CUSTOMER ANALYTICS & A/B TESTING IN PYTHON

Introduction to A/B testing

Ryan Grossman
Data Scientist, EDO

Overview


A
B

MANAGEMENT

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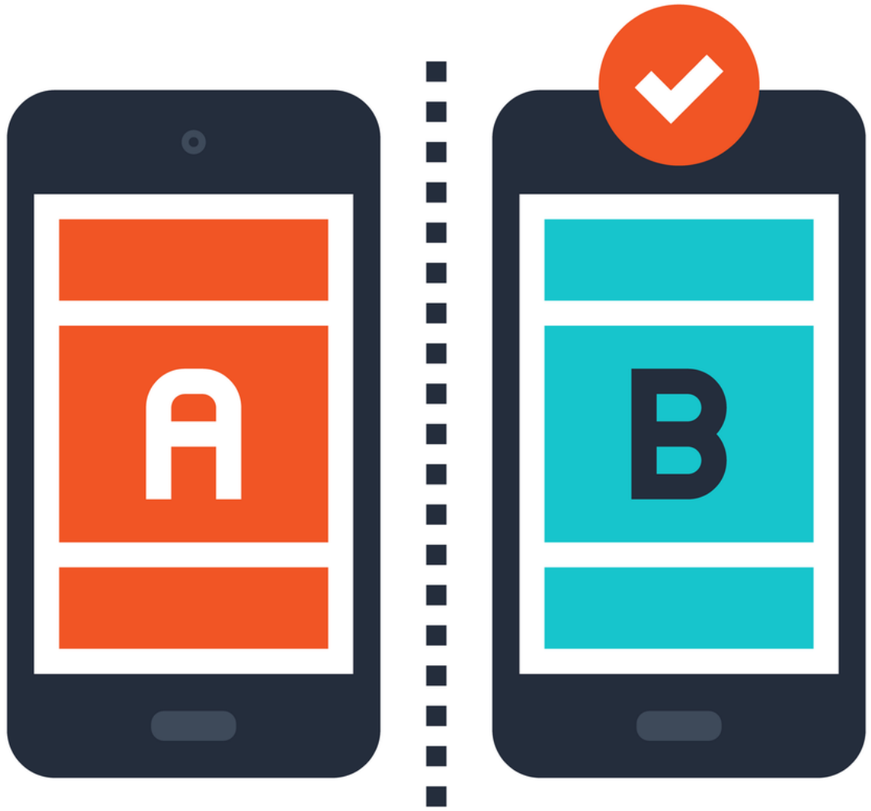
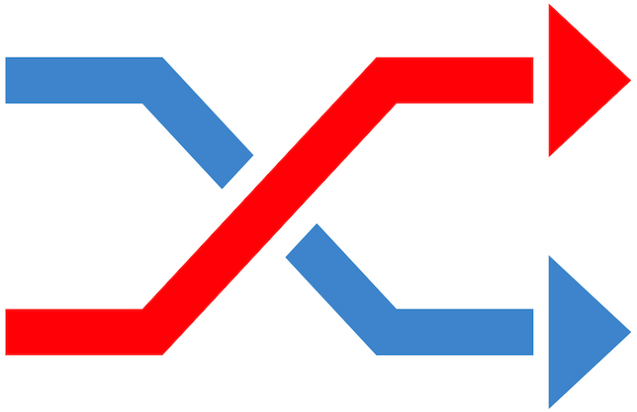


A/B TESTING

A/B Testing Example

The Importance of Randomness



A/B Testing Flexibility

Good and Bad Cases for A/B Testing

Good and Bad Cases for A/B Testing

Good and Bad Cases for A/B Testing

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Let's practice!

