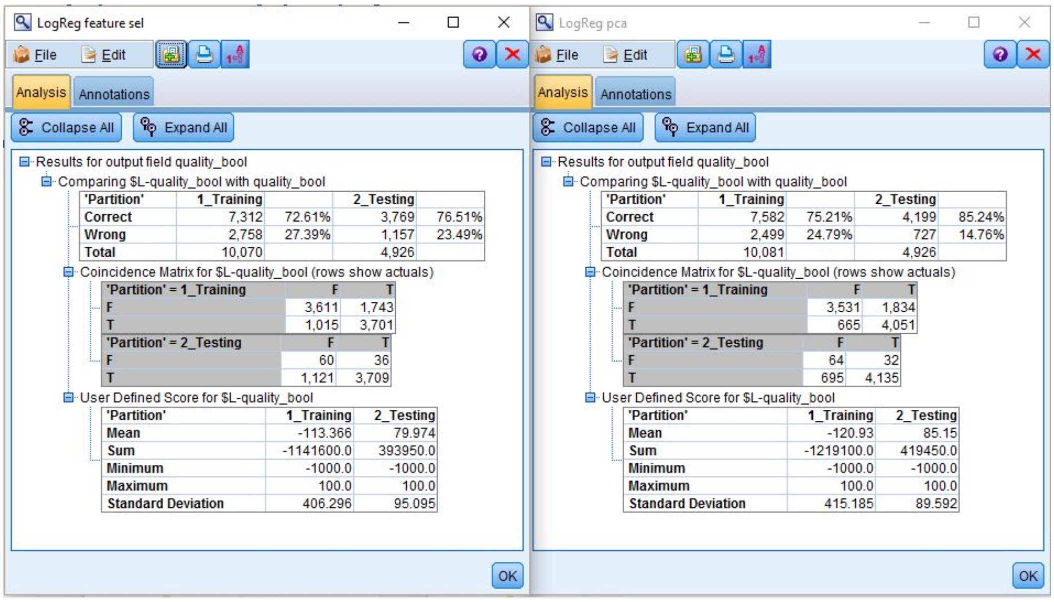
Coincidence Matrix for $N-quality_bool (rows show actuals)

'Partition' = 1_Training	F	T
F	4,012	1,353
T	464	4,252
'Partition' = 2_Testing	F	T
F	66	30
T	577	4,253

User Defined Score for $N-quality_bool

'Partition'	1_Training	2_Testing
Mean	-69.834	86.774
Sum	-704000.0	427450.0
Minimum	-1000.0	-1000.0
Maximum	100.0	100.0
Standard Deviation	366.984	86.729

Abbildung 10: Neuronal Net with *Feature Selection* compared to *PAC*



LogReg feature sel

Results for output field quality_bool

Comparing $L-quality_bool with quality_bool

'Partition'	1_Training		2_Testing	
Correct	7,312	72.61%	3,769	76.51%
Wrong	2,758	27.39%	1,157	23.49%
Total	10,070		4,926	

Coincidence Matrix for $L-quality_bool (rows show actuals)

'Partition' = 1_Training	F	T
F	3,611	1,743
T	1,015	3,701
'Partition' = 2_Testing	F	T
F	60	36
T	1,121	3,709

User Defined Score for $L-quality_bool

'Partition'	1_Training	2_Testing
Mean	-113.366	79.974
Sum	-1141600.0	393950.0
Minimum	-1000.0	-1000.0
Maximum	100.0	100.0
Standard Deviation	406.296	95.095

LogReg pca

Results for output field quality_bool

Comparing $L-quality_bool with quality_bool

'Partition'	1_Training		2_Testing	
Correct	7,582	75.21%	4,199	85.24%
Wrong	2,499	24.79%	727	14.76%
Total	10,081		4,926	

Coincidence Matrix for $L-quality_bool (rows show actuals)

'Partition' = 1_Training	F	T
F	3,531	1,834
T	665	4,051
'Partition' = 2_Testing	F	T
F	64	32
T	695	4,135

User Defined Score for $L-quality_bool

'Partition'	1_Training	2_Testing
Mean	-120.93	85.15
Sum	-1219100.0	419450.0
Minimum	-1000.0	-1000.0
Maximum	100.0	100.0
Standard Deviation	415.185	89.592

