In [1]:

```python
import numpy as np
import pandas as pd
import toad
from toad.plot import bin_plot
```

In [2]:

```python
data = pd.read_csv('test_data.csv')
print('Shape:',data.shape)
data.head(10)
```

```
Shape: (500, 7)
```

Out[2]:

	A	B	C	D	E	F	target
0	0.417022	87	0.154276	0.383389	NaN	84.100880	0
1	0.720324	57	0.758797	0.769808	NaN	74.668182	1
2	0.000114	24	0.197145	-0.105166	NaN	7.504475	0
3	0.302333	55	0.442048	0.300465	NaN	46.824730	1
4	0.146756	49	0.399363	0.096637	NaN	45.993059	1
5	0.092339	52	0.045981	-0.022774	NaN	50.068966	1
6	0.186260	24	0.322268	-0.039216	NaN	37.597628	0
7	0.345561	15	0.311033	0.412043	NaN	26.698194	1
8	0.396767	67	0.393938	0.435124	NaN	56.782580	0
9	0.538817	73	0.407933	0.509187	NaN	71.328520	0

In [3]:

```python
train = data.iloc[0:400]
OOT = data.iloc[400:500]
print('Train Shape:',train.shape)
print('OOT Shape:',OOT.shape)
```

```
Train Shape: (400, 7)
OOT Shape: (100, 7)
```

检测数据情况（EDA）。输出每列特征的统计性特征和其他信息，主要的信息包括：缺失值、unique values、数值变量的平均值、离散值变量的众数等。

In [4]:

```python
toad.detect(train)
```

Out[4]:

	type	size	missing	unique	mean_or_top1	std_or_top2	min_or_top3	1
A	float64	400	4.00%	384	0.510225	0.295621	0.000114	
B	int64	400	0.00%	99	50.977500	28.473036	0.000000	
C	float64	400	4.00%	384	0.519693	0.346923	-0.334533	
D	float64	400	4.00%	384	0.508233	0.307564	-0.136864	
E	float64	400	96.75%	13	0.479722	0.328087	0.100977	
F	float64	400	0.00%	400	51.034749	30.841419	-19.534221	-
target	int64	400	0.00%	2	0.502500	0.500620	0.000000	

输出每个变量的iv值，gini，entropy，和unique values，结果以iv值排序。”target”为目标列，”iv_only”决定是否只输出iv值

要去掉主键，日期等高unique values且不用于建模的特征

In [5]:
```
toad.quality(train, target='target', iv_only=False)
```

Out[5]:

	iv	gini	entropy	unique
F	0.491614	0.494035	0.693135	400.0
D	0.420634	0.496323	0.693134	385.0
A	0.364871	0.494007	0.693135	385.0
C	0.352290	0.494480	0.693134	385.0
B	0.310251	0.496334	0.693135	99.0
E	0.026629	0.496044	0.691793	14.0

根据缺失值占比，iv值，和高相关性进行变量筛选，赋值为：

（1）empty=0.9: 若变量的缺失值大于0.9被删除

（2）iv=0.02: 若变量的iv值小于0.02被删除

（3）corr=0.7: 若两个相关性高于0.7时，iv值低的变量被删除

（4）return_drop=False: 若为True，function将返回被删去的变量列

（5）exclude=None: 明确不被删去的列名 下面结果表明空值条件删除了E列，iv值没有删除任何列，相关性删除了A，B，C列，剩余D，F列，输入为list格式

In [6]:
```
train_selected, dropped = toad.selection.select(train,target = 'target', empty =
print(dropped)
print(train_selected.shape)
```

```
{'empty': array(['E'], dtype='<U1'), 'iv': array([], dtype=object), 'corr': array
(['C', 'B', 'A'], dtype=object)}
(400, 3)
```