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Initial A/B test design

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Increasing Revenue through A/B Testing

Generalizabiliy of A/B Testing

Paywall Views & Demographics Data

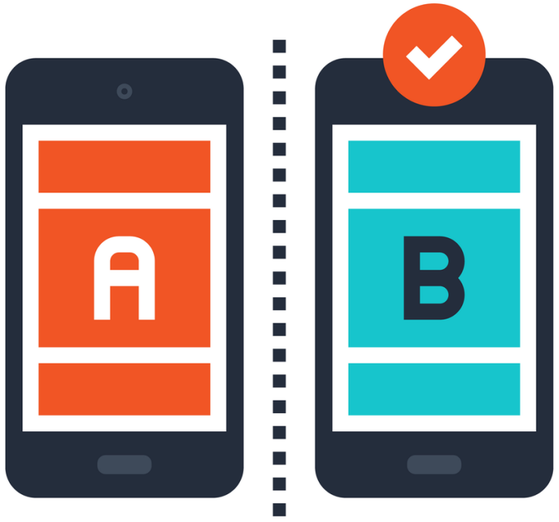
```
In [1]: demographics_data = pd.read_csv('user_demographics.csv')

In [2]: demographics_data.head(n=4)

Out[2]:
uid                reg_date    device    gender    country    age
0    52774929    2018-03-07    and        F        FRA        27
1    84341593    2017-09-22    iOS        F        TUR        22
2    41201055    2017-11-24    and        F        USA        20
3    68477880    2016-12-08    and        F        BRA        18
```

```
In [3]: paywall_views = pd.read_csv('paywall_views.csv')

In [4]: paywall_views.head(n=4)

Out [4]:
        uid        date                    purchase        sku        price
0    52774929    2018-03-11 04:11:01        0            NaN        NaN
1    52774929    2018-03-13 21:28:54        0            NaN        NaN
2    52774929    2018-03-14 12:22:17        0            NaN        NaN
3    84341593    2017-09-25 06:13:14        0            NaN        NaN
```

A/B Testing Terminology

Response Variable

Factors & Variants



Experimental Unit

Calculating Experimental Units

Calculating Experimental Units

```
In [5]: purchase_data = demographics_data.merge(paywall_views,
                                               how='left', on=['uid'])

In [6]: purchase_data_agg = purchase_data.groupby(by=['uid'],
                                                  as_index=False)

In [7]: total_purchases = purchase_data_agg.purchase.sum()

In [8]: total_purchases.purchase = np.where(
                                        np.isnan(total_purchases.purchase),
                                        0, total_purchases.purchase)

In [9]: total_purchases.purchase.mean()
```

Calculating Experimental Units

```
In [9]: total_purchases.purchase.mean()

Out[9]: 3.15
```

Calculating Experimental Units

```
In [10]: min(total_purchases.purchase)

Out[10]: 0.0

In [11]: max(total_purchases.purchase)

Out [12]: 17.0
```

Calculating Experimental Units

Calculating Experimental Units

```
In [13]: purchase_data_agg.date = paywall_views.date.dt.floor('d')

In [14]: purchase_data_agg = purchase_data.groupby(
                                        by=['uid', 'date'],
                                        as_index=False)

In [15]: total_purchases = purchase_data_agg.purchase.sum()

In [16]: total_purchases.purchase = np.where(
                                    np.isnan(total_purchases.purchase),
                                    0, total_purchases.purchase)

In [17]:total_purchases.purchase.mean()

Out[17]: 0.0346

In [18]: min(total_purchases.purchase)

Out[18]: 0.0

In [19]: max(total_purchases.purchase)

Out[19]: 3.0
```

Randomness of Experimental Units

Designing Your A/B Test

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Preparing to run an A/B test

