ДЗ 2:

1. Применить ранговую трансформацию (потом t-test) и сравнить с результатами по Манну-Уитни на:

- метрике cart_added_cnt

(1 балл)

2. Реализовать cuped-трансформацию и сравнить мощность t-критерия на:

- обычной метрике cart_added_cnt
- логарфимированной метрике cart_added_cnt
- метрике cart_added_cnt (а после подвергнуть ранговому преобразованию)

(3 балла)

В каждом случае фиксировать, на сколько сокращается дисперсия, проверять равны ли средние в группах в ковариате и совпадают ли средние в метрике до и после применения cuped

3. Реализовать разбивку на бакеты, оценить t-критерием и сравнить с результатом без бакетирования:

- на логнормальном распределении (сгенерированные данные)
- на метрике cart_added_cnt

(2 балла)

4. Реализовать постстратификацию на данных shop_metrics_old для метрики cart_added_cnt:

- на сочетании пола и возраста (возраст разбить на подгруппы: 18-24, 25-45, 46-60, 61-75, 76+)

подсчитать результаты для случая без постстратификации и с постстратификацией

- проверить мощность и корректность t-критерия для постстратифицированного случая

(2 балла)

Импорт библиотек, и данных, и функций

In [1]:
```
import numpy as np
```

```
import scipy
import matplotlib.pyplot as plt
import scipy.stats as stats
import statsmodels
import statsmodels.sandbox.stats.multicomp
import pandas as pd
from statsmodels.stats.weightstats import ztest

import matplotlib.pyplot as plt
import seaborn as sns

from tqdm import tqdm
from sklearn.utils import shuffle
import hashlib
from base64 import b64encode
import collections
import datetime
```

In [2]:
```
shop_metrics_new = pd.read_csv('shop_df_metrics_dec.csv').drop(columns='Unnamed: 0'
shop_metrics_old = pd.read_csv('shop_df_metrics_sept.csv').drop(columns='Unnamed: 0
shop_users_info = pd.read_csv('shop_df_users.csv').drop(columns='Unnamed: 0')

shop_metrics_new.sample(5)
```

Out[2]:

	user_id	group	is_viewed	products_viewed_cnt	price_sum	is_cart_a
159622	1515915625599809309	B	1	1	28.25	
47742	1515915625564451163	B	1	4	115.55	
195583	1515915625606292558	B	1	1	11.00	
108860	1515915625592684920	B	1	3	1597.68	
11202	1515915625546836307	B	1	2	40.96	

In [3]:
```
def salt_generator(salt=None):
    import os
    from base64 import b64encode # кодирует байтоподобный объект с помощью Base64 и
    salt = os.urandom(8)

    return b64encode(salt).decode('ascii')

def groups_splitter(df, user_salt=None):

    if user_salt == None:
        salt = salt_generator()
    else:
        salt = user_salt

    df['hash'] = ((df['user_id'].astype(str)) + '#' + salt).apply(lambda x: hashlib

    df['group'] = ((df['hash'].str.slice(start=-6).apply(int, base=16) % 2).map(lam

    return df[['user_id', 'group']].drop_duplicates()
```

In [4]:
```
def rank_transformation(df_a, df_b, metric):
    df = pd.concat([df_a, df_b], axis = 0)
    df['rank'] = df[metric].rank()

    return df
```

In [5]:
```
def cuped_transform(df, metrics):

    new_columns = [str(m+'_cuped') for m in metrics]
    df[new_columns] = pd.DataFrame([[0] * len(new_columns)], index=df.index)

    df_mini = df.fillna(0)
    for m in metrics:
        covariate_column = str(m+'_covariate')
        cuped_column = str(m+'_cuped')
        mean_covariate = df_mini[covariate_column].mean()

        theta = (df_mini[m].cov(df_mini[covariate_column]))/(df_mini.loc[:,covariat
        df_mini[cuped_column] = df_mini[m] - (df_mini[covariate_column] - mean_cova

    df.update(df_mini)

    return df.drop_duplicates()
```