分箱功能支持数值型数据和离散型分箱，默认分箱方法使用 卡方分箱。 *** initalise: ***c = toad.transform.Combiner() *训练分箱*: c.fit(dataframe, y = ‘target’, method = ‘chi’, min_samples = None, n_bins = None, empty_separate = False) y: 目标列 method: 分箱方法，支持’chi’ (卡方分箱), ‘dt’ (决策树分箱), ‘kmean’ , ‘quantile’ (等频分箱), ‘step’ (等步长分箱) min_samples: 每箱至少包含样本量，可以是数字或者占比 n_bins: 箱数，若无法分出这么多箱数，则会分出最多的箱数 empty_separate: 是否将空箱单独分开 *查看分箱节点*: c.export() *手动调整分箱*: c.load(dict) *apply分箱结果*: c.transform(dataframe, labels=False): labels: 是否将分箱结果转化成箱标签。False时输出0,1,2…（离散变量根据占比高低排序），True输出(-inf, 0], (0,10], 同样要删除不用于建模的量 下面结果是两个连续数据给出的分箱节点(10, inf)。

In [7]:
```
# initialise
c = toad.transform.Combiner()
```

```
# 使用特征筛选后的数据进行训练：使用稳定的卡方分箱，规定每箱至少有5%数据，空值将自
c.fit(train_selected, y = 'target', method = 'chi', min_samples = 0.05) #empty_s

# 为了演示，仅展示部分分箱
print('D:',c.export()['D'])
print('F:',c.export()['F'])
```

```
D: [0.2152696212524343, 0.7149982120917635]
F: [14.605645472881228, 48.47334638888314, 54.189909599726825, 79.67128729823014,
88.62058274679619]
```

时间内观察： toad.plot.bin_plot(dataframe, x = None, target = 'target) bar代表了样本量占比，红线代表了正样本占比（e.g. 坏账率）

In [8]:
```
col = 'F'
bin_plot(c.transform(train_selected[[col,'target']], labels=True), x=col, target
```

```
D:\daily_work\examination\venv\lib\site-packages\seaborn\_oldcore.py:1498: Future
Warning: is_categorical_dtype is deprecated and will be removed in a future versi
on. Use isinstance(dtype, CategoricalDtype) instead
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```
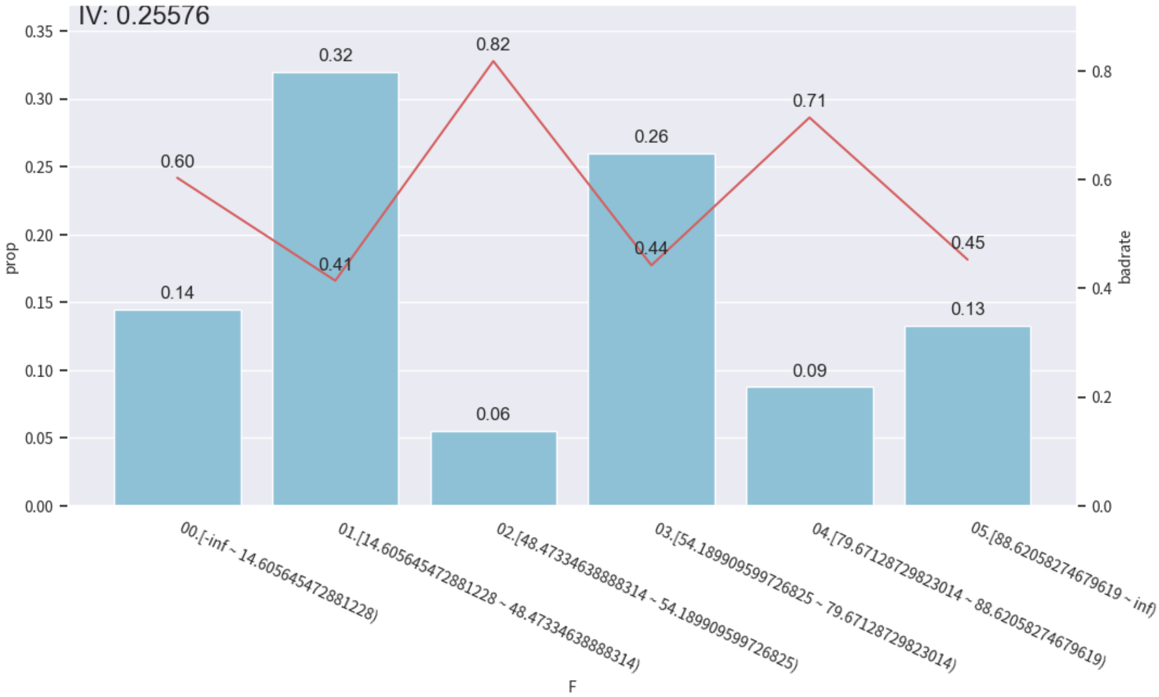

Out[8]:
```
<Axes: xlabel='F', ylabel='prop'>
```



跨时间观察： toad.plot.badrate_plot(dataframe, target = 'target', x = None, by = None) 输出不同时间段中每箱的正样本占比

In [9]:

```
c.transform(train[[col,'target']]).index
```

Out[9]:

```
RangeIndex(start=0, stop=400, step=1)
```

In [10]:

```
from toad.plot import badrate_plot
col = 'F'

# 观察 'F' 在E下的稳定性
# 这里因为没有时间数据选择了一个重复率较大，缺失值较少的E作为x轴来展示F随E变化的稳
badrate_plot(c.transform(train[[col,'target','E']], labels=True), target='target
# badrate_plot(c.transform(OOT[[col,'target']], labels=True), target='target',x

# badrate_plot(c.transform(data[[col,'target']], labels=True), target='target',x
'''
敞口随时间变化而增大为优，代表了变量在更新的E的区分度更强。线之前没有交叉为优，代
'''
```

```
D:\daily_work\examination\venv\lib\site-packages\seaborn\_oldcore.py:1498: Future
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```
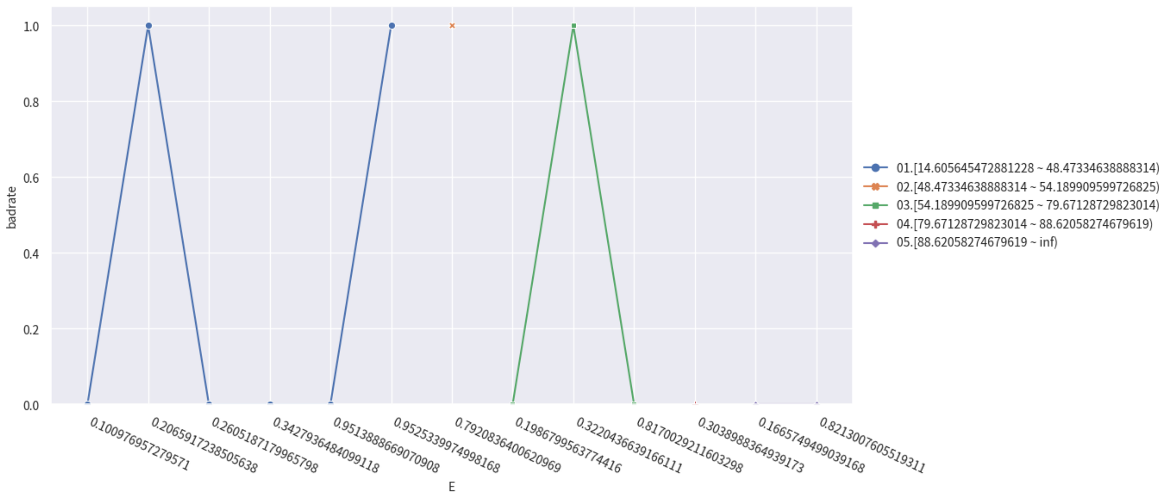

Out[10]: '\n敞口随时间变化而增大为优，代表了变量在更新的E的区分度更强。线之前没有交叉为优，代表分箱稳定。\n'