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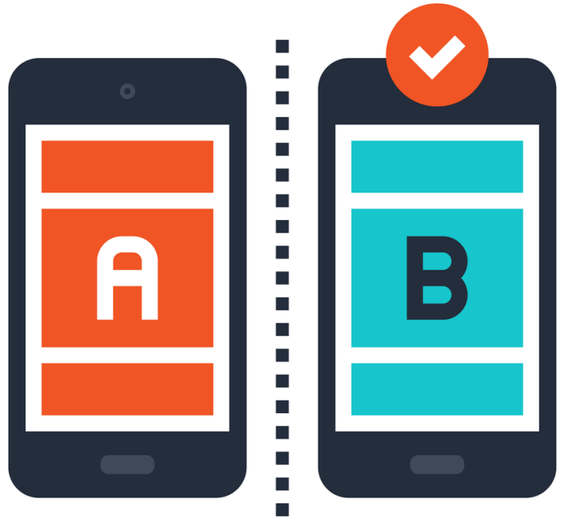
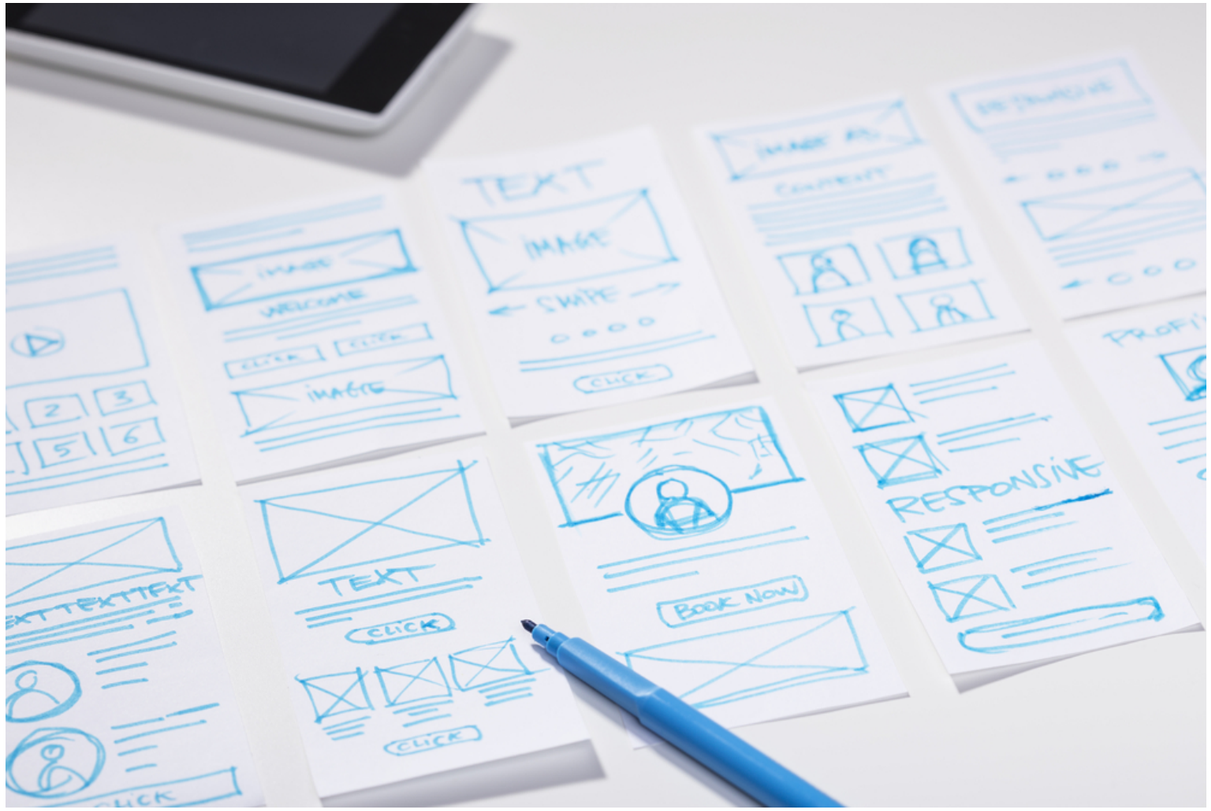
Paywall A/B Test Variants



Main Concerns in Designing a Test



Test Sensitivity

Evaluating Different Sensitivities

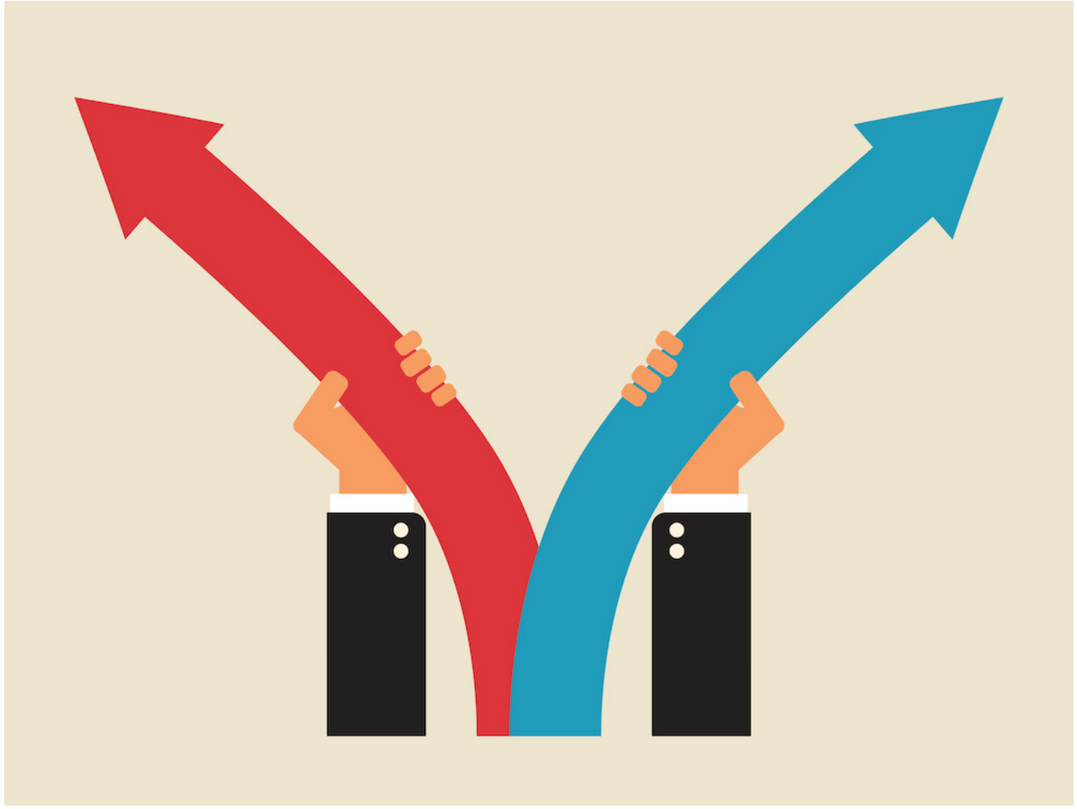
Finding Revenue Per User

```
In [1]: purchase_data = demographics_data.merge(paywall_views,
                                                how='left', on=['uid'])

In [2]: purchase_data_agg = purchase_data.groupby(by=['uid'],
                                                  as_index=False)

In [3]: total_revenue = purchase_data_agg.price.sum()

In [4]: total_revenue.price = np.where(np.isnan(total_revenue.price),
                                       0, total_revenue.price)

In [5]: avg_revenue = total_revenue.price.mean()

In [6]: avg_revenue

Out[6]: 16.161
```

Evaluating Our Sensitivities

```
In [7]: one_pct_lift = avg_revenue * 1.01

In [8]: one_pct_lift

Out[8]: 16.322839545454478

In [9]: ten_pct_lift = avg_revenue * 1.1

In [10]: ten_pct_lift

Out[10]: 17.77

In [11]: twenty_pct_lift = avg_revenue * 1.2

In [12]: twenty_pct_lift

Out [12]: 19.393
```

Understanding Variability in Our Data



Standard Deviation

```
In [13]: revenue_variation = total_revenue.price.std()

In [14]: revenue_variation

Out[14]: 17.520
```

Variability of Revenue Per User

```
In [15]: revenue_variation / avg_revenue

Out[15]: 1.084
```

Variability of Purchases Per User

```
In [16]: total_purchases = purchase_data_agg.purchase.sum()

In [17]: total_purchases.purchase = np.where(
                                        np.isnan(total_purchases.purchase),
                                        0, total_purchases.purchase)

In [18]: avg_purchases = total_purchases.purchase.mean()

In [19]: avg_purchases

Out[19]: 3.15

In [20]: purchase_variation = total_purchases.purchase.std()

In [21]: purchase_variation

Out[21]: 2.68

In [22]: purchase_variation / avg_purchases

Out [22]: 0.850
```

Choosing our Experimental Unit & Response Variable

Choosing our Experimental Unit & Response Variable

```
In [23]: purchase_data = demographics_data.merge(paywall_views,
                                how='inner', on=['uid'])

In [24]: purchase_data_agg = purchase_data.groupby(by=['uid'],
                                                   as_index=False)

In [25]: conversion_rate = (sum(purchase_data.purchase) /
            purchase_data.purchase.count())

In [26]: conversion_rate

Out[26]: 0.347
```

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Calculating Sample Sizes

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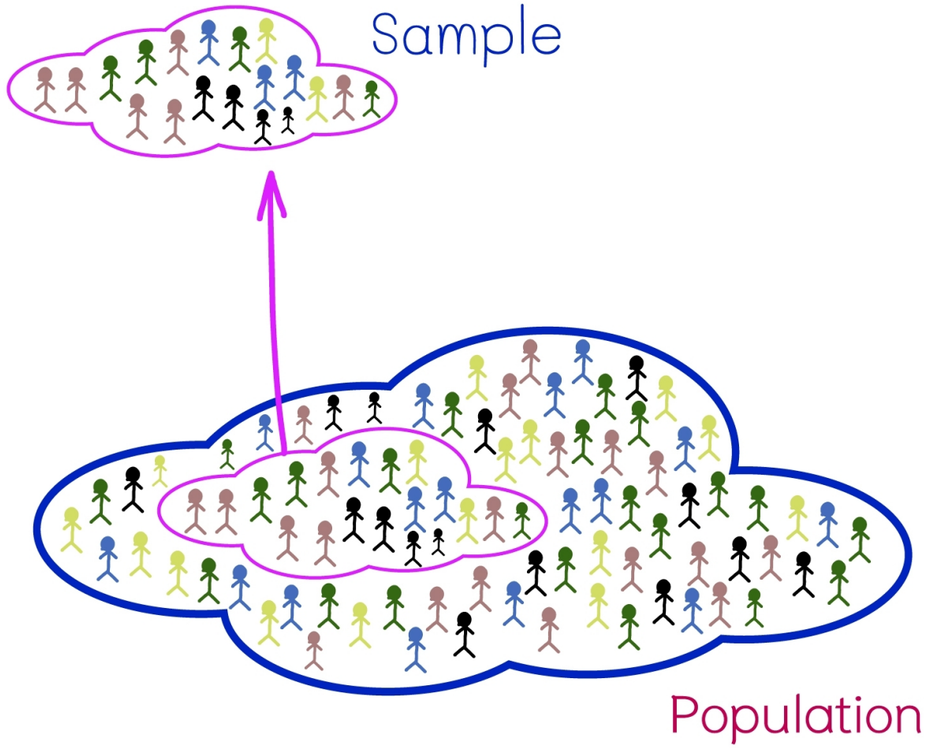
Calculating Sample Sizes



Null Hypothesis

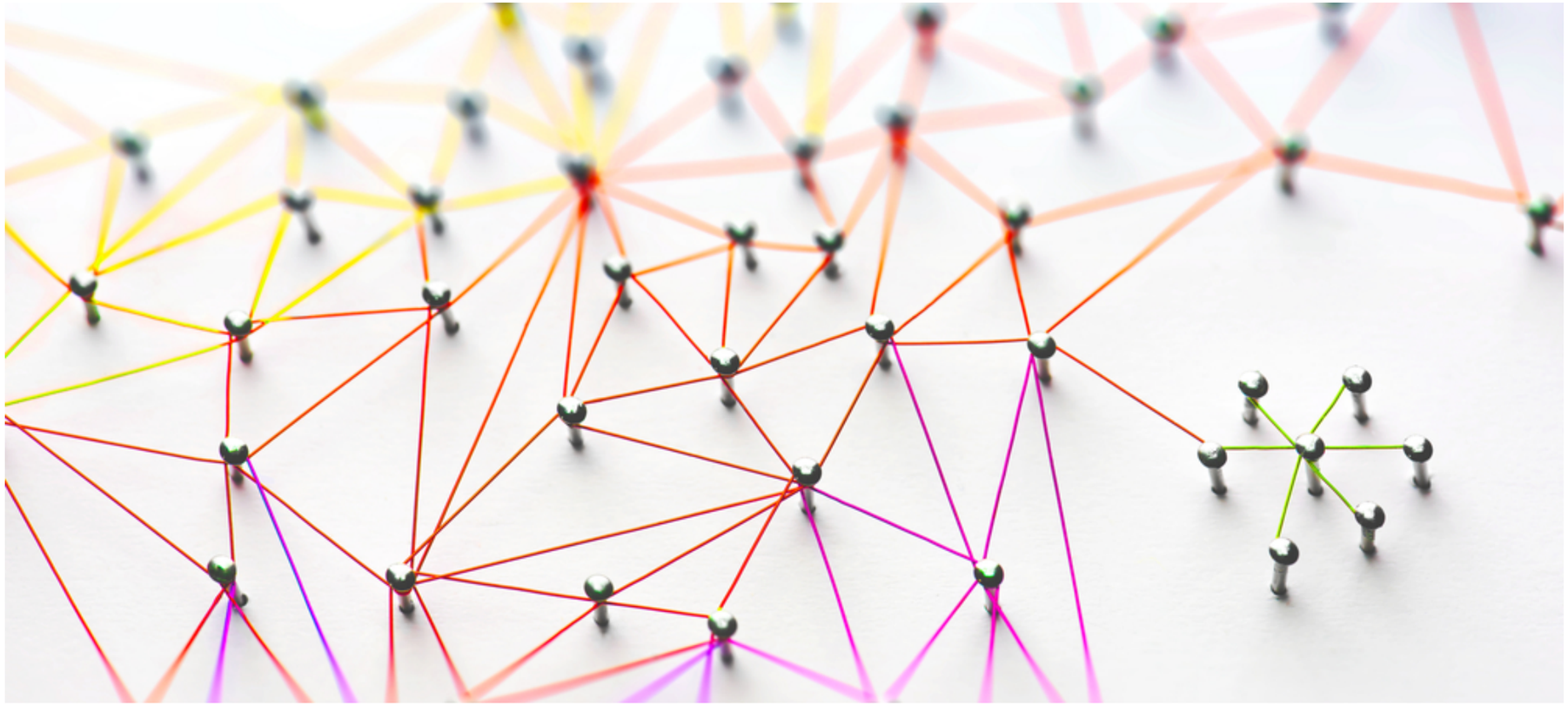
Types of Error

Null Hypothesis	Null Hypothesis		
		TRUE	FALSE
	Accept	Correct	Type II Error
	Reject	Type I Error	Correct

Confidence Level

Statistical Power

Connecting the Different Components



Power Formula

$$\alpha = 1 - \text{confidence level}$$

$$p_1 = \text{Base Rate},\ p_2 = \text{Base Rate} + \text{Sensitivity Lift}$$

$$qu = \Phi^{-1}\left(1 - \frac{\alpha}{2}\right)$$

$$diff = |p_1 - p_2|$$

$$\bar{p} = \frac{(p_1 + p_2)}{2}$$

$$v_1 = p_1 \times (1 - p_1),\ v_2 = p_2 \times (1 - p_2)$$

$$\bar{v} = \bar{p} \times (1 - \bar{p})$$

$$Power = \Phi\left(\frac{\sqrt{n} \times diff - qu \times \sqrt{2\bar{v}}}{\sqrt{v_1 + v_2}}\right) + 1 - \Phi\left(\frac{\sqrt{n} \times diff + qu \times \sqrt{2\bar{v}}}{\sqrt{v_1 + v_2}}\right)$$

Sample Size Function

```
def get_power(n, p1, p2, cl):
    alpha = 1 - cl
    qu = stats.norm.ppf(1 - alpha/2)
    diff = abs(p2 - p1)
    bp = (p1 + p2) / 2

    v1 = p1 * (1 - p1)
    v2 = p2 * (1 - p2)
    bv = bp * (1 - bp)
    power_part_one = stats.norm.cdf((n**0.5 * diff - qu * (2 * bv)**0.5)/
                            (v1 + v2)**0.5)
    power_part_two = 1 - stats.norm.cdf((n**0.5 * diff + qu * (2 * bv)**0.5)/
                            (v1 + v2)**0.5)

    power = power_part_one + power_part_two
    return(power)
```

```
def get_sample_size(power, p1, p2, cl, max_n = 1000000):
    n = 1
    while n <= max_n:
        tmp_power = get_power(n, p1, p2, cl)
        if tmp_power >= power:
            return n
        else:
            n = n + 1
```

Calculating our Needed Sample Size

```
In [3]: sample_size_per_group =  get_sample_size(0.8,
            conversion_rate, conversion_rate * 1.1, 0.95)

In [4]: sample_size_per_group

Out[4]: 45788
```

Generalness of this Function

Decreasing the Sample Size

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