1. Применить ранговую трансформацию (потом t-test) и сравнить с результатами по Манну-Уитни на:

- метрике cart_added_cnt

In [6]:
```
ranked = rank_transformation(shop_metrics_new[shop_metrics_new.group == 'A'],
                             shop_metrics_new[shop_metrics_new.group == 'B'], 'cart
```

In [7]:
```
print(ranked[ranked.group == 'A']['rank'].mean(),
      ranked[ranked.group == 'B']['rank'].mean(),
      ((ranked[ranked.group == 'B']['rank'].mean() - ranked[ranked.group == 'A']['r
       ranked[ranked.group == 'A']['rank'].mean()*100))

print(stats.ttest_ind(ranked[ranked.group == 'A']['rank'], ranked[ranked.group == '

stats.mannwhitneyu(shop_metrics_new[shop_metrics_new.group == 'A']['cart_added_cnt'
                   shop_metrics_new[shop_metrics_new.group == 'B']['cart_added_cnt'
```

```
111170.45633348604 111351.6421897482 0.16298022175842064
Ttest_indResult(statistic=-1.2743727811526857, pvalue=0.20253266477504916)
```

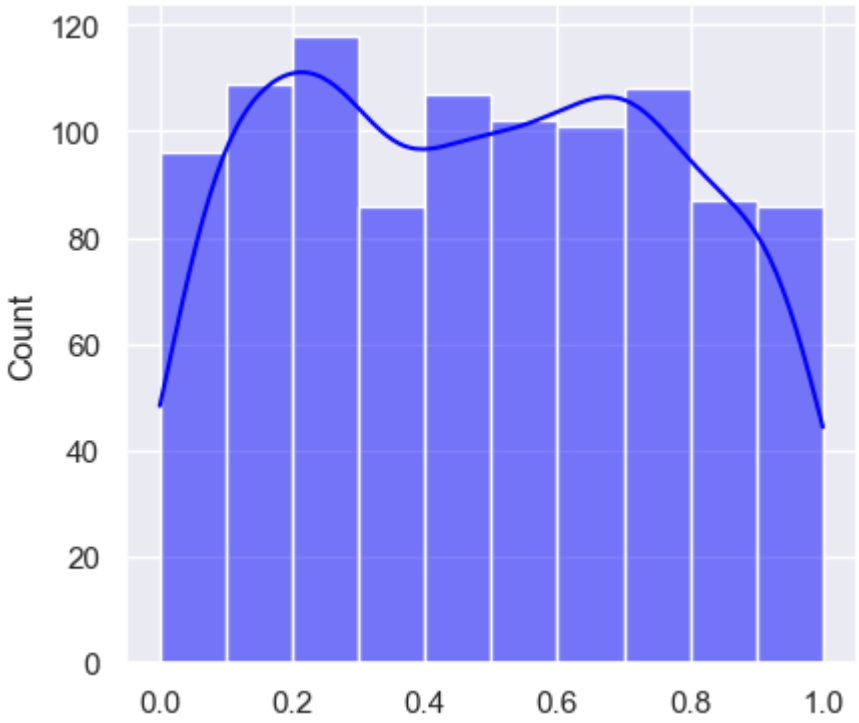
Out[7]:
```
MannwhitneyuResult(statistic=6179368188.5, pvalue=0.2025319893087626)
```