In [11]:

```python
# 看'D'的分箱
col = 'D'

#观察单个变量分箱结果时，建议设置'labels = True'
bin_plot(c.transform(train_selected[[col,'target']], labels=True), x=col, target
```

```
D:\daily_work\examination\venv\lib\site-packages\seaborn\_oldcore.py:1498: Future
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  with pd.option_context('mode.use_inf_as_na', True):
```
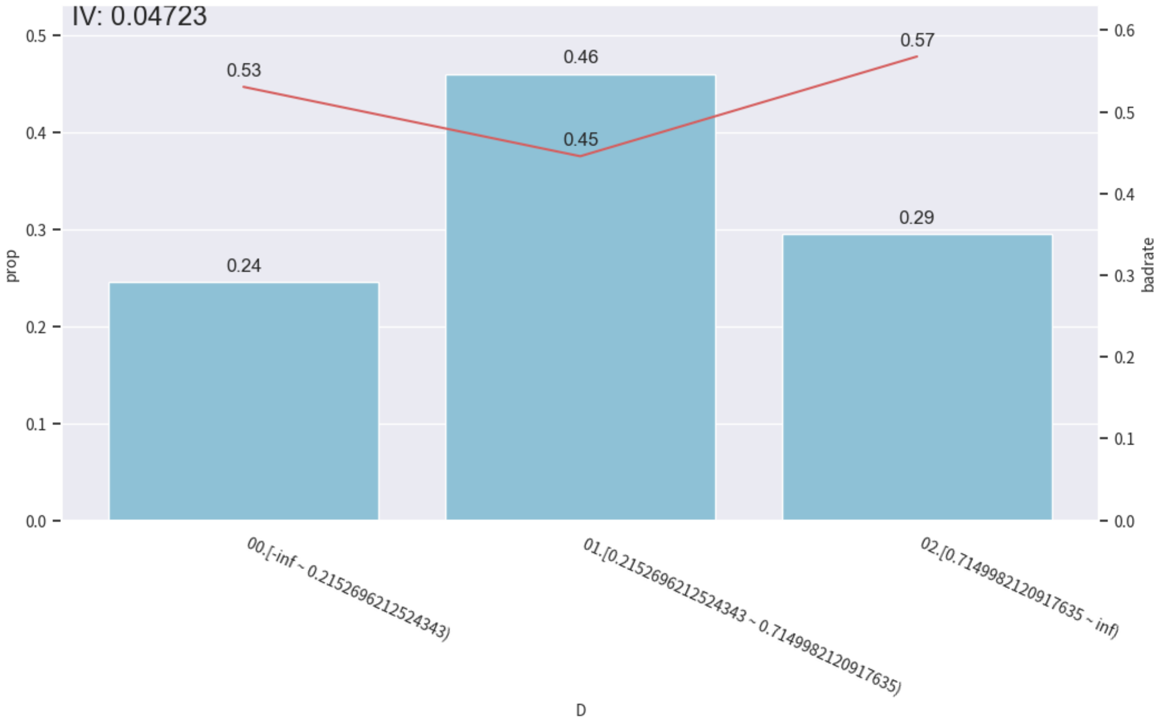

Out[11]:

```
<Axes: xlabel='D', ylabel='prop'>
```



羡慕展示如何调整分箱

In [12]:

```
rule = {'D':[-1,0,1,2]}

#调整分箱
c.update(rule)

#查看手动分箱稳定性
bin_plot(c.transform(train_selected[['D','target']], labels=True), x='D', target
badrate_plot(c.transform(OOT[['D','target','E']], labels=True), target='target',
```

```
D:\daily_work\examination\venv\lib\site-packages\seaborn\_oldcore.py:1498: Future
Warning: is_categorical_dtype is deprecated and will be removed in a future versi
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```