Abbildung 11: Logistic Regression with *Feature Selection* compared to *PAC*

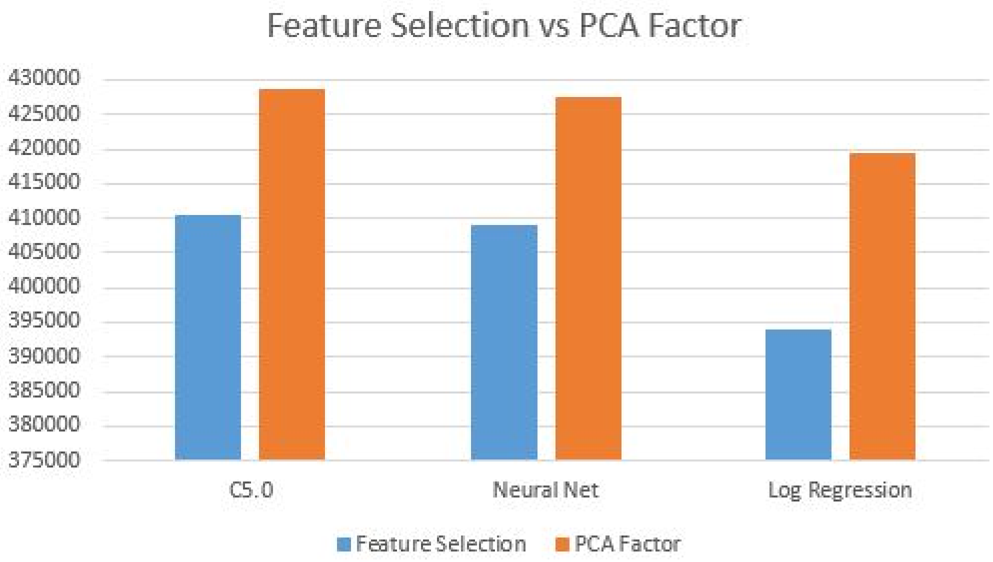
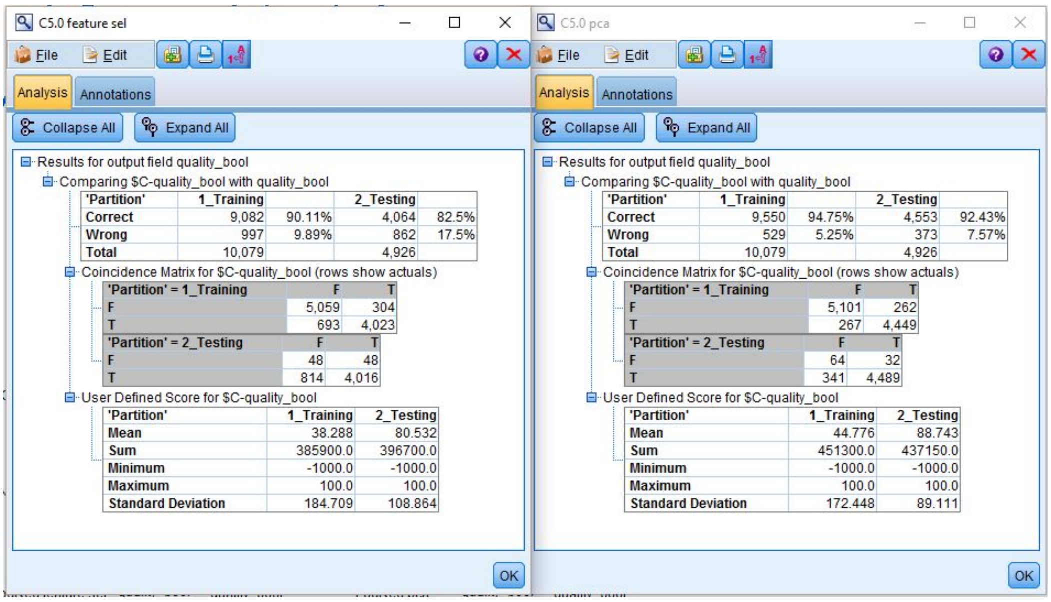


Abbildung 12: The chart shows the results of the comparison between *Feature Selection* and *PAC*