Оба тесты показывают практически одинаковый p_value

In [8]:
```
# мощность и корректность для ранговой трансформации
```

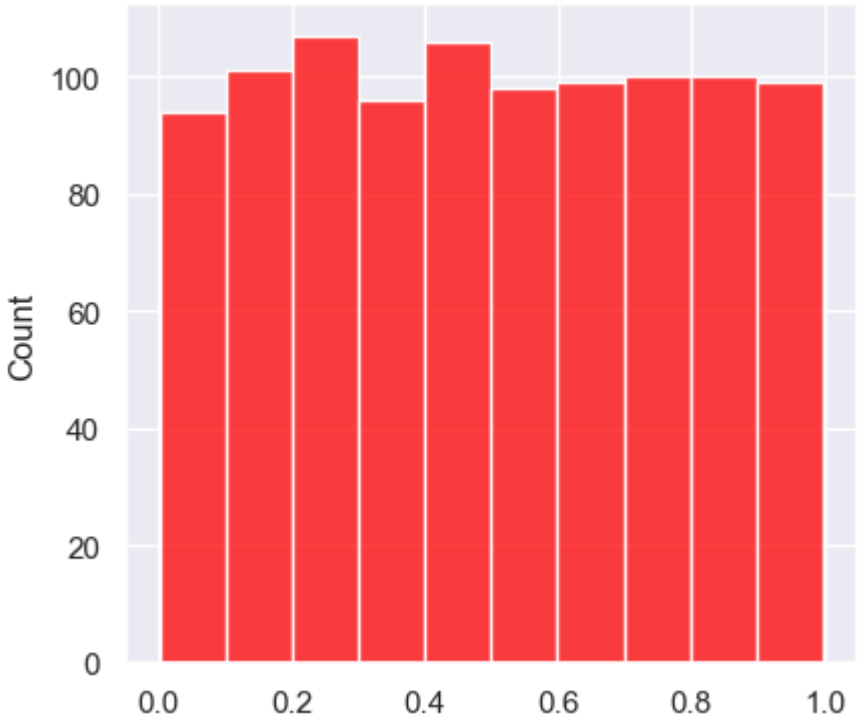
```
shop = shop_metrics_new.drop(columns=['group'])

correctness = []
power = []

for i in tqdm(range(1000)):

    new_group = groups_splitter(shop.copy(), user_salt=salt_generator())
    new_df = pd.merge(shop, new_group, how="left", on=['user_id']).drop_duplicates(

    ranked_df = rank_transformation(new_df[new_df.group == 'A'], new_df[new_df.grou

    vec_a = ranked_df[(ranked_df['group'] == 'A')]['rank']
    vec_b = ranked_df[(ranked_df['group'] == 'B')]['rank']

    vec_b_effect = new_df[new_df['group'] == 'B']['cart_added_cnt'] * 1.05
    new_df_b = new_df[new_df.group == 'B'].drop(columns=['cart_added_cnt'])
    new_df_b['cart_added_cnt'] = list(vec_b_effect)

    ranked_df_effect = rank_transformation(new_df[new_df.group == 'A'], new_df_b, '
    vec_a_power = ranked_df_effect[(ranked_df_effect['group'] == 'A')]['rank']
    vec_b_power = ranked_df_effect[(ranked_df_effect['group'] == 'B')]['rank']


    p_cor, p_power = stats.ttest_ind(vec_a, vec_b)[1], stats.ttest_ind(vec_a_power,
    correctness.append(p_cor)
    power.append(p_power)

correctness = np.array(correctness)
sns.set(rc={'figure.figsize':(4.7,4.27)})
sns.histplot(data=correctness, bins=10, color='blue', kde=True)

power = np.array(power)

print((vec_b_effect.mean() - vec_a.mean())/vec_a.mean())
print(f' power: {(power[power < 0.05].shape[0] / power.shape[0]) * 100}% , correctn
```

```
100%|██████████████████████████████████████████████████████████████████████████|
1000/1000 [09:58<00:00,  1.67it/s]
-0.9999987137420602
 power: 100.0% , correctness: 95.39999999999999%
```