```
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  with pd.option_context('mode.use_inf_as_na', True):
```
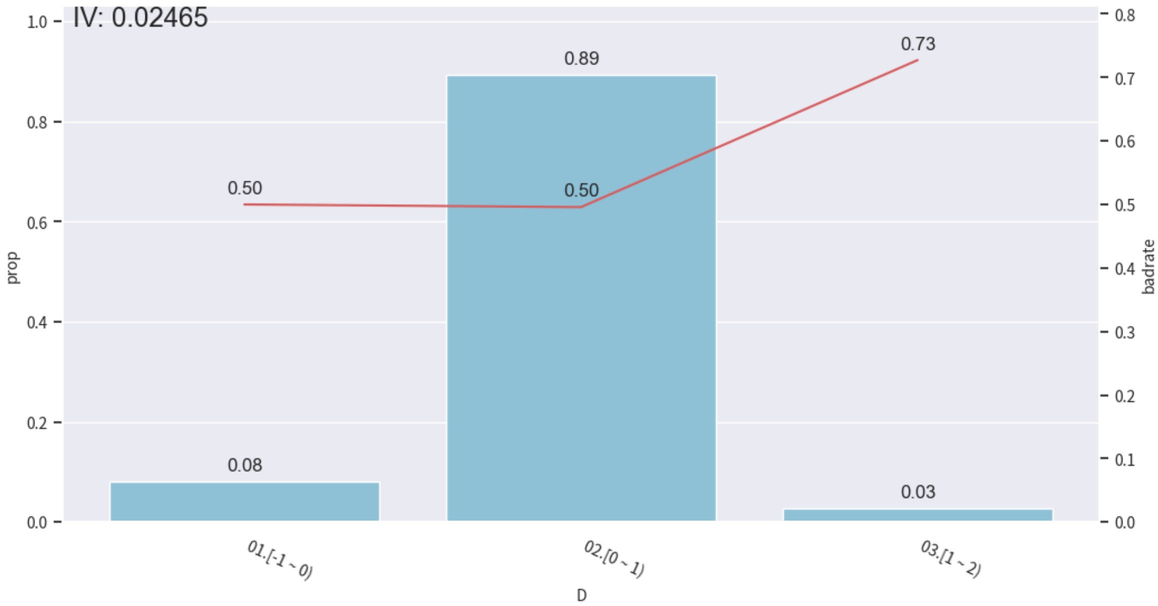
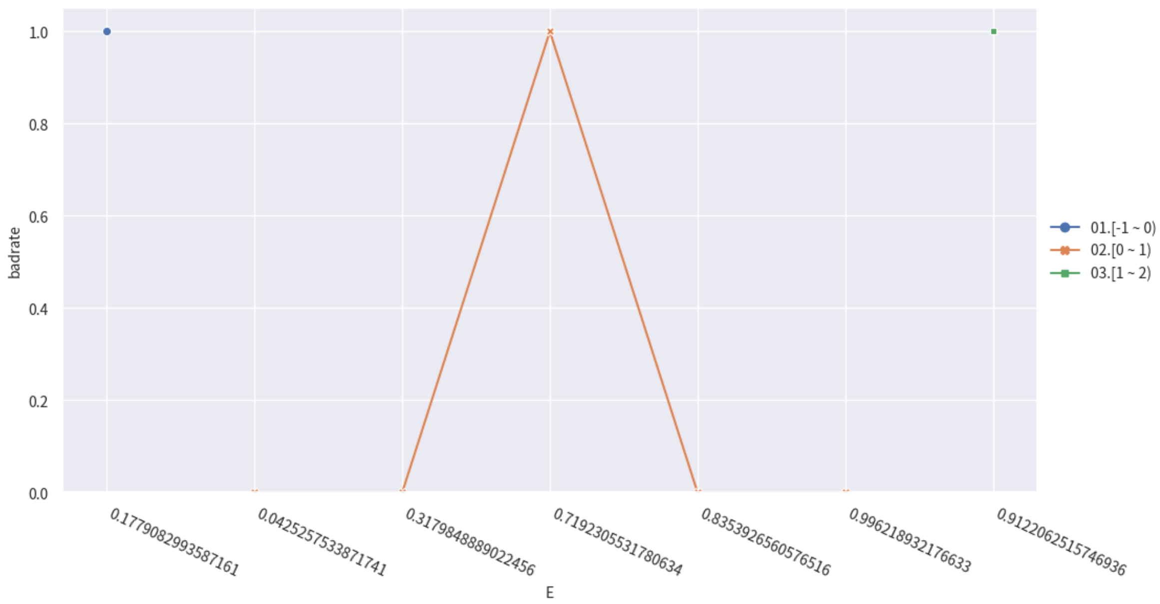

Out[12]: <Axes: xlabel='E', ylabel='badrate'>





WOE转化在分箱调整好之后进行，步骤如下：

用调整好的Combiner转化数据: c.transform(dataframe, labels=False)

只会转化被分箱的变量

初始化woe transer: transer = toad.transform.WOETransformer()

fit_transform: transer.fit_transform(dataframe, target, exclude = None)

训练并输出woe转化的数据，用于转化train/时间内数据

target：目标列数据（非列名） exclude: 不需要被WOE转化的列 注意：会转化所有列，包括未被分箱transform的列，通过 'exclude' 删去不要WOE转化的列，特别是target列 *根据训练好的transer，转化test/OOT数据：* transer.transform(dataframe)

In [13]:
```
# 初始化
transer = toad.transform.WOETransformer()