1.3.2 What are results when C5.0 is modified ?



C5.0 feature sel

Results for output field quality_bool

Comparing $C-quality_bool with quality_bool

'Partition'	1_Training		2_Testing	
Correct	9,082	90.11%	4,064	82.5%
Wrong	997	9.89%	862	17.5%
Total	10,079		4,926	

Coincidence Matrix for $C-quality_bool (rows show actuals)

'Partition' = 1_Training	F	T
F	5,059	304
T	693	4,023

'Partition' = 2_Testing	F	T
F	48	48
T	814	4,016

User Defined Score for $C-quality_bool

'Partition'	1_Training	2_Testing
Mean	38.288	80.532
Sum	385900.0	396700.0
Minimum	-1000.0	-1000.0
Maximum	100.0	100.0
Standard Deviation	184.709	108.864

C5.0 pca

Results for output field quality_bool

Comparing $C-quality_bool with quality_bool

'Partition'	1_Training		2_Testing	
Correct	9,550	94.75%	4,553	92.43%
Wrong	529	5.25%	373	7.57%
Total	10,079		4,926	

Coincidence Matrix for $C-quality_bool (rows show actuals)

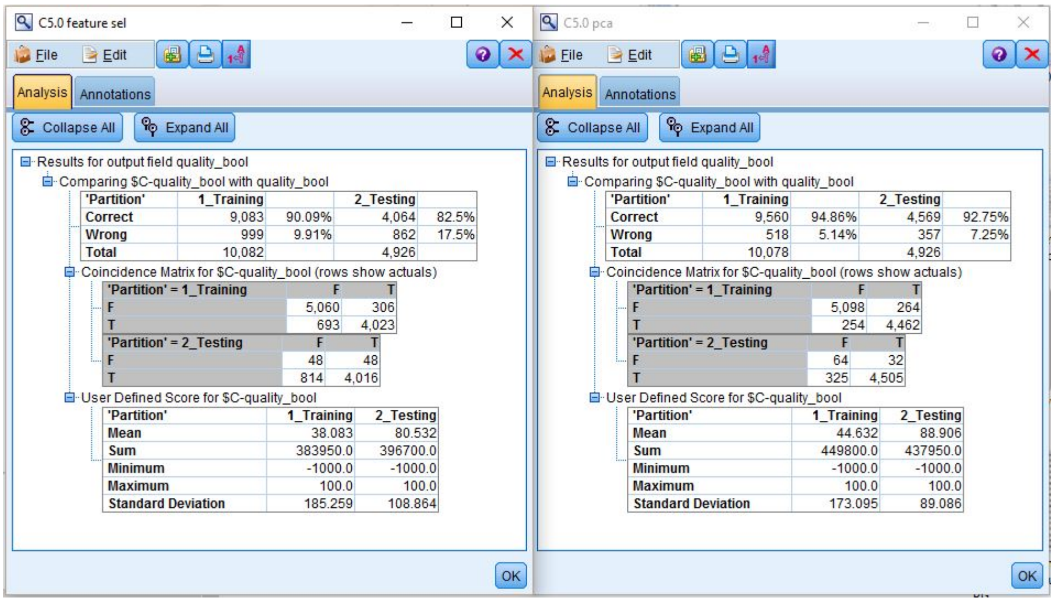
'Partition' = 1_Training	F	T
F	5,101	262
T	267	4,449

'Partition' = 2_Testing	F	T
F	64	32
T	341	4,489

User Defined Score for $C-quality_bool

'Partition'	1_Training	2_Testing
Mean	44.776	88.743
Sum	451300.0	437150.0
Minimum	-1000.0	-1000.0
Maximum	100.0	100.0
Standard Deviation	172.448	89.111

Abbildung 13: C5.0 (costs for TF=10) with *Feature Selection* compared to *PAC*



C5.0 feature sel

Results for output field quality_bool

Comparing $C-quality_bool with quality_bool

'Partition'	1_Training		2_Testing	
Correct	9,083	90.09%	4,064	82.5%
Wrong	999	9.91%	862	17.5%
Total	10,082		4,926	

Coincidence Matrix for $C-quality_bool (rows show actuals)

'Partition' = 1_Training	F	T
F	5,060	306
T	693	4,023

'Partition' = 2_Testing	F	T
F	48	48
T	814	4,016

User Defined Score for $C-quality_bool

'Partition'	1_Training	2_Testing
Mean	38.083	80.532
Sum	383950.0	396700.0
Minimum	-1000.0	-1000.0
Maximum	100.0	100.0
Standard Deviation	185.259	108.864