In [9]:
```
correctness = []
power = []

for i in tqdm(range(1000)):
    new_group = groups_splitter(shop.copy(), user_salt=salt_generator())
    new_df = pd.merge(shop, new_group, how="left", on=['user_id']).drop_duplicates(

    vec_a = new_df[(new_df['group'] == 'A')]['cart_added_cnt']
    vec_b = new_df[(new_df['group'] == 'B')]['cart_added_cnt']

    vec_b_effect = new_df[new_df['group'] == 'B']['cart_added_cnt'] * 1.05

    p_correctness, p_power = stats.mannwhitneyu(vec_a, vec_b)[1], stats.mannwhitney
    correctness.append(p_correctness)
    power.append(p_power)

correctness = np.array(correctness)
sns.set(rc={'figure.figsize':(4.7,4.27)})
sns.histplot(data=correctness, bins=10, color='red')

power = np.array(power)
print(f' power: {(power[power < 0.05].shape[0] / power.shape[0]) * 100}% , correctn
```

```
100%|██████████████████████████████████████████████████████████████████████████████|
1000/1000 [10:16<00:00,  1.62it/s]
 power: 100.0% , correctness: 94.6%
```



2. Реализовать cuped-трансформацию и сравнить мощность t-критерия на:

- обычной метрике cart_added_cnt
- логарфимированной метрике cart_added_cnt
- метрике cart_added_cnt (а после подвергнуть ранговому преобразованию)

Обычная метрика

In [10]:
```
shop_metrics_all = pd.merge(shop_metrics_new, shop_metrics_old[['user_id', 'cart_ad
shop_metrics_all = shop_metrics_all.rename(columns={'cart_added_cnt_x': 'cart_added
shop_metrics_all_cuped = cuped_transform(shop_metrics_all.copy(), ['cart_added_cnt'

print('\033[1m'+'t-test'+'\033[0m')
print(stats.ttest_ind(shop_metrics_all_cuped[shop_metrics_all_cuped.group == 'A']['
                      shop_metrics_all_cuped[shop_metrics_all_cuped.group == 'B']['cart_a
```

t-test
Ttest_indResult(statistic=-1.3855896128552472, pvalue=0.16587364048446882)

In [11]:
```
print('\033[1m'+'Средние'+'\033[0m')

print(f'метрика_cuped A: {shop_metrics_all_cuped[shop_metrics_all_cuped.group == "A
      метрика_cuped B: {shop_metrics_all_cuped[shop_metrics_all_cuped.group == "B
print(f'метрика без cuped A: {shop_metrics_all_cuped[shop_metrics_all_cuped.group =
      метрика без cuped B: {shop_metrics_all_cuped[shop_metrics_all_cuped.group =

print('\033[1m'+'Дисперсии'+'\033[0m')
```

```
print(f'метрика_cuped A: {shop_metrics_all_cuped[shop_metrics_all_cuped.group == "A
      метрика_cuped B: {shop_metrics_all_cuped[shop_metrics_all_cuped.group == "B
print(f'метрика без cuped A: {shop_metrics_all_cuped[shop_metrics_all_cuped.group =
      метрика без cuped B: {shop_metrics_all_cuped[shop_metrics_all_cuped.group =
```

Средние

метрика_cuped A: 0.13638231572690157, метрика_cuped B: 0.13721028984747924
метрика без cuped A: 0.1350419058398685, метрика без cuped B: 0.138552158273
3813

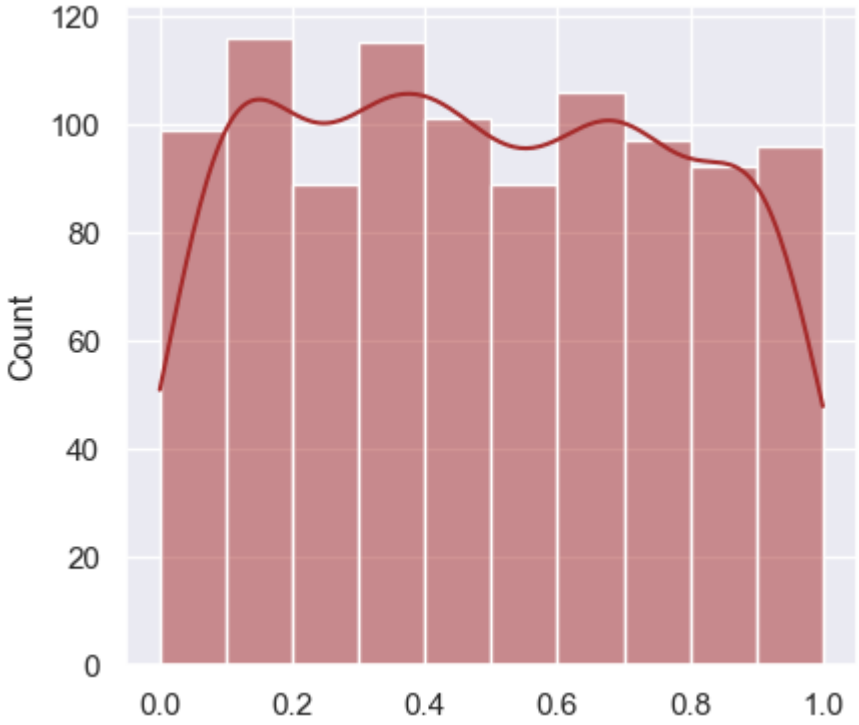
Дисперсии

метрика_cuped A: 0.018235183599737075, метрика_cuped B: 0.02149536345518971
метрика без cuped A: 0.3805867322092098, метрика без cuped B: 0.424718989356
3619

Из значимых изменений -- сильно сокращаются дисперсии при тех же средних

In [12]:
```
correctness = []
power = []

for i in tqdm(range(1000)):

    new_group = groups_splitter(shop.copy(), user_salt=salt_generator())
    new_df = pd.merge(shop, new_group, how="left", on=['user_id']).drop_duplicates(
    all_df = pd.merge(new_df, shop_metrics_old[['user_id', 'cart_added_cnt']], on=[
    all_df = all_df.rename(columns={'cart_added_cnt_x': 'cart_added_cnt', 'cart_add

    cuped_df = cuped_transform(all_df, ['cart_added_cnt'])

    vec_a = cuped_df[(cuped_df['group'] == 'A')]['cart_added_cnt_cuped']
    vec_b = cuped_df[(cuped_df['group'] == 'B')]['cart_added_cnt_cuped']

    vec_b_effect = vec_b * 1.05


    p_cor, p_power = stats.ttest_ind(vec_a, vec_b)[1], stats.ttest_ind(vec_a, vec_b
    correctness.append(p_cor)
    power.append(p_power)

correctness = np.array(correctness)
sns.set(rc={'figure.figsize':(4.7,4.27)})
sns.histplot(data=correctness, bins=10, color='brown', kde=True)

power = np.array(power)

print(f' power: {(power[power < 0.05].shape[0] / power.shape[0]) * 100}% , correctn
```

```
100%|██████████████████████████████████████████████████████████████████████████|
1000/1000 [10:45<00:00,  1.55it/s]
 power: 100.0% , correctness: 95.5%
```



Логарифмированная метрика

In [13]:
```
shop_metrics_all['ln_cart_added_cnt'] = np.log(shop_metrics_all['cart_added_cnt']+1
shop_metrics_all['ln_cart_added_cnt_covariate'] = np.log1p(shop_metrics_all['cart_a
shop_metrics_all_cuped = cuped_transform(shop_metrics_all.copy(), ['ln_cart_added_c

print('\033[1m'+'t-test'+'\033[0m')

print(stats.ttest_ind(shop_metrics_all_cuped[shop_metrics_all_cuped.group == 'A']['
                      shop_metrics_all_cuped[shop_metrics_all_cuped.group == 'B']['ln_car
```

t-test

Ttest_indResult(statistic=-1.7814011922262785, pvalue=0.0748482971637577)

In [14]:
```
print('\033[1m'+'Средние'+'\033[0m')

print(f'метрика_cuped A: {shop_metrics_all_cuped[shop_metrics_all_cuped.group == "A
      метрика_cuped B: {shop_metrics_all_cuped[shop_metrics_all_cuped.group == "B
print(f'метрика без cuped A: {shop_metrics_all_cuped[shop_metrics_all_cuped.group =
      метрика без cuped B: {shop_metrics_all_cuped[shop_metrics_all_cuped.group =

print('\033[1m'+'Дисперсии'+'\033[0m')


print(f'метрика_cuped A: {shop_metrics_all_cuped[shop_metrics_all_cuped.group == "A
      метрика_cuped B: {shop_metrics_all_cuped[shop_metrics_all_cuped.group == "B
print(f'метрика без cuped A: {shop_metrics_all_cuped[shop_metrics_all_cuped.group =
      метрика без cuped B: {shop_metrics_all_cuped[shop_metrics_all_cuped.group =
```

Средние

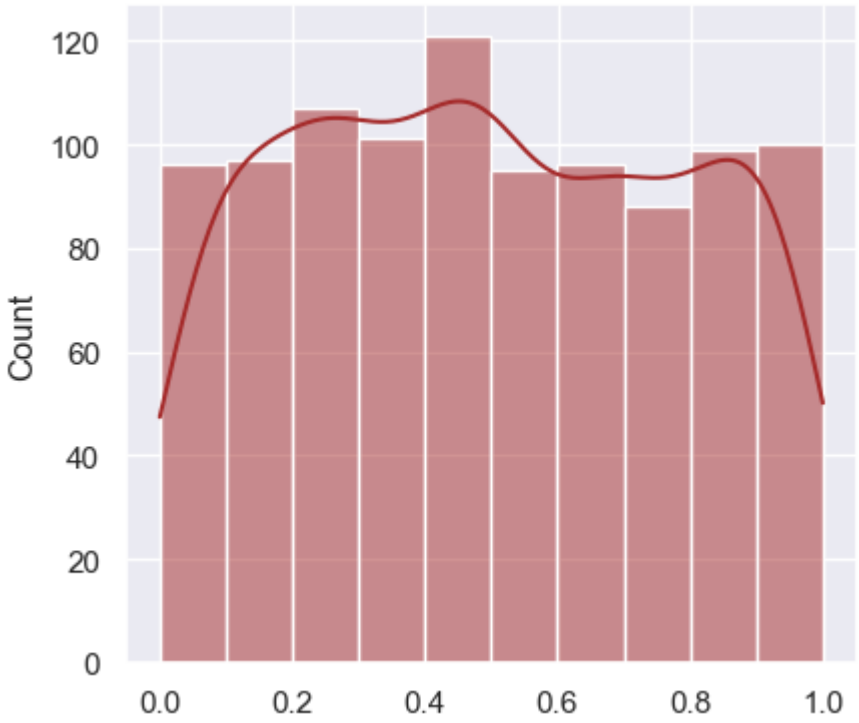
метрика_cuped A: 0.0803370848010829, метрика_cuped B: 0.08072536244233741
метрика без cuped A: 0.0797428906264097, метрика без cuped B: 0.081320203172
46845

Дисперсии

метрика_cuped A: 0.002786515421119718, метрика_cuped B: 0.002499024070070461
4
метрика без cuped A: 0.0646623295575808, метрика без cuped B: 0.066282591084
85138