# combiner.transform() & transer.fit_transform() 转化训练数据，并去掉target列
train_woe = transer.fit_transform(c.transform(train_selected), train_selected['t
OOT_woe = transer.transform(c.transform(OOT))

print(train_woe.head(3))
```

```
          D         F  target
0 -0.026807  0.906291       0
1 -0.026807 -0.241802       1
2 -0.010000  0.409854       0
```

逐步回归特征筛选，支持向前，向后和双向。

- estimator: 用于拟合的模型，支持'ols', 'lr', 'lasso', 'ridge'
- direction: 逐步回归的方向，支持'forward', 'backward', 'both' （推荐）
- criterion: 评判标准，支持'aic', 'bic', 'ks', 'auc'
- max_iter: 最大循环次数

- return_drop: 是否返回被剔除的列名
- exclude: 不需要被训练的列名，比如ID列和时间列

In [14]:
```
# 将woe转化后的数据做逐步回归
final_data = toad.selection.stepwise(train_woe,target = 'target', estimator='ols

# 将选出的变量应用于test/OOT数据
final_OOT = OOT_woe[final_data.columns]

print(final_data.shape) # 逐步回归从7个变量中选出了1个
col = list(final_data.drop(['target'],axis=1).columns)
print(col)
```

```
(400, 2)
['F']
```

输出每列特征的PSI，可以用于检验WOE转化后的特征稳定性

In [15]:
```
toad.metrics.PSI(final_data[col], final_OOT[col])
```

Out[15]:
```
F    0.041555
dtype: float64
```

常用模型评分: toad. metrics. KS, F1, AUC

In [16]:
```
from sklearn.linear_model import LogisticRegression

lr = LogisticRegression()
lr.fit(final_data[col], final_data['target'])

# 预测训练和隔月的OOT
pred_train = lr.predict_proba(final_data[col])[:,1]
pred_OOT = lr.predict_proba(final_OOT[col])[:,1]
```

In [17]:
```
from toad.metrics import KS, AUC

print('train KS',KS(pred_train, final_data['target']))
print('train AUC',AUC(pred_train, final_data['target']))

print('OTT KS',KS(pred_OOT, final_OOT['target']))
print('OTT AUC',AUC(pred_OOT, final_OOT['target']))
```

```
train KS 0.2021300532513313
train AUC 0.6170154253856346
OTT KS 0.12645523885989562
OTT AUC 0.4636692091529506
```

PSI 同样可以用于验证分数的稳定性

In [18]:
```
print(toad.metrics.PSI(pred_train,pred_OOT))
```

