October 20, 2021 - cascad#210

Execution Report

Title: **The Fairness of Credit Scoring Models**

Authors: **Christophe Hurlin, Christophe Pérignon and Sébastien Saurin**

Full reference: Hurlin, Christophe, Pérignon, Christophe, and Saurin, Sébastien, "The Fairness of Credit Scoring Models" Working paper, October 20, 2021.

The structure and contents of this execution report provided by **cascad** for the certification are similar to those recommended by the AEA Data Editor.

1. DATA DESCRIPTION

This study uses the the German Credit Dataset (Dua and Gra (2019)), which includes 1,000 consumer loans extended to respectively 310 women and 690 men. This dataset can be downloaded here: https://archive.ics.uci.edu/ml/datasets/statlog+(german+credit+data) All the variables used in the model are described in Tables 5 and 6 in the article.

2. CODE DESCRIPTION

For the purpose of this certification, we aimed to check the results displayed in Figures 2-10 and in Tables 1-4.

There are eleven files in the replication package:

1. GermanDataset.data: Database used in the paper.

2. Fairness_func.py: Python file including functions used to implement fairness tests and Fairness Partial Dependence Plots (FPDP)

3. KPrototypes.py: Python file used to create classes of individuals having similar characteristics according to KPrototype method.

4. Data_management.py: Python file used to manage the database to estimate models and apply the framework.

5. Modelisation_no_gender.py: Python file used to estimate all models excluding the gender variable from the list of explanatory variables.

6. Modelisation_gender.py: Python file used to estimate all models including the gender variable in the list of explanatory variables.

7. Workspace.py: Python file used to save (restore) environment variables in (from) an external file of format "variables day-month-year.out". For example: "variables 01-01-2021.out" for the following date: January 1st of 2021.

8. package_version.py: Python file used to save in an Excel file "packages_version.xlsx" all the packages used in the code as well as their python version.

9. Tables.py: Python file used to produce a LaTeX file of format "All_figures-day-month-year.out" with all the figures (except Table 7) of the paper from the results obtained with the other files. This file is also converted in pdf and read directly from this python code.

10. Execute.py: Python file used to run all the previously mentioned files.

11. packages_version.xlsx: Excel file including all python packages version used to reproduce the results of the paper.

3. REPLICATION STEPS

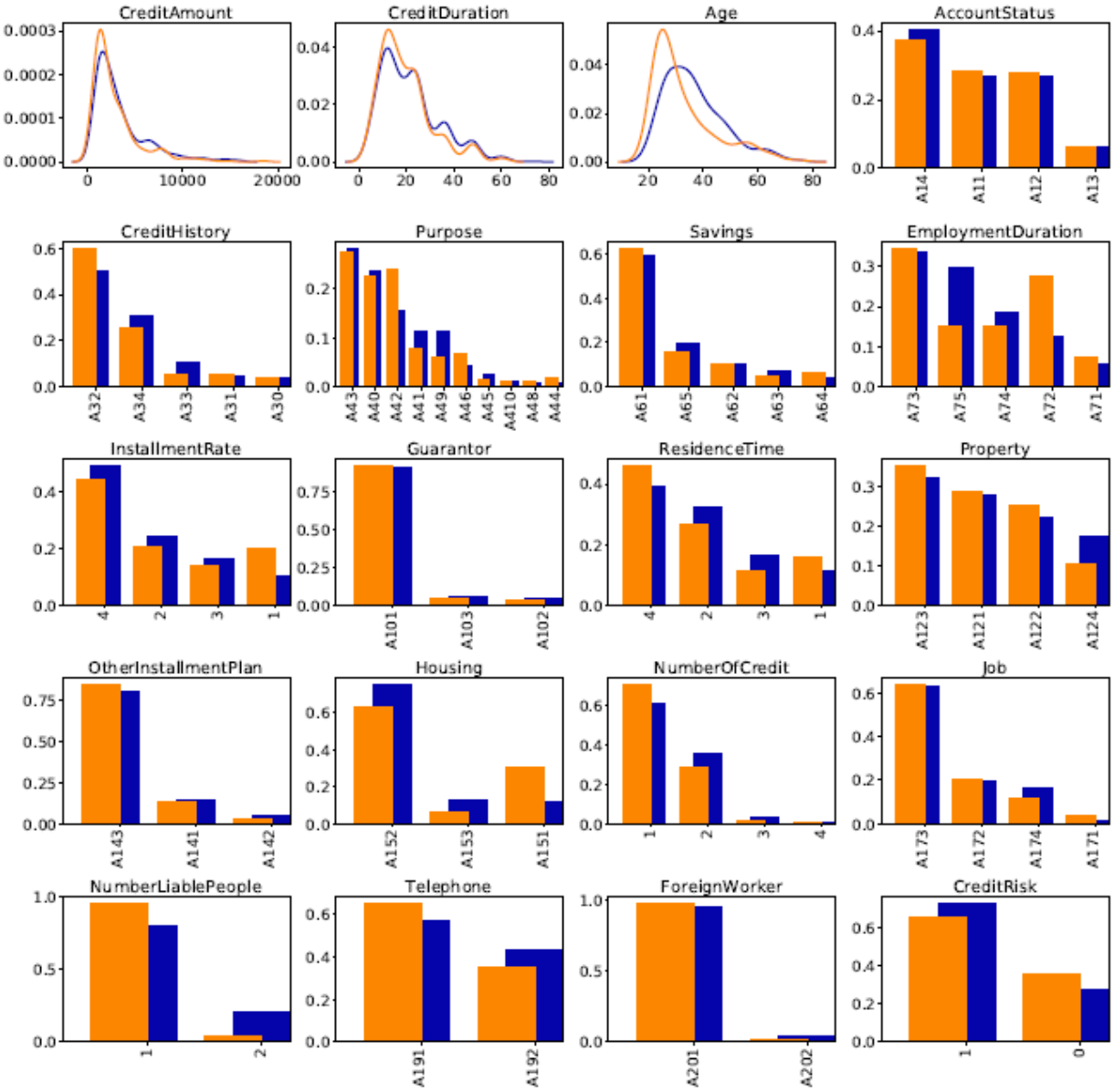
The replication material, using Python 3.8 with the latest Anaconda distribution (2021.05) on a computer with 64GB RAM, intel® Core™ i9-9900K CPU @3.60-5.00GHz, Nvidia Geforce RTX 2060, and Windows 10 OS. We encountered no issues during the replication.

4. FINDINGS

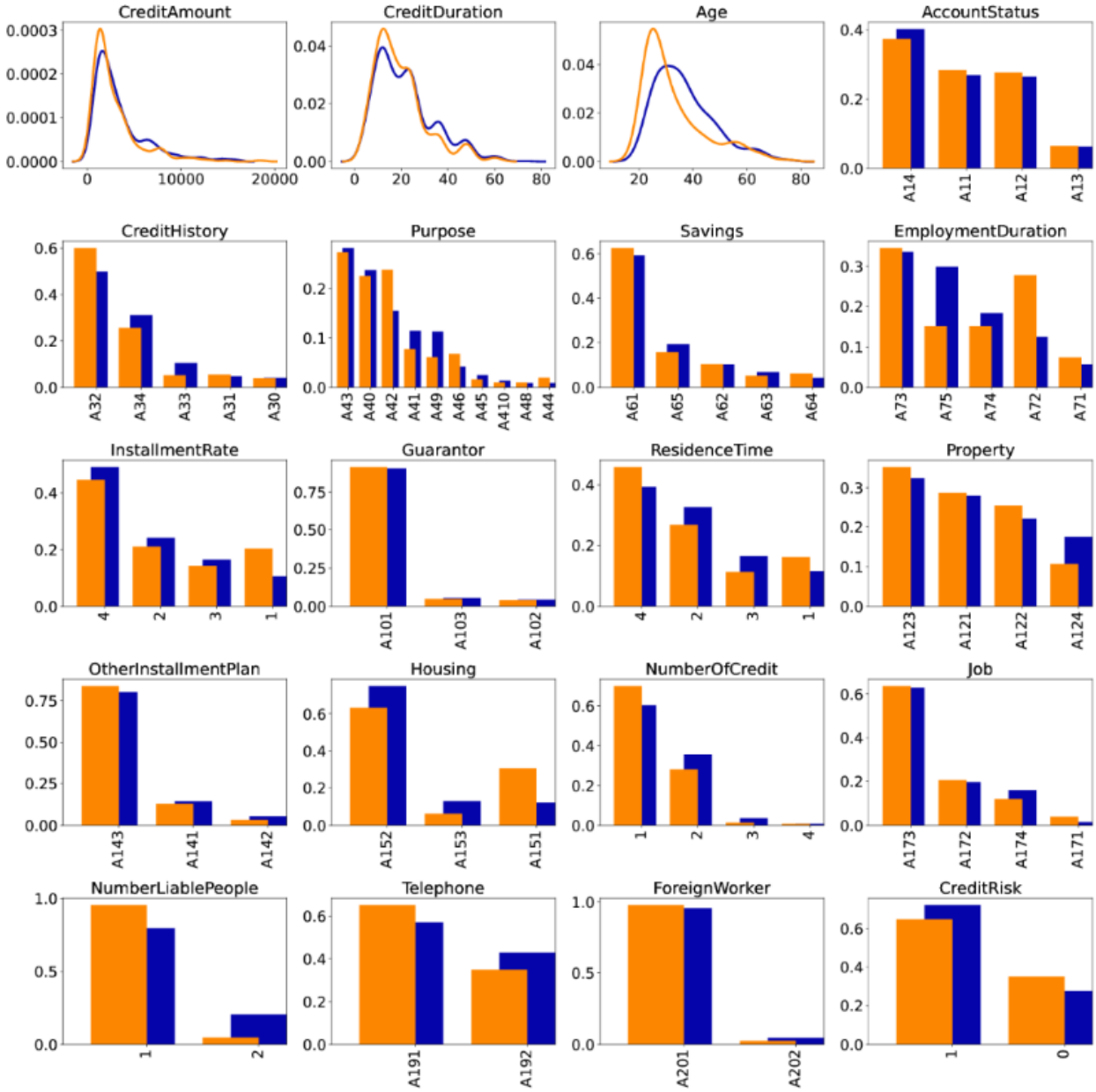
We reproduced all tables and figures with perfect accuracy.