C5.0 pca

Results for output field quality_bool

Comparing $C-quality_bool with quality_bool

'Partition'	1_Training		2_Testing	
Correct	9,560	94.86%	4,569	92.75%
Wrong	518	5.14%	357	7.25%
Total	10,078		4,926	

Coincidence Matrix for $C-quality_bool (rows show actuals)

'Partition' = 1_Training	F	T
F	5,098	264
T	254	4,462

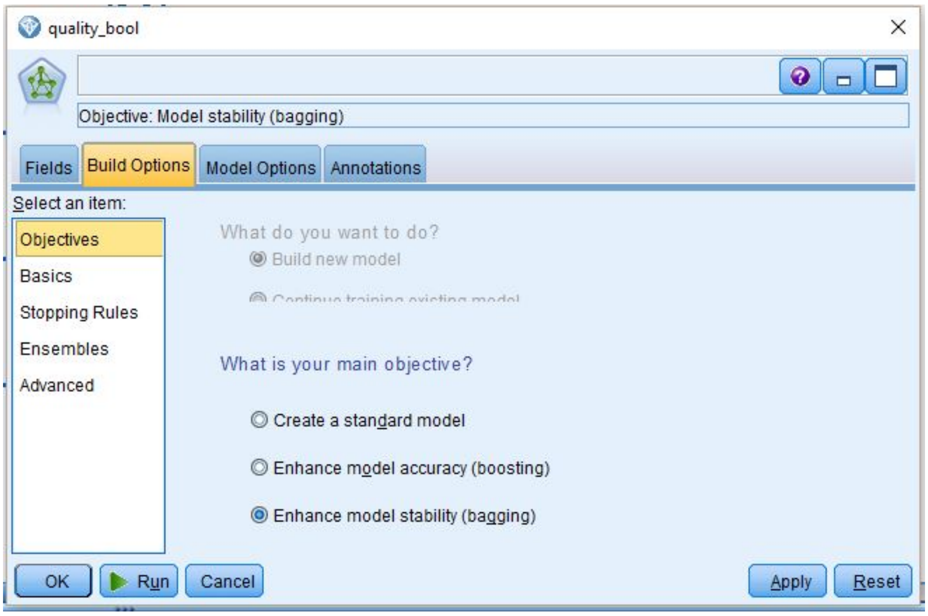
'Partition' = 2_Testing	F	T
F	64	32
T	325	4,505

User Defined Score for $C-quality_bool

'Partition'	1_Training	2_Testing
Mean	44.632	88.906
Sum	449800.0	437950.0
Minimum	-1000.0	-1000.0
Maximum	100.0	100.0
Standard Deviation	173.095	89.086

Abbildung 14: C5.0 (costs for TF=10, prun serv=10) with *Feature Selection* compared to *PAC*

1.3.3 What are results when the Neural Net is modified ?



Objective: Model stability (bagging)

Select an item:

What do you want to do?

● Build new model

○ Continue training existing model

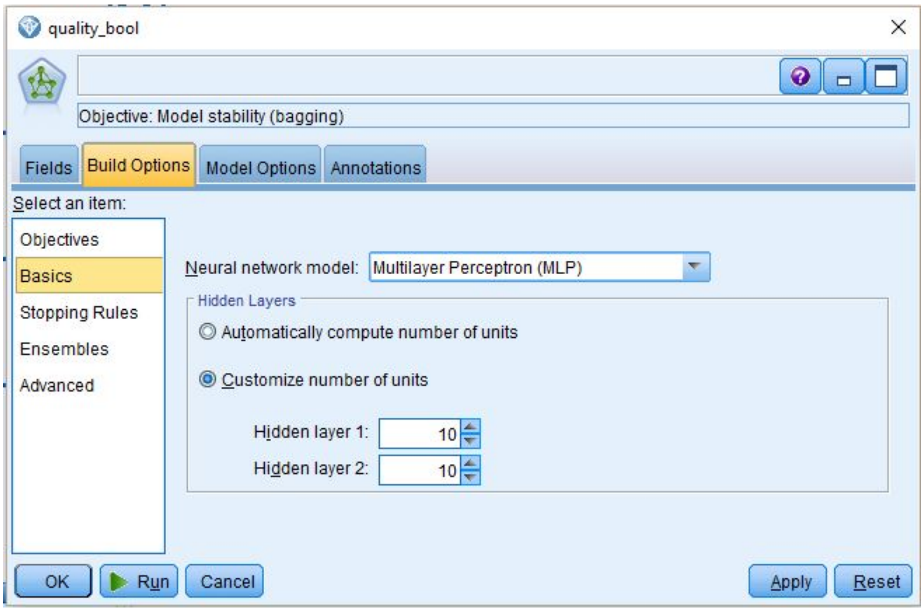
What is your main objective?

○ Create a standard model

○ Enhance model accuracy (boosting)

● Enhance model stability (bagging)

Abbildung 15: Part one of Neural Net settings



quality_bool

Objective: Model stability (bagging)

Neural network model: Multilayer Perceptron (MLP)

Hidden Layers

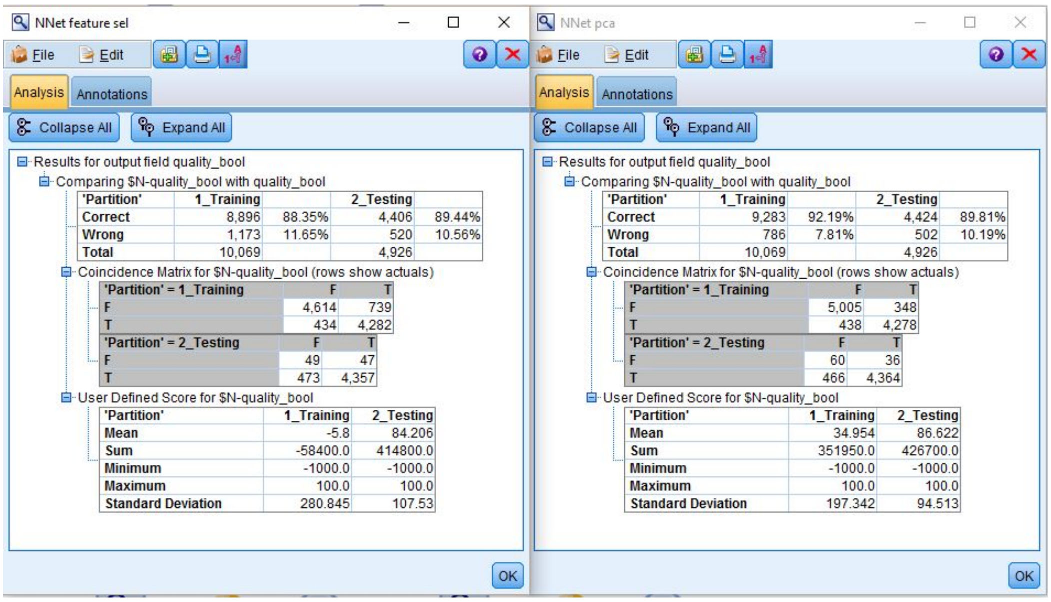
○ Automatically compute number of units

● Customize number of units

Hidden layer 1: 10

Hidden layer 2: 10

Abbildung 16: Part two of Neural Net settings



NNet feature sel

Results for output field quality_bool

Comparing $N-quality_bool with quality_bool

'Partition'	1_Training		2_Testing	
Correct	8,896	88.35%	4,406	89.44%
Wrong	1,173	11.65%	520	10.56%
Total	10,069		4,926	

Coincidence Matrix for $N-quality_bool (rows show actuals)

'Partition' = 1_Training	F	T
F	4,614	739
T	434	4,282

'Partition' = 2_Testing	F	T
F	49	47
T	473	4,357

User Defined Score for $N-quality_bool

'Partition'	1_Training	2_Testing
Mean	-5.8	84.206
Sum	-58400.0	414800.0
Minimum	-1000.0	-1000.0
Maximum	100.0	100.0
Standard Deviation	280.845	107.53

NNet pca

Results for output field quality_bool

Comparing $N-quality_bool with quality_bool

'Partition'	1_Training		2_Testing	
Correct	9,283	92.19%	4,424	89.81%
Wrong	786	7.81%	502	10.19%
Total	10,069		4,926	