In [15]:
```
correctness = []
power = []

for i in tqdm(range(1000)):

    new_group = groups_splitter(shop.copy(), user_salt=salt_generator())
    new_df = pd.merge(shop, new_group, how="left", on=['user_id']).drop_duplicates(
    all_df = pd.merge(new_df, shop_metrics_old[['user_id', 'cart_added_cnt']], on=[
    all_df = all_df.rename(columns={'cart_added_cnt_x': 'cart_added_cnt', 'cart_add

    all_df['ln_cart_added_cnt'] = np.log1p(all_df['cart_added_cnt'])
    all_df['ln_cart_added_cnt_covariate'] = np.log1p(all_df['cart_added_cnt_covaria

    cuped_df = cuped_transform(all_df, ['ln_cart_added_cnt'])

    vec_a = cuped_df[(cuped_df['group'] == 'A')]['ln_cart_added_cnt_cuped']
    vec_b = cuped_df[(cuped_df['group'] == 'B')]['ln_cart_added_cnt_cuped']

    vec_b_effect = vec_b * 1.05


    p_cor, p_power = stats.ttest_ind(vec_a, vec_b)[1], stats.ttest_ind(vec_a, vec_b
    correctness.append(p_cor)
    power.append(p_power)

correctness = np.array(correctness)
sns.set(rc={'figure.figsize':(4.7,4.27)})
sns.histplot(data=correctness, bins=10, color='brown', kde=True)

power = np.array(power)

print(f' power: {(power[power < 0.05].shape[0] / power.shape[0]) * 100}% , correctn
```

```
100%|██████████████████████████████████████████████████████████████████████████|
1000/1000 [11:18<00:00,  1.47it/s]
 power: 100.0% , correctness: 95.6%
```



Метрика cart_added_cnt (а после подвергнуть ранговому преобразованию)

In [9]:
```
shop_metrics_all = pd.merge(shop_metrics_new, shop_metrics_old[['user_id', 'cart_ad
shop_metrics_all = shop_metrics_all.rename(columns={'cart_added_cnt_x': 'cart_added
shop_metrics_all_cuped = cuped_transform(shop_metrics_all.copy(), ['cart_added_cnt'

ranked = rank_transformation(shop_metrics_all_cuped[shop_metrics_all_cuped.group ==
                             shop_metrics_all_cuped[shop_metrics_all_cuped.group ==

print('\033[1m'+'t-test'+'\033[0m')

stats.ttest_ind(ranked[ranked.group == 'A']['rank'],
                ranked[ranked.group == 'B']['rank'])
```

t-test

Out[9]:
```
Ttest_indResult(statistic=-1.4459909525623789, pvalue=0.14818114788143422)
```

In [11]:
```
print('\033[1m'+'Средние'+'\033[0m')

print(f'метрика_cuped A: {ranked[ranked.group == "A"]["rank"].mean()}, \
        метрика_cuped B: {ranked[ranked.group == "B"]["rank"].mean()}')
print(f'метрика без cuped A: {ranked[ranked.group == "A"]["cart_added_cnt"].mean()}
        метрика без cuped B: {ranked[ranked.group == "B"]["cart_added_cnt"].mean()}

print('\033[1m'+'Дисперсии'+'\033[0m')


print(f'метрика_cuped A: {ranked[ranked.group == "A"]["rank"].var()}, \
        метрика_cuped B: {ranked[ranked.group == "B"]["rank"].var()}')
```

```
print(f'метрика без cuped A: {ranked[ranked.group == "A"]["cart_added_cnt"].var()},
       метрика без cuped B: {ranked[ranked.group == "B"]["cart_added_cnt"].var()}'
```

Средние

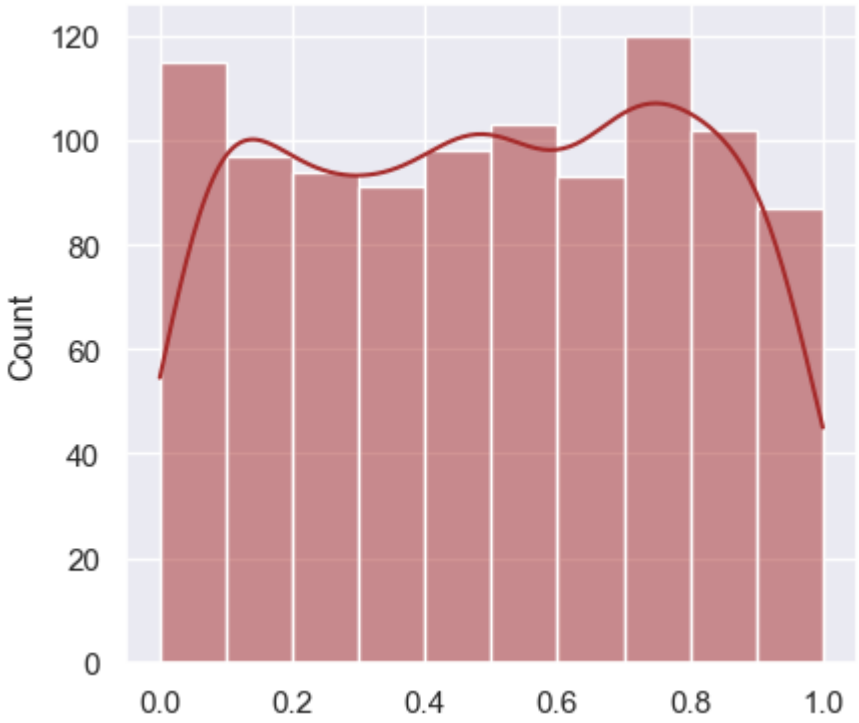
метрика_cuped A: 111157.3299691882, метрика_cuped B: 111364.78283723022
метрика без cuped A: 0.1350419058398685, метрика без cuped B: 0.138552158273
3813

Дисперсии

метрика_cuped A: 1138307738.1923919, метрика_cuped B: 1151768826.5573704
метрика без cuped A: 0.3805867322092098, метрика без cuped B: 0.424718989356
3619

In [18]:
```
correctness = []
power = []

for i in tqdm(range(1000)):

    new_group = groups_splitter(shop.copy(), user_salt=salt_generator())
    new_df = pd.merge(shop, new_group, how="left", on=['user_id']).drop_duplicates(
    all_df = pd.merge(new_df, shop_metrics_old[['user_id', 'cart_added_cnt']], on=[
    all_df = all_df.rename(columns={'cart_added_cnt_x': 'cart_added_cnt', 'cart_add

    cuped_df = cuped_transform(all_df, ['cart_added_cnt'])

    ranked_df = rank_transformation(cuped_df[cuped_df.group == 'A'],
                                    cuped_df[cuped_df.group == 'B'], 'cart_added_cnt_cuped

    vec_a = ranked_df[(ranked_df['group'] == 'A')]['rank']
    vec_b = ranked_df[(ranked_df['group'] == 'B')]['rank']

    vec_b_effect = cuped_df[cuped_df['group'] == 'B']['cart_added_cnt_cuped'] * 1.0
    new_df_b = cuped_df[cuped_df.group == 'B'].drop(columns=['cart_added_cnt_cuped'
    new_df_b['cart_added_cnt_cuped'] = list(vec_b_effect)

    ranked_df_effect = rank_transformation(cuped_df[cuped_df.group == 'A'], new_df_
    vec_a_power = ranked_df_effect[(ranked_df_effect['group'] == 'A')]['rank']
    vec_b_power = ranked_df_effect[(ranked_df_effect['group'] == 'B')]['rank']


    p_cor, p_power = stats.ttest_ind(vec_a, vec_b)[1], stats.ttest_ind(vec_a_power,
    correctness.append(p_cor)
    power.append(p_power)


correctness = np.array(correctness)
sns.set(rc={'figure.figsize':(4.7,4.27)})
sns.histplot(data=correctness, bins=10, color='brown', kde=True)

power = np.array(power)

print(f' power: {(power[power < 0.05].shape[0] / power.shape[0]) * 100}% , correctn
```

```
100%|██████████████████████████████████████████████████████████████████████████|
1000/1000 [13:07<00:00,  1.27it/s]
 power: 100.0% , correctness: 95.19999999999999%
```



Вывод

CUPED помогает нам (а именно уменьшает дисперсию) при обычной и логарифмированной метрике
В случае ранговой трансформации судить сложно, разве что у нас довольно близкими становятся дисперсии в разных группах
По p-value лучше всего показало себя логарифмирование метрики (практически приблизилось к 5%)