4.1. FIGURE 2: FEATURE DISTRIBUTIONS

Original:

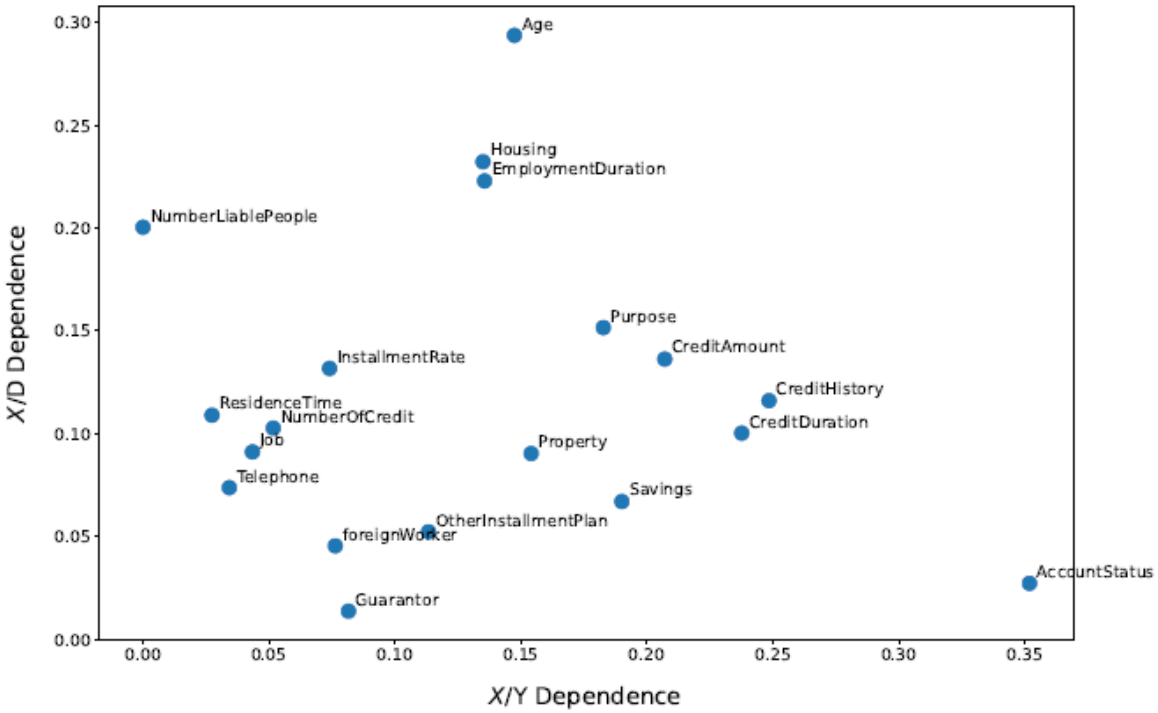


Reproduced:

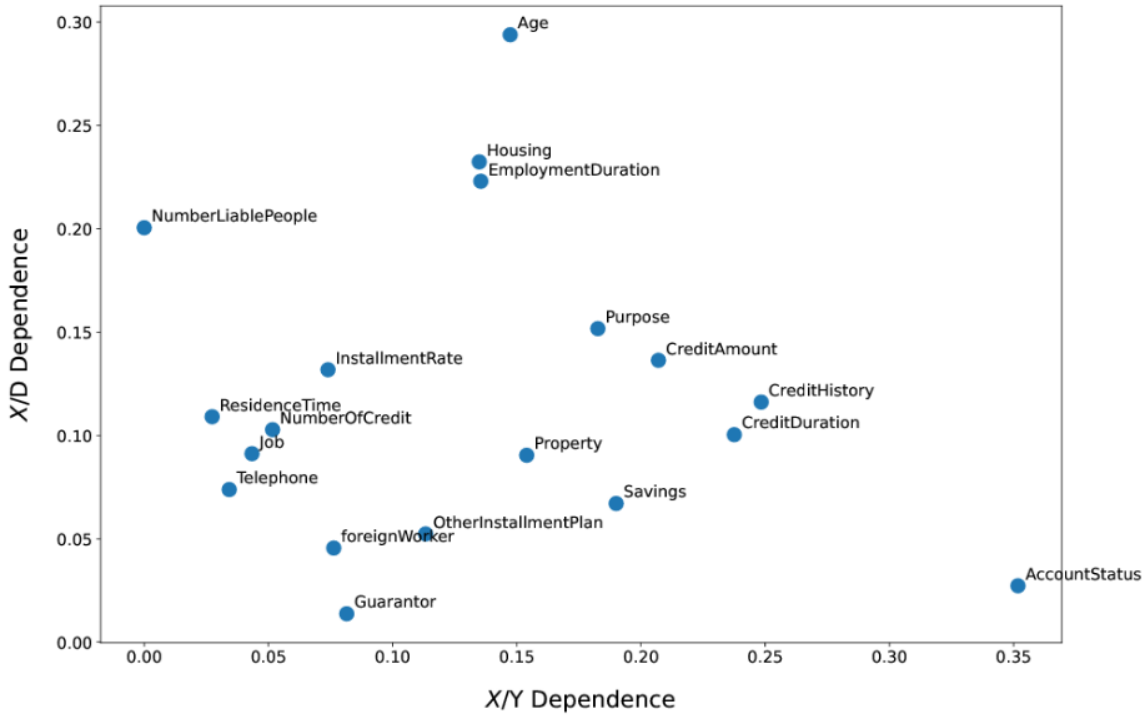

CreditAmount
CreditDuration
Age
AccountStatus
CreditHistory
Purpose
Savings
EmploymentDuration
InstallmentRate
Guarantor
ResidenceTime
Property
OtherInstallmentPlan
Housing
NumberOfCredit
Job
NumberLiablePeople
Telephone
ForeignWorker
CreditRisk

4.2. FIGURE 3: MEASURES OF ASSOCIATION BETWEEN FEATURES, TARGET VARIABLES, AND GENDER

Original:

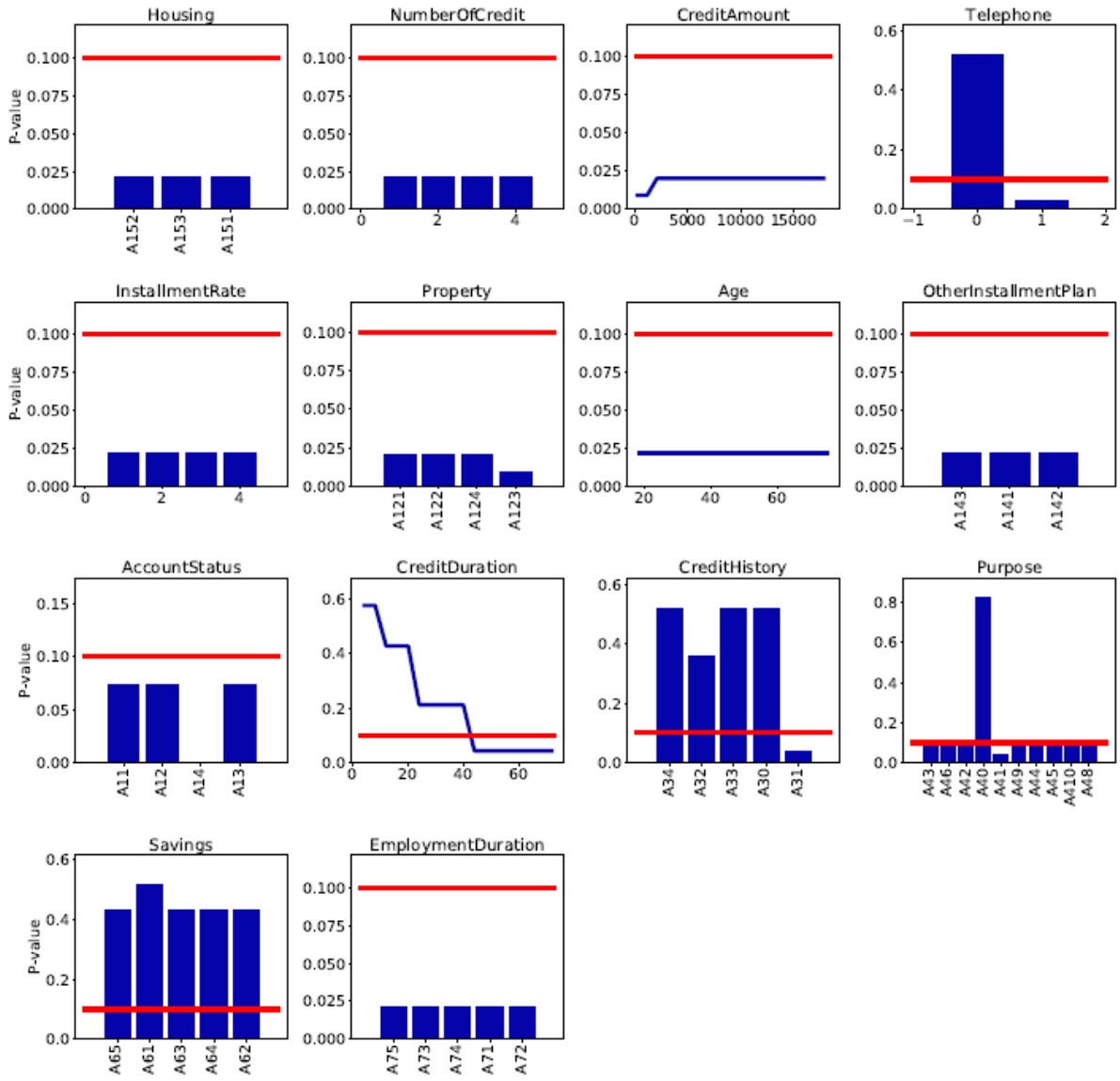


Reproduced:

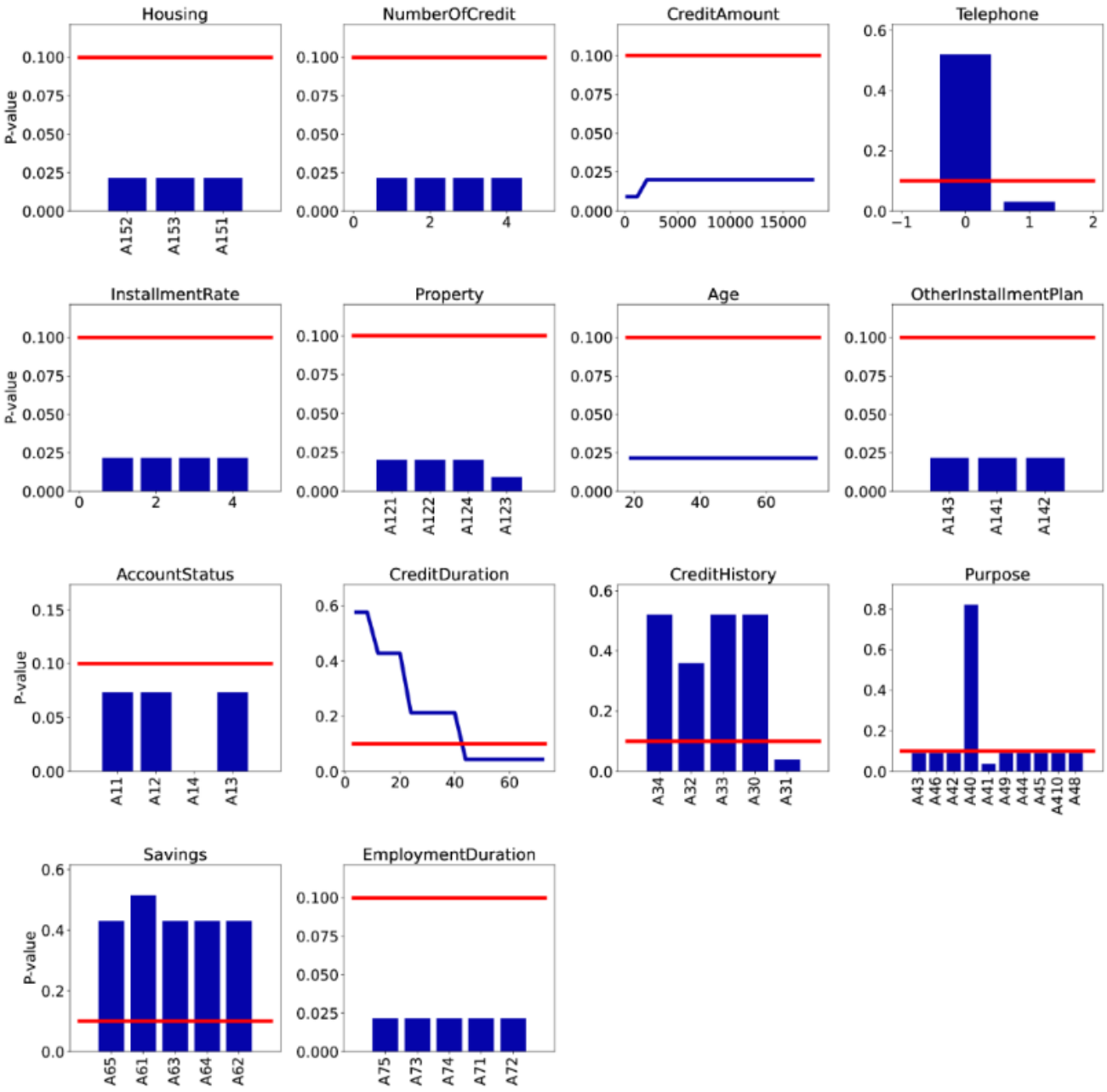


4.3. FIGURE 4: FAIRNESS PDP FOR THE STATISTICAL PARITY IN TREE PRIME MODEL

Original:

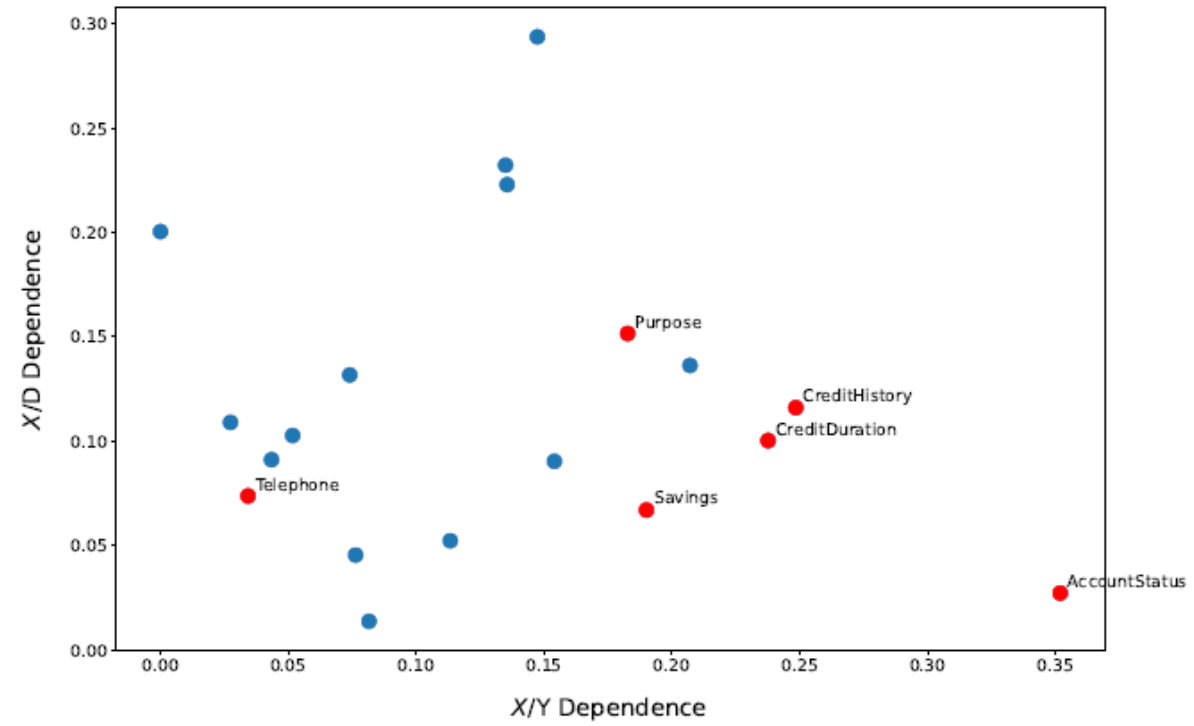


Reproduced:

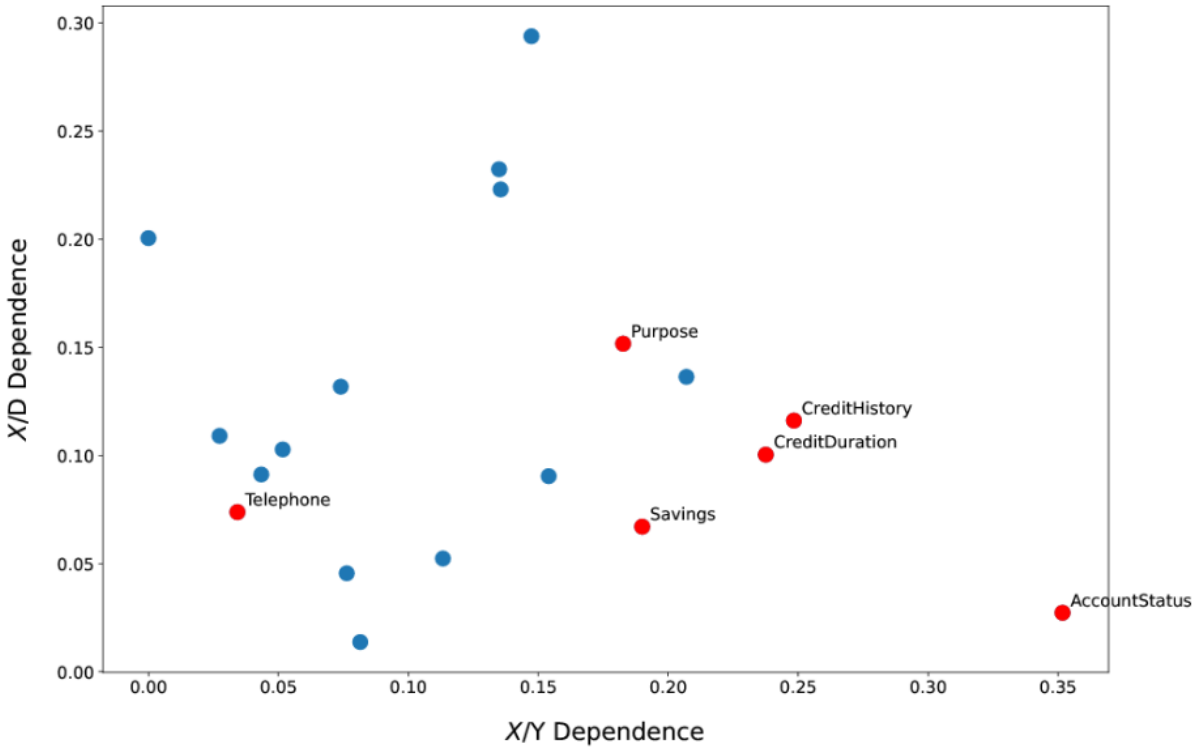

Housing
NumberOfCredit
CreditAmount
Telephone
InstallmentRate
Property
Age
OtherInstallmentPlan
AccountStatus
CreditDuration
CreditHistory
Purpose
Savings
EmploymentDuration
P-value

4.4. FIGURE 5: MEASURES OF ASSOCIATION BETWEEN FEATURES, TARGET VARIABLES, AND GENDER

Original:



Reproduced:



4.5. TABLE 1: MODEL PERFORMANCES WITH AND WITHOUT THE PROTECTED FEATURE

Original:

Panel A: Models with gender							
	LR	LR (Ridge)	TREE	RF	XGB	SVM	ANN
PCC	77.4	76.6	77.3	87.3	81.3	78.2	79.1
AUC	0.8279	0.8268	0.8266	0.938	0.8877	0.8107	0.8341
Panel B: Models without gender							
	LR	LR (Ridge)	TREE	RF	XGB	SVM	ANN
PCC	77.2	76.7	81.5	87.4	79.6	76.0	81.1
AUC	0.8264	0.8200	0.8866	0.9372	0.8261	0.8059	0.8754

Reproduced:

Panel A: Models with gender							
	LR	LR (Ridge)	TREE	RF	XGB	SVM	ANN
PCC	77.4	76.6	77.3	87.3	81.3	78.2	79.1
AUC	0.8279	0.8268	0.8266	0.938	0.8877	0.8107	0.8341
Panel B: Models without gender							
	LR	LR (Ridge)	TREE	RF	XGB	SVM	ANN
PCC	77.2	76.7	81.5	87.4	79.6	76.0	81.1
AUC	0.8264	0.82	0.8866	0.9372	0.8261	0.8059	0.8754

4.6. TABLE 2: FAIRNESS TESTS FOR MODELS WITH GENDER

Original:

	LR	Ridge	TREE	RF	XGB	SVM	ANN
Statistical parity	0.0003*	0.0001*	0.0097*	0.0349*	0.0000*	0.0041*	0.0041*
Cond. parity Group 1	0.0003*	0.0000*	0.0035*	0.0214*	0.0000*	0.0008*	0.0036*
Cond. parity Group 2	0.0719	0.0986	0.4909	0.3226	0.0331*	0.3223	0.0395*
Cond. parity (global)	0.0003*	0.0000*	0.0110*	0.0434*	0.0000*	0.0022*	0.0017*
Equal odds	0.0185*	0.0039*	0.2387	0.8220	0.0004*	0.1436	0.0802
Equal opportunity	0.0888	0.0344*	0.3012	0.7796	0.0004*	0.1675	0.6554
Predictive equality	0.0242*	0.0100*	0.1801	0.5753	0.0945	0.1598	0.0277*

Reproduced:

	LR	Ridge	TREE	RF	XGB	SVM	ANN
Statistical parity	0.0003*	0.0001*	0.0097*	0.0349*	0.0000*	0.0041*	0.0041*
Cond. parity Group 1	0.0003*	0.0000*	0.0035*	0.0214*	0.0000*	0.0008*	0.0036*
Cond. parity Group 2	0.0719	0.0986	0.4909	0.3226	0.0331*	0.3223	0.0395*
Cond. parity (global)	0.0003*	0.0000*	0.0110*	0.0434*	0.0000*	0.0022*	0.0017*
Equal odds	0.0185*	0.0039*	0.2387	0.8220	0.0004*	0.1436	0.0802
Equal opportunity	0.0888	0.0344*	0.3012	0.7796	0.0004*	0.1675	0.6554
Predictive equality	0.0242*	0.0100*	0.1801	0.5753	0.0945	0.1598	0.0277*

4.7. TABLE 3: FAIRNESS TESTS FOR MODELS WITHOUT GENDER

Original:

	LR	Ridge	TREE	RF	XGB	SVM	ANN
Statistical parity	0.0734	0.1110	0.5310	0.1206	0.0965	0.2913	0.0067*
Cond. parity Group 1	0.0989	0.0304*	0.5950	0.0966	0.0431*	0.1693	0.0072*
Cond. parity Group 2	0.0866	0.6874	0.2130	0.3226	0.3531	0.8506	0.0631
Cond. parity (global)	0.0590	0.0885	0.3998	0.1542	0.0841	0.3821	0.0048*
Equal odds	0.6712	0.4196	0.5645	0.9242	0.7202	0.6754	0.1727
Equal opportunity	0.7746	0.7209	0.8892	0.7796	0.4213	0.5175	0.6602
Predictive equality	0.3977	0.2046	0.2890	0.7783	0.9216	0.5451	0.0685

Reproduced:

	LR	Ridge	TREE	RF	XGB	SVM	ANN
Statistical parity	0.0734	0.1110	0.5310	0.1206	0.0965	0.2913	0.0067*
Cond. parity Group 1	0.0989	0.0304*	0.5950	0.0966	0.0431*	0.1693	0.0072*
Cond. parity Group 2	0.0866	0.6874	0.2130	0.3226	0.3531	0.8506	0.0631
Cond. parity (global)	0.0590	0.0885	0.3998	0.1542	0.0841	0.3821	0.0048*
Equal odds	0.6712	0.4196	0.5645	0.9242	0.7202	0.6754	0.1727
Equal opportunity	0.7746	0.7209	0.8892	0.7796	0.4213	0.5175	0.6602
Predictive equality	0.3977	0.2046	0.2890	0.7783	0.9216	0.5451	0.0685

4.8. TABLE 4: FAIRNESS TESTS FOR THE TREE MODELS

Original:

	TREE	TREE-prime	TREE-modif
Statistical parity	0.5310	0.0216*	0.5195
Cond. parity Group 1	0.5950	0.0552	0.7849
Cond. parity Group 2	0.2130	0.0305*	0.0973
Cond. parity (global)	0.3998	0.0153*	0.2438
Equal odds	0.5645	0.0363*	0.3441
Equal opportunity	0.8892	0.0101*	0.4547
Predictive equality	0.2890	0.8852	0.2095
PCC	81.5	79.0	77.8
AUC	0.8866	0.8393	0.8345

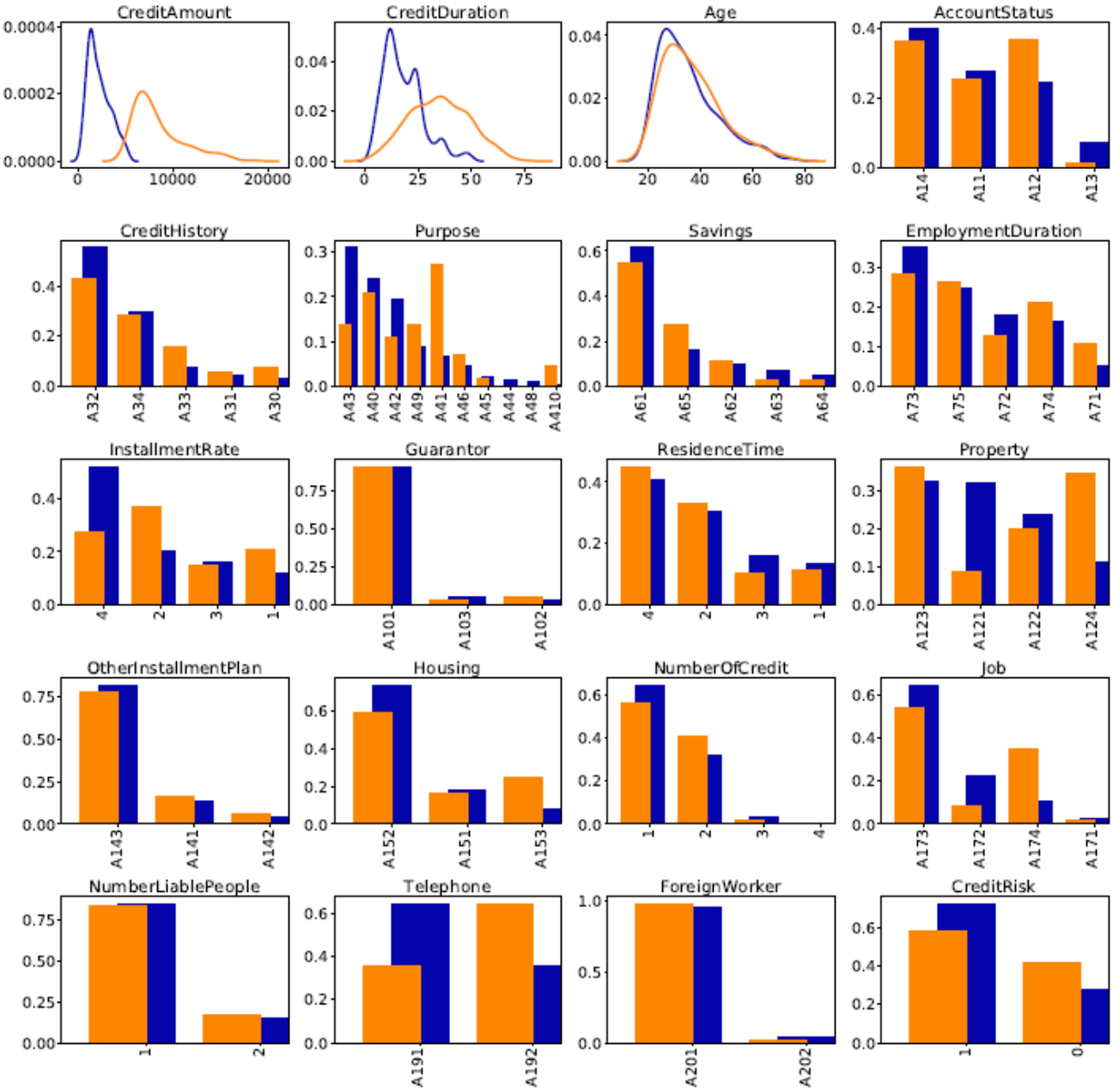
Reproduced:

Table 1: Fairness tests for the TREE models

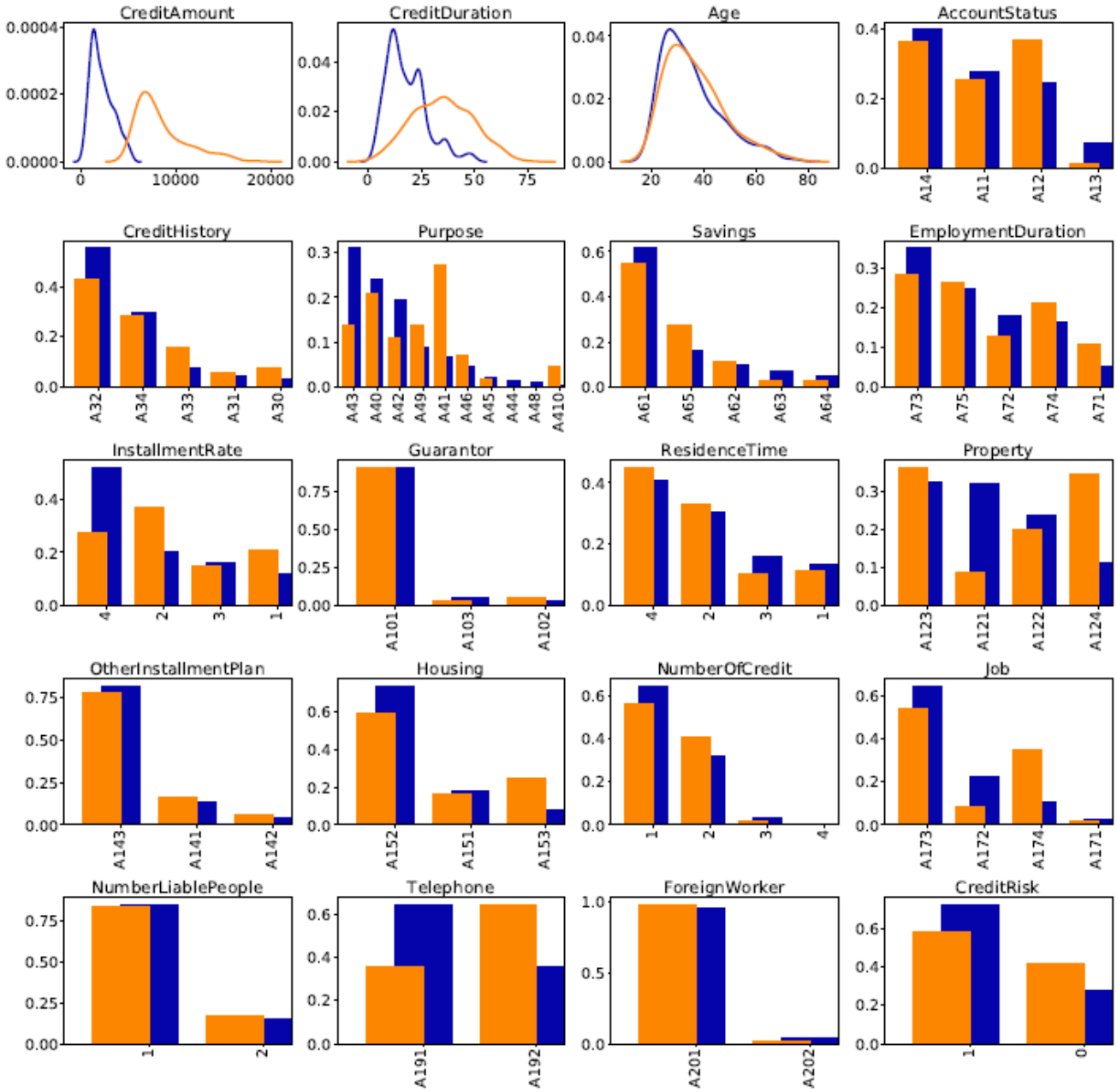
	TREE	TREE-prime	TREE-modif
Statistical parity	0.5310	0.0216*	0.5195
Cond. parity Group 1	0.5950	0.0552	0.7849
Cond. parity Group 2	0.2130	0.0305*	0.0973
Cond. parity (global)	0.3998	0.0153*	0.2438
Equal odds	0.5645	0.0363*	0.3441
Equal opportunity	0.8892	0.0101*	0.4547
Predictive equality	0.2890	0.8852	0.2095
PCC	81.5	79.0	77.8
AUC	0.8866	0.8393	0.8345

4.9. FIGURE 6: FEATURE DISTRIBUTION BY CLASS OF RISK

Original:

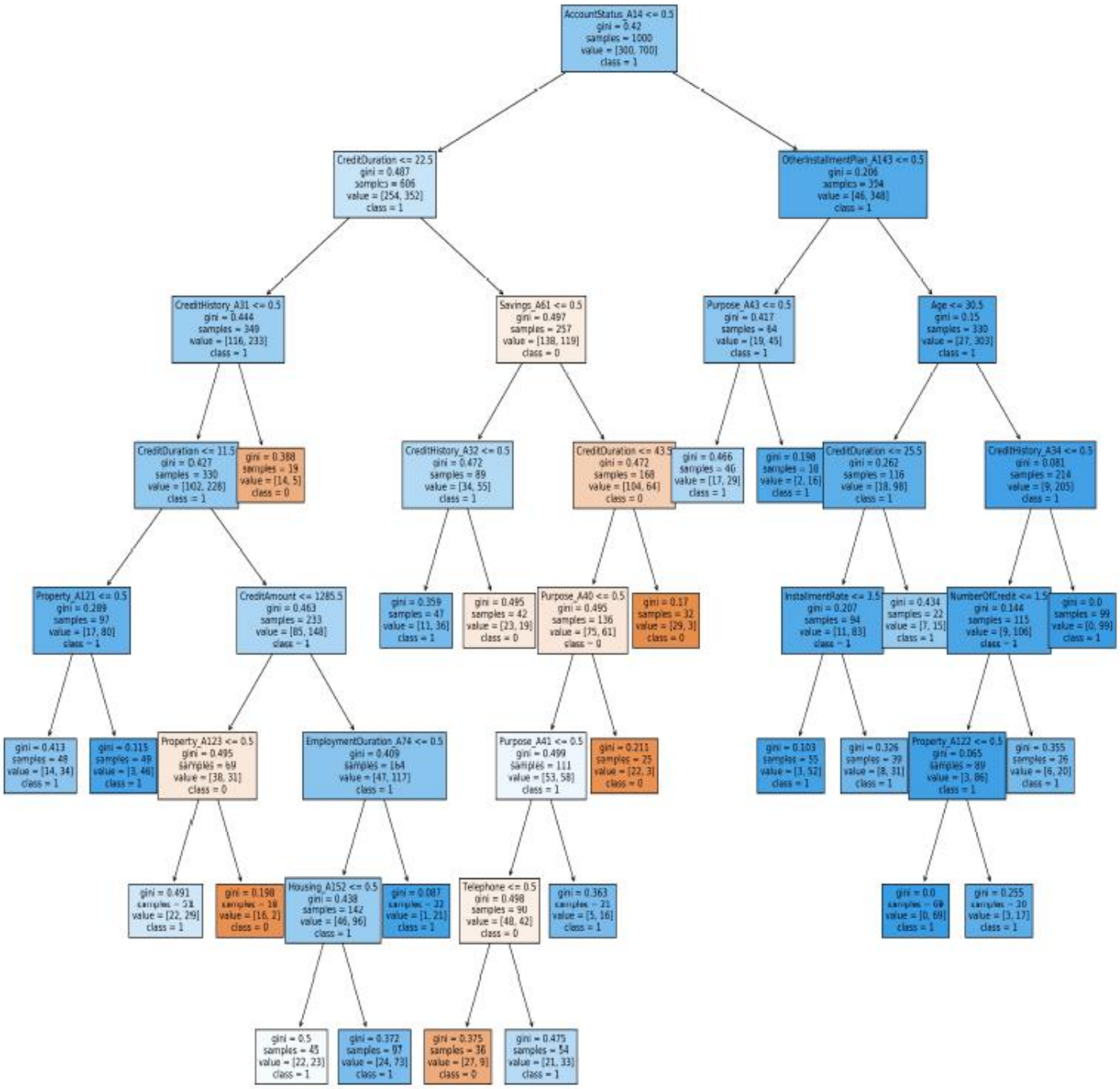


Reproduced:

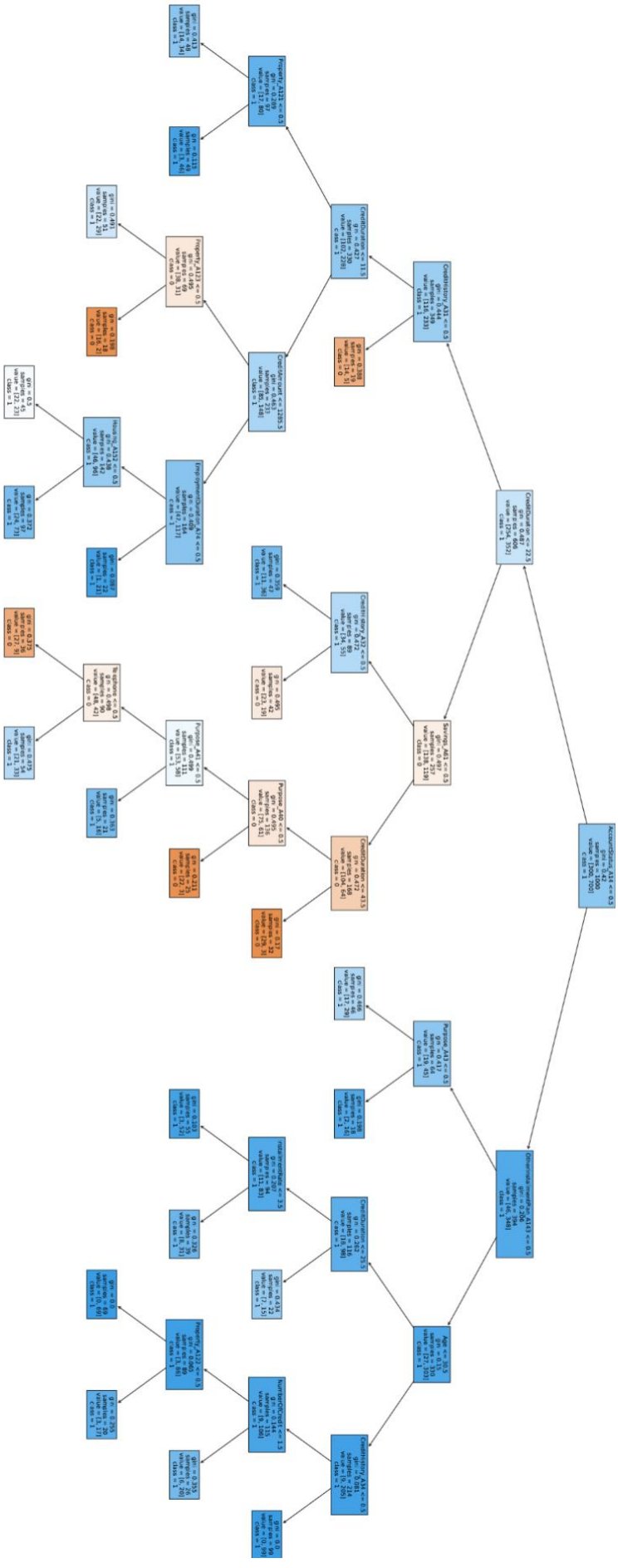

CreditAmount
CreditDuration
Age
AccountStatus
CreditHistory
Purpose
Savings
EmploymentDuration
InstallmentRate
Guarantor
ResidenceTime
Property
OtherInstallmentPlan
Housing
NumberOfCredit
Job
NumberLiablePeople
Telephone
ForeignWorker
CreditRisk

4.10. FIGUREA.4 DECISION TREE

Original:

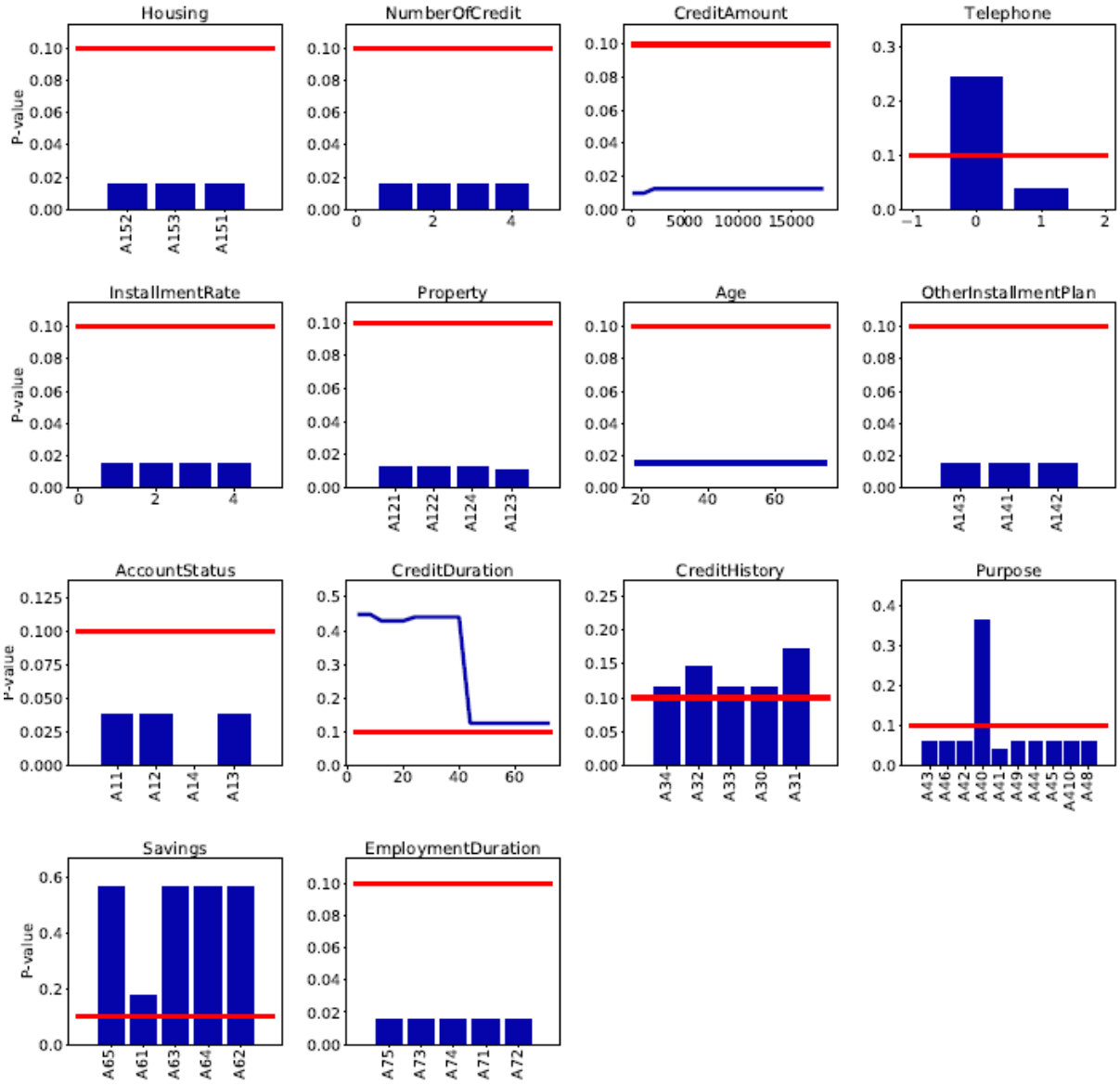


Reproduced:

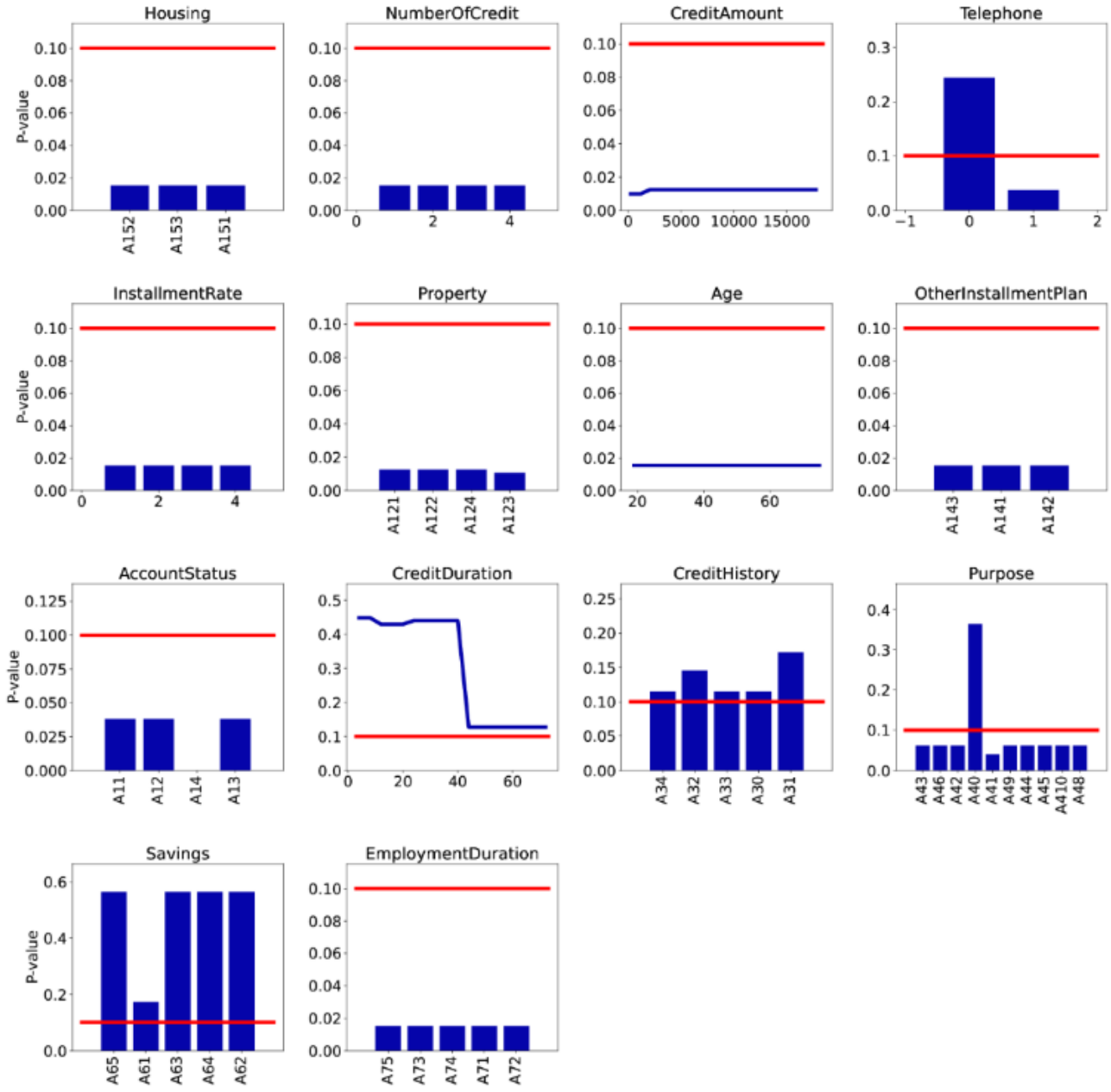


4.11. FIGURE 8: FAIRNESS PDP FOR CONDITIONAL STATISTICAL PARITY IN TREE PRIME MODEL

Original:

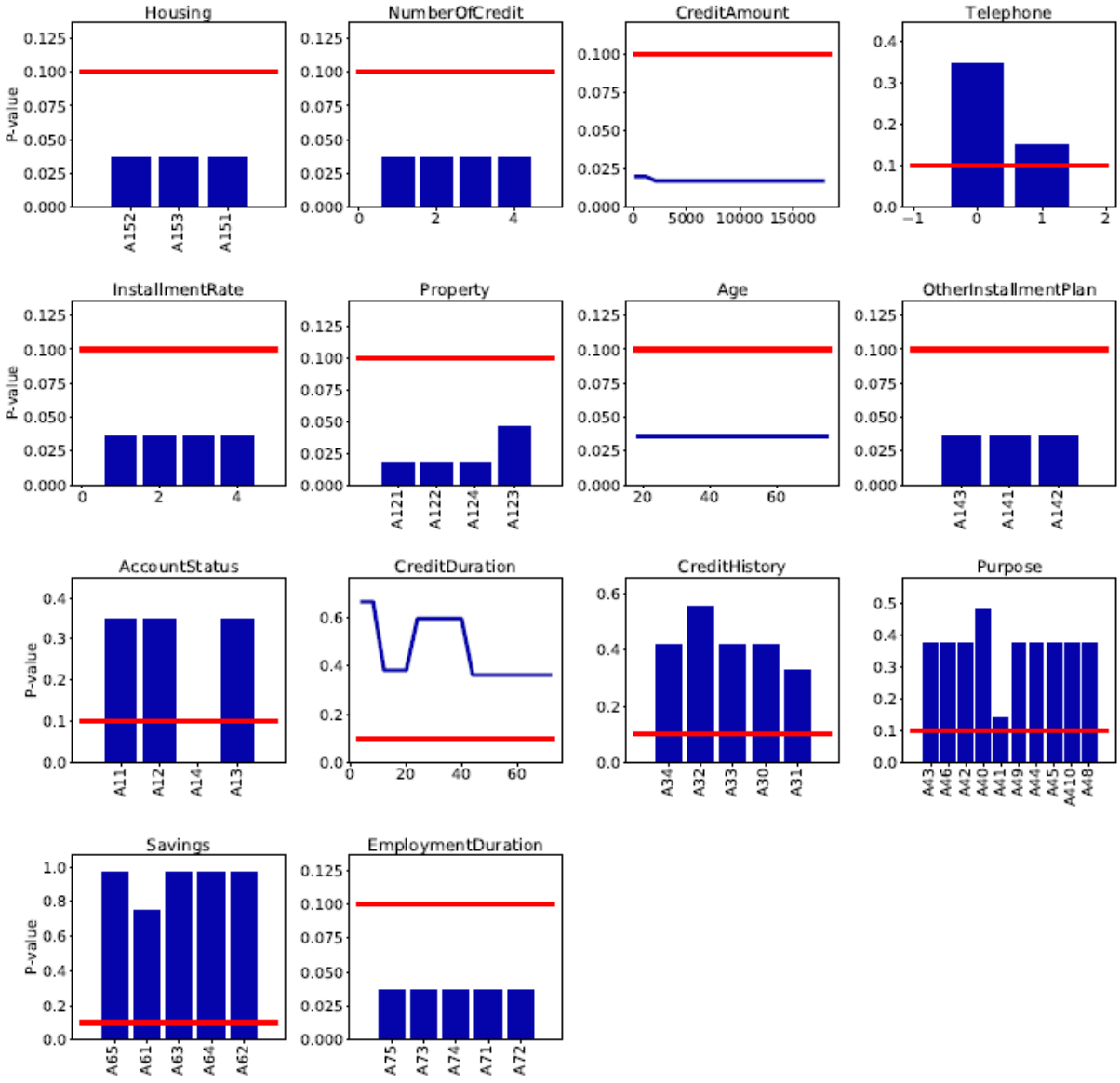


Reproduced:

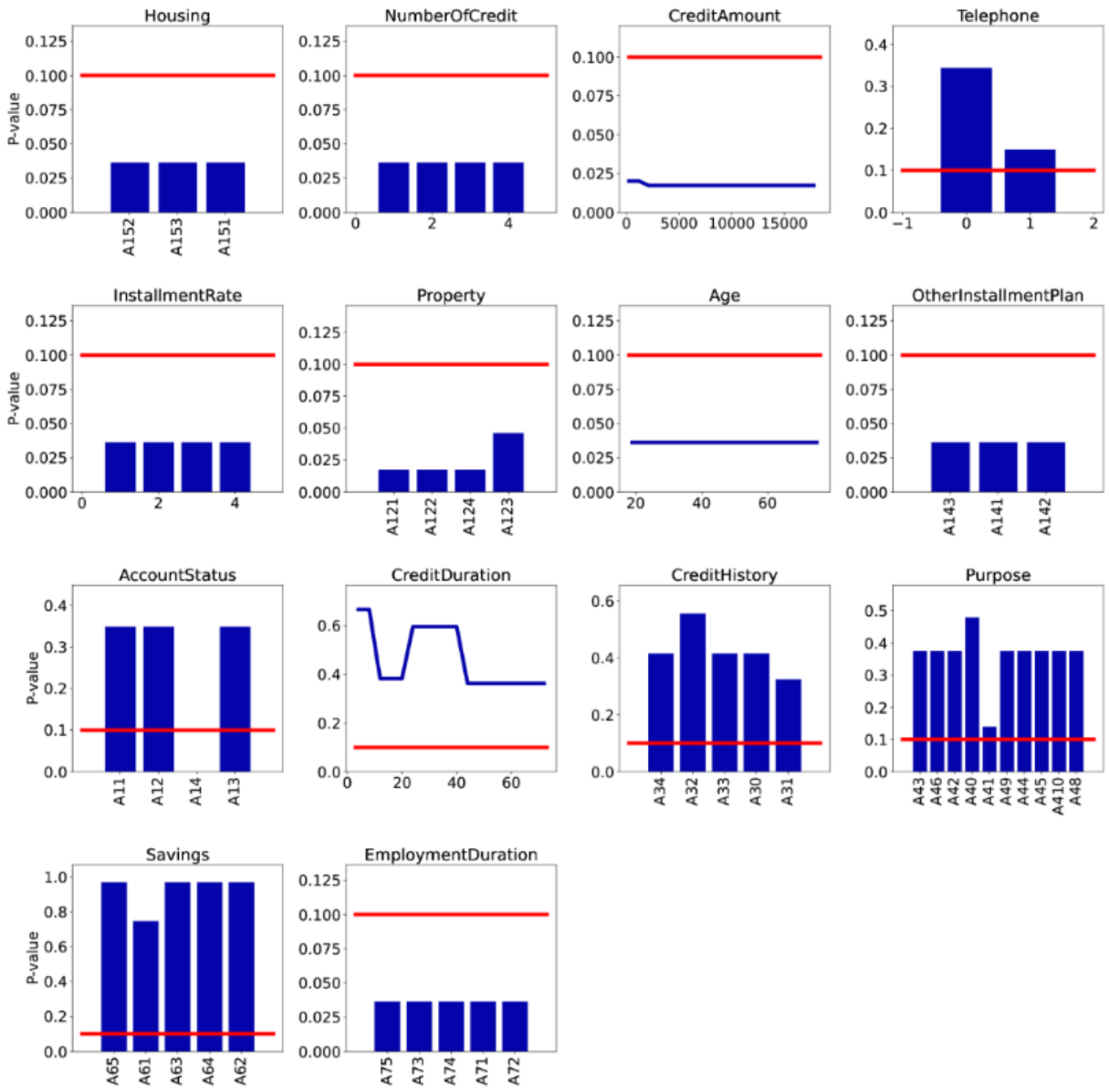

Housing
NumberOfCredit
CreditAmount
Telephone
InstallmentRate
Property
Age
OtherInstallmentPlan
AccountStatus
CreditDuration
CreditHistory
Purpose
Savings
EmploymentDuration
P-value

4.12. FIGURE 9: FAIRNESS PDP FOR EQUAL ODDS IN TREE PRIME MODEL

Original:

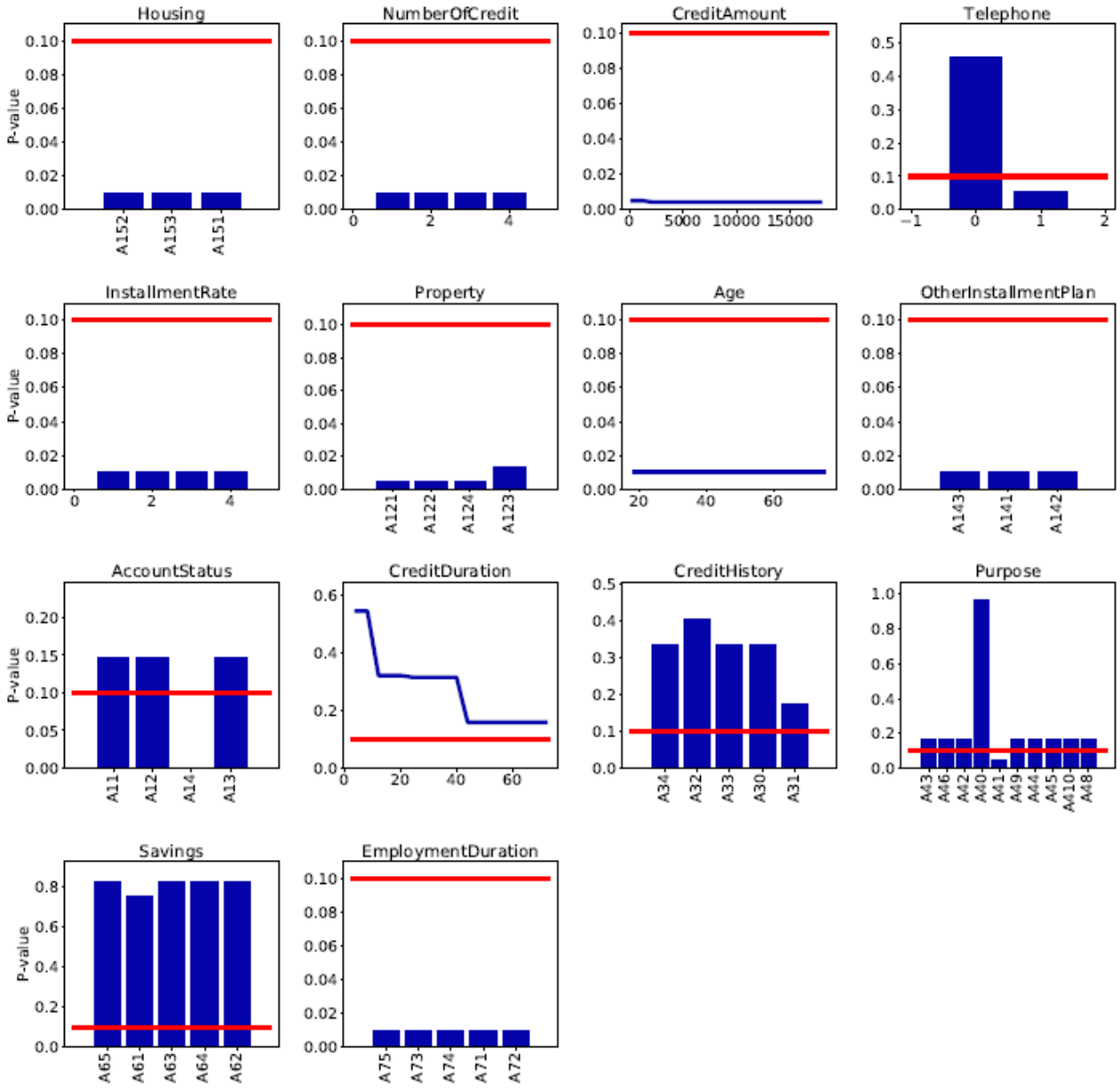


Reproduced:


Housing
NumberOfCredit
CreditAmount
Telephone
InstallmentRate
Property
Age
OtherInstallmentPlan
AccountStatus
CreditDuration
CreditHistory
Purpose
Savings
EmploymentDuration
P-value

4.13. FIGURE 10: FAIRNESS PDP FOR EQUAL OPPORTUNITY IN TREE PRIME MODEL

Original:



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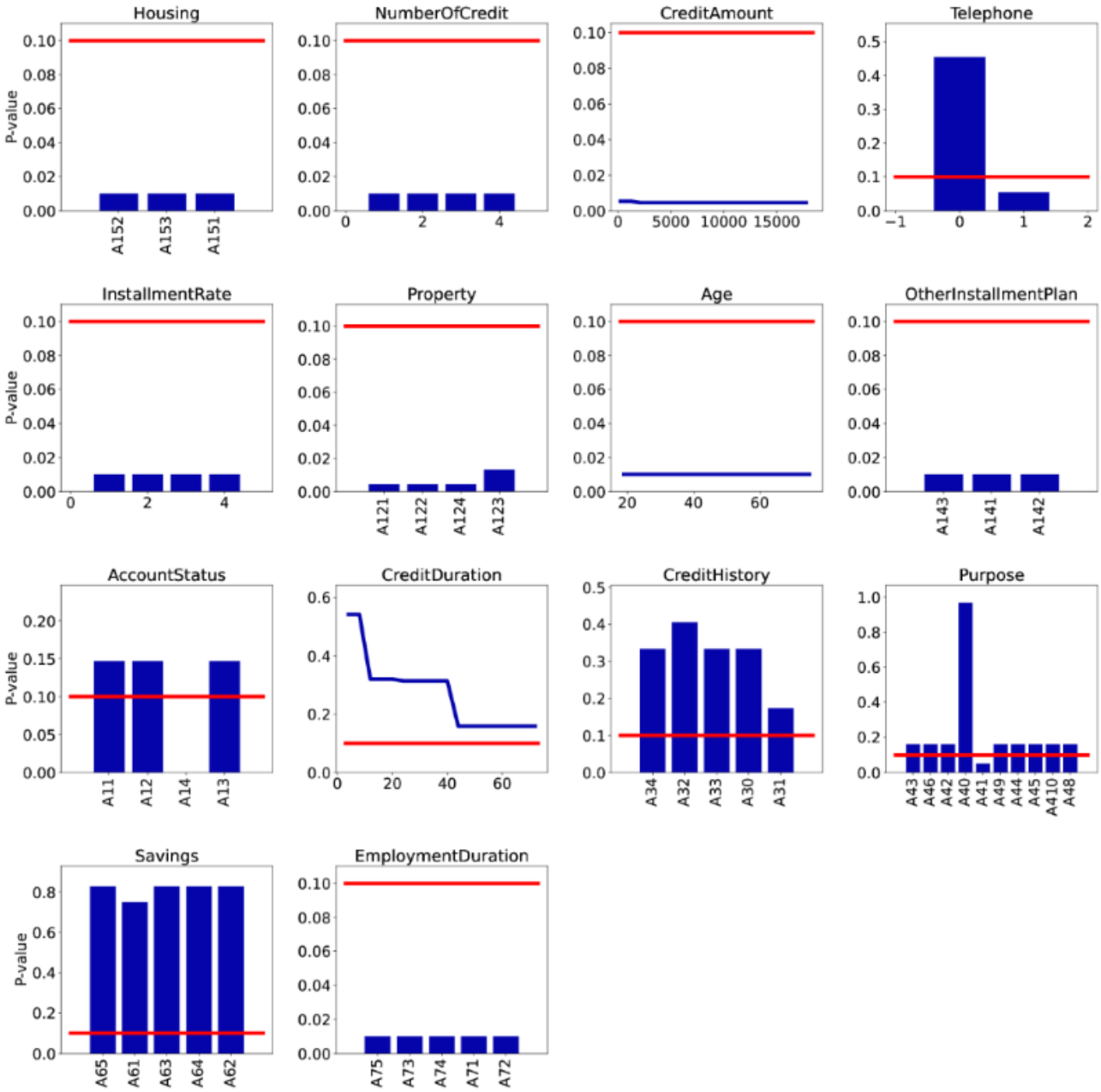
Housing
NumberOfCredit
CreditAmount
Telephone
InstallmentRate
Property
Age
OtherInstallmentPlan
AccountStatus
CreditDuration
CreditHistory
Purpose
Savings
EmploymentDuration
P-value