```
0.041554960747658715
```

KS bucket输出模型预测分箱后评判信息，包括每组的分数区间，样本量，坏账率，KS等

- bucket：分箱的数量

- method：分箱方法，建议用'quantile'（等人数），或'step' (等分数步长)

bad_rate为每组坏账率：（1）组之间的坏账率差距越大越好（2）可以用于观察是否有跳点（3）可以用与找最佳切点（4）可以对比

In [19]:
```
toad.metrics.KS_bucket(pred_train, final_data['target'], bucket=10, method = 'qu
```

Out[19]:

	min	max	bads	goods	total	bad_rate	good_rate	odds	bad_pro
0	0.417589	0.417589	53	75	128	0.414062	0.585938	0.706667	0.26368
1	0.444632	0.444632	46	58	104	0.442308	0.557692	0.793103	0.22885
2	0.454699	0.454699	24	29	53	0.452830	0.547170	0.827586	0.11940
3	0.598802	0.598802	35	23	58	0.603448	0.396552	1.521739	0.17412
4	0.705780	0.807956	43	14	57	0.754386	0.245614	3.071429	0.21393

5 rows × 22 columns

逻辑回归模型转标准评分卡，支持传入逻辑回归参数，进行调参 combiner: 传入训练好的 toad.Combiner 对象

- transer: 传入先前训练的 toad.WOETransformer 对象
- pdo、rate、base_odds、base_score: e.g. pdo=60, rate=2, base_odds=20,base_score=750 实际意义为当比率为1/20，输出基准评分750，当比率为基准比率2倍时，基准分下降60分
- card: 支持传入专家评分卡
- **kwargs: 支持传入逻辑回归参数（参数详见 sklearn.linear_model.LogisticR
- 评分卡在 fit 时使用 WOE 转换后的数据来计算最终的分数，分数一旦计算完成，便无需 WOE 值，可以直接使用 原始数据 进行评分。toad 采用标准评分卡转换逻辑进行评分转换egression)

In [20]:
```
card = toad.ScoreCard(
    combiner = c,
    transer = transer,
)

card.fit(final_data[col], final_data['target'])
```

Out[20]:

```
▾ ScoreCard
ScoreCard(combiner=<toad.transform.Combiner object at 0x000001EFBA984160>,
          transer=<toad.transform.WOETransformer object at 0x000001EFBCE216D0
>)
```

In [21]:
```
# 直接使用原始数据进行评分
card.predict(train)
```

```
Out[21]:  array([366.50381777, 461.49287492, 407.57723136, 471.04021051,
          471.04021051, 317.87245001, 471.04021051, 471.04021051,
          461.49287492, 461.49287492, 317.87245001, 471.04021051,
          471.04021051, 457.97164454, 471.04021051, 471.04021051,
          407.57723136, 457.97164454, 457.97164454, 461.49287492,
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       471.04021051, 457.97164454, 471.04021051, 471.04021051,
       471.04021051, 471.04021051, 317.87245001, 461.49287492,
       461.49287492, 366.50381777, 366.50381777, 407.57723136,
       366.50381777, 461.49287492, 457.97164454, 407.57723136,
       461.49287492, 407.57723136, 407.57723136, 407.57723136,
       407.57723136, 461.49287492, 366.50381777, 471.04021051,
       457.97164454, 407.57723136, 461.49287492, 471.04021051,
       407.57723136, 461.49287492, 471.04021051, 471.04021051,
       457.97164454, 461.49287492, 471.04021051, 461.49287492,
       471.04021051, 471.04021051, 461.49287492, 471.04021051])
```

In [22]:
```python
#输出标准评分卡
card.export()
```

Out[22]:
```
{'F': {'[-inf ~ 14.605645472881228)': 407.58,
  '[14.605645472881228 ~ 48.47334638888314)': 471.04,
  '[48.47334638888314 ~ 54.189909599726825)': 317.87,
  '[54.189909599726825 ~ 79.67128729823014)': 461.49,
  '[79.67128729823014 ~ 88.62058274679619)': 366.5,
  '[88.62058274679619 ~ inf)': 457.97}}
```

用gbdt编码，用于gbdt + lr建模的前置

In [23]:
```python
gbdt_transer = toad.transform.GBDTTransformer()
gbdt_transer.fit(final_data[col+['target']], 'target', n_estimators = 10, max_de
```

```
D:\daily_work\examination\venv\lib\site-packages\sklearn\base.py:457: UserWarnin
g: X has feature names, but DecisionTreeRegressor was fitted without feature name
s
  warnings.warn(
```

Out[23]: <toad.transform.GBDTTransformer at 0x1ef87f93280>

In [24]:
```
gbdt_vars = gbdt_transer.transform(final_data[col])
gbdt_vars.shape
```

```
D:\daily_work\examination\venv\lib\site-packages\sklearn\base.py:457: UserWarnin
g: X has feature names, but DecisionTreeRegressor was fitted without feature name
s
  warnings.warn(
```

Out[24]: (400, 40)

In [ ]: