Generalized Linear Models

Logit Models

In [61]:

```
import pandas as pd
import seaborn as sns
from statsmodels.formula.api import logit, glm
import statsmodels.api as sm

from plotnine import *

# import data set, set directory
home_dir = "/home/tobias_giesemann/Dropbox/Uni_Master/02SS19/01Advanced_Statistical_Modelling/Essay/"

# using pandas dataframe as a similar data structure to R dataframes
allbus_df = pd.read_csv(home_dir+"data/allbus_full.csv")
print("full data set: ", allbus_df.shape)
allbus_df = allbus_df[["eastwest","sex","age","lt15"]]
allbus_df.contacts = allbus_df.lt15
allbus_df["any_contact"] = 0
allbus_df.loc[allbus_df.contacts >0, "any_contact"] = 1

print(allbus_df.contacts.unique())
print(allbus_df.any_contact.unique())


#show head
allbus_df.head()
```

```
full data set:  (3490, 793)
[nan  1.  2.  4.  3.  6.  5.  9.  8. 12.  7. 18. 11. 10.]
[0 1]
```

```
/home/tobias_giesemann/.local/lib/python3.6/site-packages/ipykernel_launcher.py:16: UserWarning: Pandas doesn't allow column
s to be created via a new attribute name - see https://pandas.pydata.org/pandas-docs/stable/indexing.html#attribute-access
  app.launch_new_instance()
```

Out[61]:

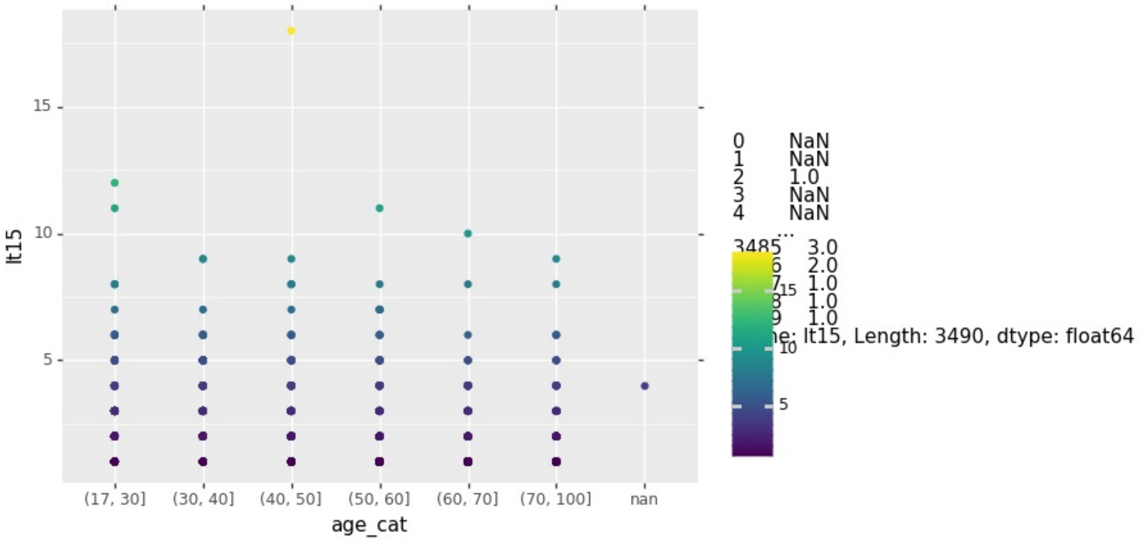
	eastwest	sex	age	lt15	any_contact
0	NEUE BUNDESLAENDER	FRAU	47.0	NaN	0
1	NEUE BUNDESLAENDER	MANN	52.0	NaN	0
2	ALTE BUNDESLAENDER	MANN	61.0	1.0	1
3	ALTE BUNDESLAENDER	FRAU	54.0	NaN	0
4	ALTE BUNDESLAENDER	MANN	71.0	NaN	0

In [58]:

```
allbus_df["age_cat"] = pd.cut(allbus_df.age, [17,30,40,50,60,70,100])

(ggplot(data = allbus_df,
       mapping = aes(x = "age_cat",
                     y = "lt15"))
 +geom_point(mapping=aes(color=allbus_df["lt15"]))
)
```

```
/home/tobias_giesemann/.local/lib/python3.6/site-packages/mizani/bounds.py:352: RuntimeWarning: invalid value encountered in
less
  outside = (x < range[0]) | (x > range[1])
/home/tobias_giesemann/.local/lib/python3.6/site-packages/mizani/bounds.py:352: RuntimeWarning: invalid value encountered in
greater
  outside = (x < range[0]) | (x > range[1])
/home/tobias_giesemann/.local/lib/python3.6/site-packages/matplotlib/colors.py:527: RuntimeWarning: invalid value encountere
d in less
  xa[xa < 0] = -1
/home/tobias_giesemann/.local/lib/python3.6/site-packages/plotnine/layer.py:449: UserWarning: geom_point : Removed 1756 rows
containing missing values.
  self.data = self.geom.handle_na(self.data)
/home/tobias_giesemann/.local/lib/python3.6/site-packages/plotnine/utils.py:553: MatplotlibDeprecationWarning:
The iterable function was deprecated in Matplotlib 3.1 and will be removed in 3.3. Use np.iterable instead.
  return cbook.iterable(var) and not is_string(var)
```



Out[58]:

```
<ggplot: (8771815829859)>
```

Probit Modell

In [79]:

```
# Probit Modell als GLM


probit_model = glm("any_contact ~ age + sex + eastwest", data = allbus_df, family = sm.families.Binomial(link=sm.families.links.probit)).
fit()
print(probit_model.summary())
```

```
                 Generalized Linear Model Regression Results
==============================================================================
Dep. Variable:            any_contact   No. Observations:                 3486
Model:                            GLM   Df Residuals:                     3482
Model Family:                Binomial   Df Model:                            3
Link Function:                 probit   Scale:                          1.0000
Method:                          IRLS   Log-Likelihood:                -2288.8
Date:                Thu, 25 Jul 2019   Deviance:                       4577.6
Time:                        22:18:47   Pearson chi2:                 3.49e+03
No. Iterations:                     5
Covariance Type:            nonrobust
==================================================================================================
                                     coef    std err          z      P>|z|      [0.025      0.975]
--------------------------------------------------------------------------------------------------
Intercept                          0.7664      0.071     10.745      0.000       0.627       0.906
sex[T.MANN]                       -0.0074      0.043     -0.170      0.865      -0.092       0.078
eastwest[T.NEUE BUNDESLAENDER]    -0.5642      0.046    -12.145      0.000      -0.655      -0.473
age                               -0.0114      0.001     -9.150      0.000      -0.014      -0.009
==================================================================================================
```

```
/home/tobias_giesemann/.local/lib/python3.6/site-packages/ipykernel_launcher.py:4: DeprecationWarning: Calling Family(..) wi
th a link class as argument is deprecated.
Use an instance of a link class instead.
  after removing the cwd from sys.path.
```

Logit Modell

In [88]:

```
#selbiges Modell wie oben
logit_model = glm("any_contact ~ age + sex + eastwest", data = allbus_df,
                  family = sm.families.Binomial(link=sm.families.links.logit # or None, da logit default für Binomialfamilie
                                                )).fit()
print(logit_model.summary())

print("Maximal beobachtbare Effekte der Einflussgrößen: \n",0.25*logit_model.params)
print("Multiplikative Effektinterpretation: \n", (np.exp(logit_model.params)-1)*100)

# Margins konnten leider nicht herausgearbeitet werden, da ist die Dokumentation unvollständig,
# allerdings funktioniert es für das logit modell über einen Umweg:

logit_model2 = logit("any_contact ~ age + sex + eastwest", allbus_df).fit()
print(logit_model2.summary())

margins = logit_model2.get_margeff().summary_frame()
print(margins)
```

```
                 Generalized Linear Model Regression Results
==============================================================================
Dep. Variable:            any_contact   No. Observations:                 3486
Model:                            GLM   Df Residuals:                     3482
Model Family:                Binomial   Df Model:                            3
Link Function:                  logit   Scale:                          1.0000
Method:                          IRLS   Log-Likelihood:                -2288.7
Date:                Thu, 25 Jul 2019   Deviance:                       4577.5
Time:                        22:33:19   Pearson chi2:                 3.49e+03
No. Iterations:                     4
Covariance Type:            nonrobust
==================================================================================================
                                     coef    std err          z      P>|z|      [0.025      0.975]
--------------------------------------------------------------------------------------------------
Intercept                          1.2419      0.117     10.651      0.000       1.013       1.470
sex[T.MANN]                       -0.0115      0.070     -0.163      0.871      -0.149       0.126
eastwest[T.NEUE BUNDESLAENDER]    -0.9089      0.076    -12.021      0.000      -1.057      -0.761
age                               -0.0186      0.002     -9.120      0.000      -0.023      -0.015
==================================================================================================
Maximal beobachtbare Effekte der Einflussgrößen: 
 Intercept                         0.310475
sex[T.MANN]                      -0.002864
eastwest[T.NEUE BUNDESLAENDER]   -0.227232
age                              -0.004643
dtype: float64
Multiplikative Effektinterpretation: 
 Intercept                         246.218916
sex[T.MANN]                        -1.139177
eastwest[T.NEUE BUNDESLAENDER]    -59.704452
age                                -1.840169
dtype: float64
Optimization terminated successfully.
         Current function value: 0.656554
         Iterations 5
                           Logit Regression Results
==============================================================================
Dep. Variable:            any_contact   No. Observations:                 3486
Model:                          Logit   Df Residuals:                     3482
Method:                           MLE   Df Model:                            3
Date:                Thu, 25 Jul 2019   Pseudo R-squ.:                 0.05277
Time:                        22:33:20   Log-Likelihood:                -2288.7
converged:                       True   LL-Null:                       -2416.3
Covariance Type:            nonrobust   LLR p-value:                 5.390e-55
==================================================================================================
                                     coef    std err          z      P>|z|      [0.025      0.975]
--------------------------------------------------------------------------------------------------
Intercept                          1.2419      0.117     10.651      0.000       1.013       1.470
sex[T.MANN]                       -0.0115      0.070     -0.163      0.871      -0.149       0.126
eastwest[T.NEUE BUNDESLAENDER]    -0.9089      0.076    -12.021      0.000      -1.057      -0.761
age                               -0.0186      0.002     -9.120      0.000      -0.023      -0.015
==================================================================================================
                                   dy/dx  Std. Err.          z      Pr(>|z|)  \
sex[T.MANN]                    -0.002660   0.016330  -0.162902  8.705953e-01
eastwest[T.NEUE BUNDESLAENDER] -0.211037   0.016105 -13.104195  3.115508e-39
age                            -0.004312   0.000451  -9.559622  1.181875e-21

                                Conf. Int. Low  Cont. Int. Hi.
sex[T.MANN]                          -0.034666        0.029345
eastwest[T.NEUE BUNDESLAENDER]       -0.242602       -0.179473
age                                  -0.005196       -0.003428

/home/tobias_giesemann/.local/lib/python3.6/site-packages/ipykernel_launcher.py:1: DeprecationWarning: Calling Family(..) wi
th a link class as argument is deprecated.
Use an instance of a link class instead.
  """Entry point for launching an IPython kernel.
```

Poisson -Regression

In [99]:

```
#selbiges Modell wie oben
logit_model = glm("lt15 ~ age + sex + eastwest", data = allbus_df,
                  family = sm.families.Poisson()).fit()
print(logit_model.summary())

print("Multiplikative Effektinterpretation: \n", (np.exp(logit_model.params)-1)*100)
```

```
                 Generalized Linear Model Regression Results
==============================================================================
Dep. Variable:                   lt15   No. Observations:                 1733
Model:                            GLM   Df Residuals:                     1729
Model Family:                 Poisson   Df Model:                            3
Link Function:                    log   Scale:                          1.0000
Method:                          IRLS   Log-Likelihood:                -2858.5
Date:                Thu, 25 Jul 2019   Deviance:                       1447.2
Time:                        23:28:51   Pearson chi2:                 1.85e+03
No. Iterations:                     4
Covariance Type:            nonrobust
==================================================================================================
                                  coef    std err          z      P>|z|      [0.025      0.975]
--------------------------------------------------------------------------------------------------
Intercept                       0.9280      0.052     17.816      0.000       0.826       1.030
sex[T.MANN]                     0.0219      0.034      0.650      0.516      -0.044       0.088
eastwest[T.NEUE BUNDESLAENDER]    -0.1311      0.042     -3.150      0.002      -0.213      -0.050
age                            -0.0043      0.001     -4.381      0.000      -0.006      -0.002
==================================================================================================
Multiplikative Effektinterpretation:
 Intercept                         152.942160
sex[T.MANN]                         2.218618
eastwest[T.NEUE BUNDESLAENDER]    -12.290349
age                                -0.428598
dtype: float64
```

Hier funktioniert der Trick nicht, ein einfacheres Modell zur Margin Schätzung zu verwenden. Die müsste man dann wohl zu Fuß berechnen.

Negativ-Binomial- Regression

In [101]:

```
#selbiges Modell wie oben
logit_model = glm("lt15 ~ age + sex + eastwest", data = allbus_df,
                  family = sm.families.NegativeBinomial()).fit()
print(logit_model.summary())

print("Multiplikative Effektinterpretation: \n", (np.exp(logit_model.params)-1)*100)
```

```
                 Generalized Linear Model Regression Results
==============================================================================
Dep. Variable:                   lt15   No. Observations:                 1733
Model:                            GLM   Df Residuals:                     1729
Model Family:        NegativeBinomial   Df Model:                            3
Link Function:                    log   Scale:                          1.0000
Method:                          IRLS   Log-Likelihood:                -3323.1
Date:                Thu, 25 Jul 2019   Deviance:                       438.23
Time:                        23:29:41   Pearson chi2:                     610.
No. Iterations:                     5
Covariance Type:            nonrobust
==================================================================================================
                                  coef    std err          z      P>|z|      [0.025      0.975]
--------------------------------------------------------------------------------------------------
Intercept                       0.9326      0.092     10.179      0.000       0.753       1.112
sex[T.MANN]                     0.0227      0.059      0.386      0.699      -0.093       0.138
eastwest[T.NEUE BUNDESLAENDER]    -0.1338      0.071     -1.892      0.059      -0.272       0.005
age                            -0.0044      0.002     -2.584      0.010      -0.008      -0.001
==================================================================================================
Multiplikative Effektinterpretation:
 Intercept                         154.116026
sex[T.MANN]                         2.297112
eastwest[T.NEUE BUNDESLAENDER]    -12.522152
age                                -0.437916
dtype: float64
```