Coincidence Matrix for $N-quality_bool (rows show actuals)

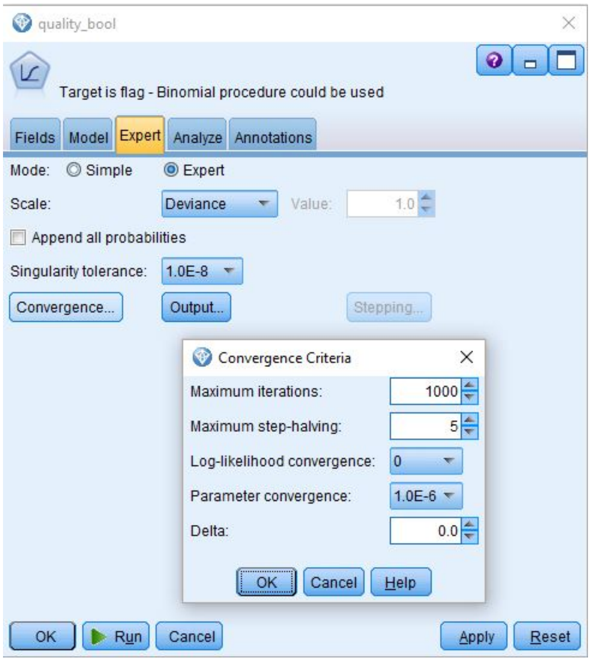
'Partition' = 1_Training	F	T
F	5,005	348
T	438	4,278

'Partition' = 2_Testing	F	T
F	60	36
T	466	4,364

User Defined Score for $N-quality_bool

'Partition'	1_Training	2_Testing
Mean	34.954	86.622
Sum	351950.0	426700.0
Minimum	-1000.0	-1000.0
Maximum	100.0	100.0
Standard Deviation	197.342	94.513

Abbildung 17: Neural Net with *Feature Selection* compared to *PAC*



Target is flag - Binomial procedure could be used

Mode: ○ Simple ● Expert

Scale: Deviance Value: 1.0

□ Append all probabilities

Singularity tolerance: 1.0E-8

Convergence... Output...

Convergence Criteria

Maximum iterations: 1000

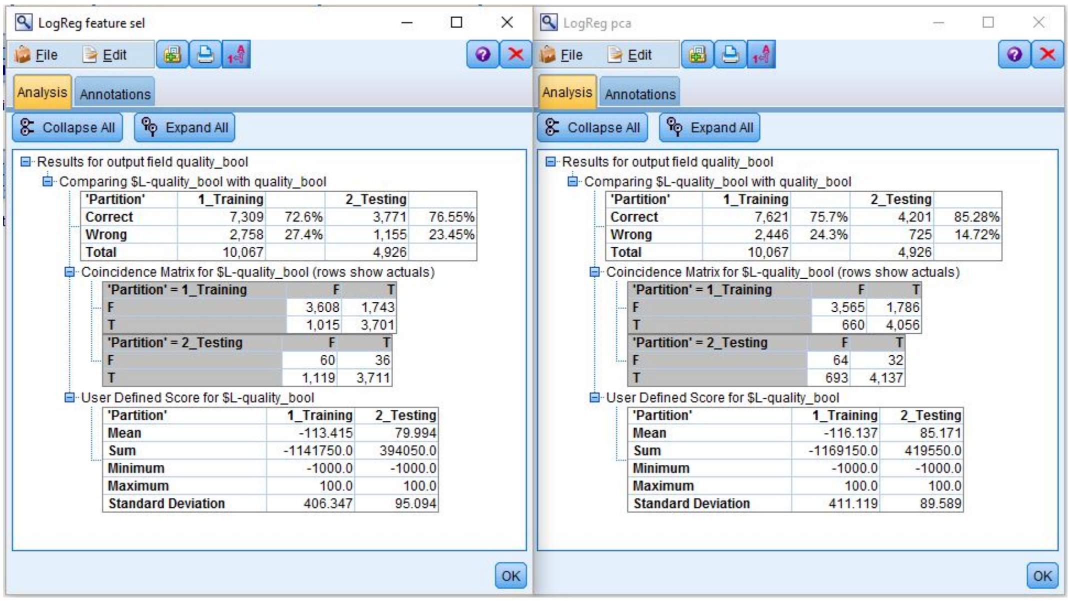
Maximum step-halving: 5

Log-likelihood convergence: 0

Parameter convergence: 1.0E-6

Delta: 0.0

Abbildung 18: Logistic Regression Settings



LogReg feature sel

Results for output field quality_bool

Comparing $L-quality_bool with quality_bool

'Partition'	1_Training		2_Testing	
Correct	7,309	72.6%	3,771	76.55%
Wrong	2,758	27.4%	1,155	23.45%
Total	10,067		4,926	

Coincidence Matrix for $L-quality_bool (rows show actuals)

'Partition' = 1_Training	F	T
F	3,608	1,743
T	1,015	3,701
'Partition' = 2_Testing	**F**	**T**
F	60	36
T	1,119	3,711

User Defined Score for $L-quality_bool

'Partition'	1_Training	2_Testing
Mean	-113.415	79.994
Sum	-1141750.0	394050.0
Minimum	-1000.0	-1000.0
Maximum	100.0	100.0
Standard Deviation	406.347	95.094

LogReg pca

Results for output field quality_bool

Comparing $L-quality_bool with quality_bool

'Partition'	1_Training		2_Testing	
Correct	7,621	75.7%	4,201	85.28%
Wrong	2,446	24.3%	725	14.72%
Total	10,067		4,926	

Coincidence Matrix for $L-quality_bool (rows show actuals)

'Partition' = 1_Training	F	T
F	3,565	1,786
T	660	4,056
'Partition' = 2_Testing	**F**	**T**
F	64	32
T	693	4,137

User Defined Score for $L-quality_bool

'Partition'	1_Training	2_Testing
Mean	-116.137	85.171
Sum	-1169150.0	419550.0
Minimum	-1000.0	-1000.0
Maximum	100.0	100.0
Standard Deviation	411.119	89.589

Abbildung 19: Logistic regression with *Feature Selection* compared to *PAC*

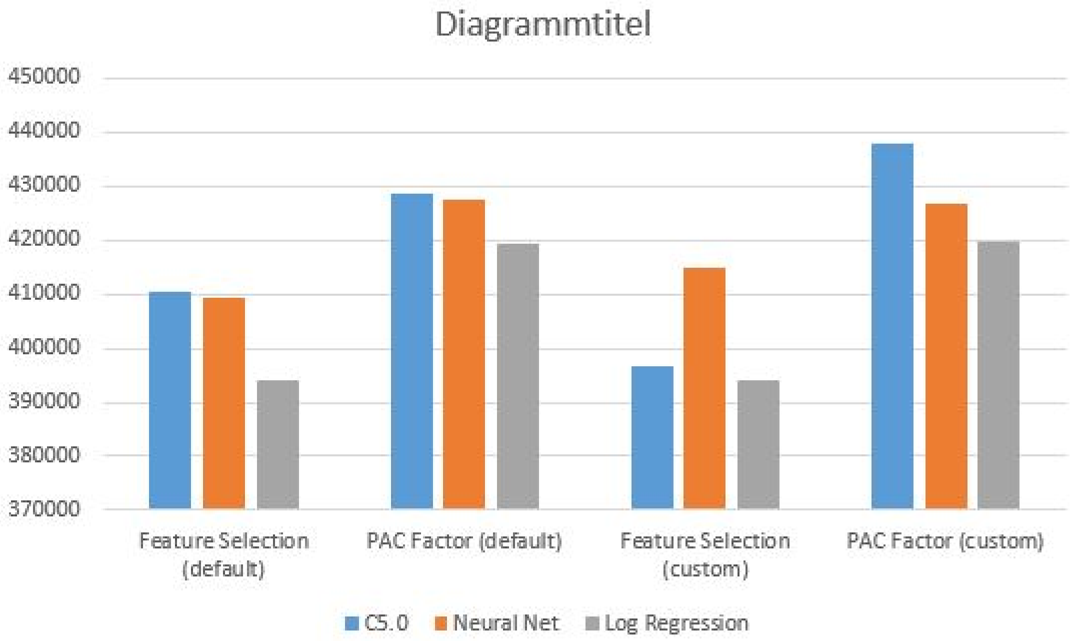


Abbildung 20: All results of the experiments in a table