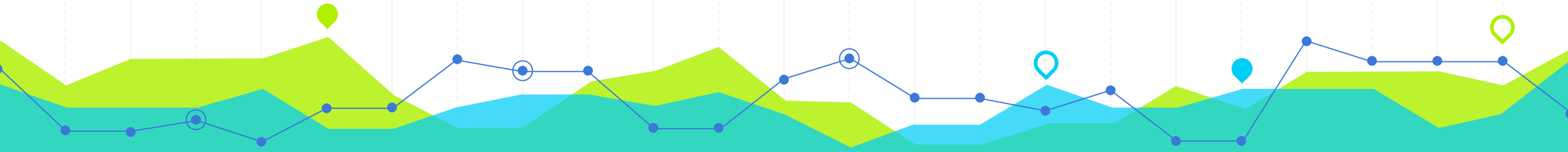
The Hygroscopic Capacity of Different Types of Paper Towel



Project Members:	Chan Tsz Ngai	1155110087
	Chan King Yeung	1155119394
	Ching Sze Wai	1155126012
	Lam Zi Jin	1155126578
	Tsang Wai Ying	1155127086

Abstract

- Background
- Methods
  - Defining the objectives
  - Identifying the variations
  - Rules
  - Difficulties
- Results
  - Data
  - Result
  - Discussion
- Conclusion

Background

- Topic: Hygroscopic Capacity of Paper Towels
  - Different types and brands
- From a broken cup of water
- Being Curious
- Close to life
  - Anywhere
  - Anytime

Define the objectives of the experiment

- Compare the hygroscopic capacity of different types of paper towel.
- Each type of paper towel is designed for different use.
- The weight of the water which is absorbed by the paper towel is different.

Identify all sources of variation

a. Treatment factors and their levels

- Three types of paper towel
  - kitchen paper
  - mini pocket tissue
  - toilet paper
- purchased at a local popular store
- cut into similar size

Identify all sources of variation

b. Identify the experimental units

- The weight loss of water.
- Different types of paper towel and water.

Experiment procedure:

- A cup of water will be put on a digital scale.
- The paper towel will be cut to the same size by using rulers and scissors.
- The paper towel can be completely beneath the water and put under the water for 10 seconds.
- Wait for 10 seconds to drip water into the cup.

Identify all sources of variation

Blocking factors:

- Water trapping ability of the paper.
- After the paper towel absorbed water and be picked up, the paper towels are held and extra water on the paper surface would be dripped off.
- Weak water trapping ability makes the dripping non-stop and causing extra of water is dripped out.
- The data collected is smaller than expected and cannot show the true power of water absorption of the paper.

Identify all sources of variation

Noise factors:

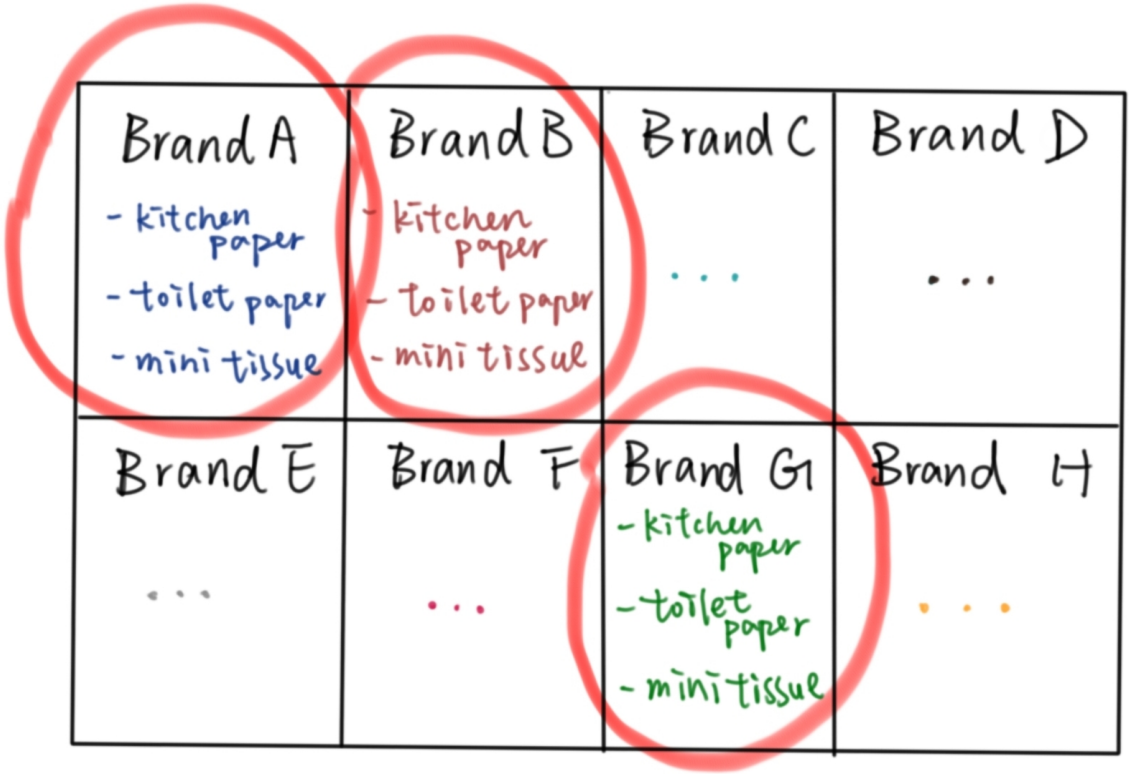
- Air humidity
  - Hong Kong has a humid weather and paper towels used for the experiment may unavoidably absorb the moisture in the air.
  - The data collected would be smaller than expected and cannot show the true power of water absorption of the paper.
- The accuracy of the digital scale
  - The digital scale was bought in the local popular store and the small error of the digital scale was neglectable.

Covariates:

- The difference in brands of paper towel may resulting in different hygroscopic capacity.
  - Cluster random sampling is used in the experiment.

Choose a rule by which to assign the experimental units to the levels of the treatment factors

- cluster random sampling



- 150 observations

Choose a rule by which to assign the experimental units to the levels of the treatment factors

- Using different brands of the same type of paper towels
- The same area (10×20cm)
- Time for absorption: 10 seconds
- Time for water dripping: 10 seconds
- Newly bought paper towels

The experimental procedure

Place the container of water on the digital scale.

Picked up A piece of paper towel using the forceps.

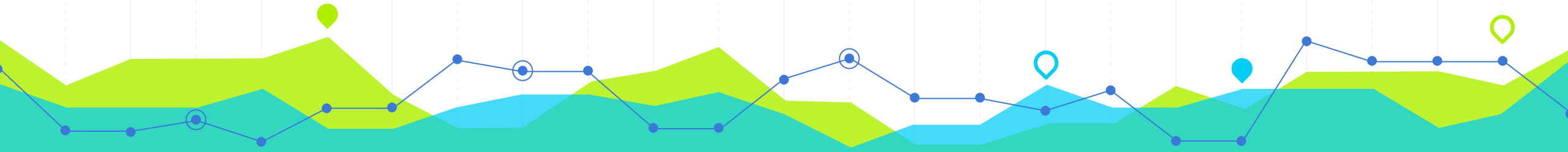
Immerse the paper towel in water for 10 s.

removed the paper towel from the water and drip for 10 s.

The measurements to be made

Types (Levels)	Paper towel	Pre-weight of the water (grams)	Post-weight of the water (grams)	Weight loss (grams)
Kitchen Paper	1	1000	992	14
	2	1000	991	15
	3	1000	991	13
	...			
Mini pocket tissue	51	1000	992	11
	52	1000	991	10
	53	1000	992	12
	...			
Toilet paper	101	1000	990	9
	102	1000	990	8
	103	1000	991	9

- Neglecting the decimal point of the data



Difficulties & Solution

How we ensure the fairness and reliability of the data

We will discuss...

- Expected Difficulties & Solution
- Pilot experiment
- Difficulties encountered & Solution

Expected Difficulties

- Damage due to unifying size
- Water stick on tools
- Damage due to operations

Solution

- Regulate a specific size
- Gentle flick
- Gentle handle and dull surface of tool

Pilot experiment

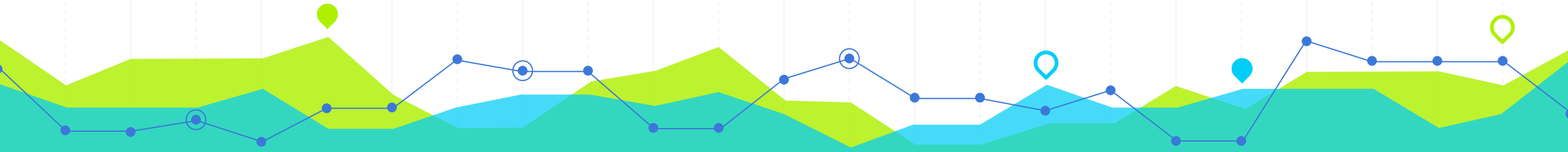
- Random container
- Random Amount of water

Difficulties encountered

- Irregular shape
- Splash of water

Solution

- Lager size of container & Flatly put
- Gentle manner



Data management

How we analysis data that we collected

Software

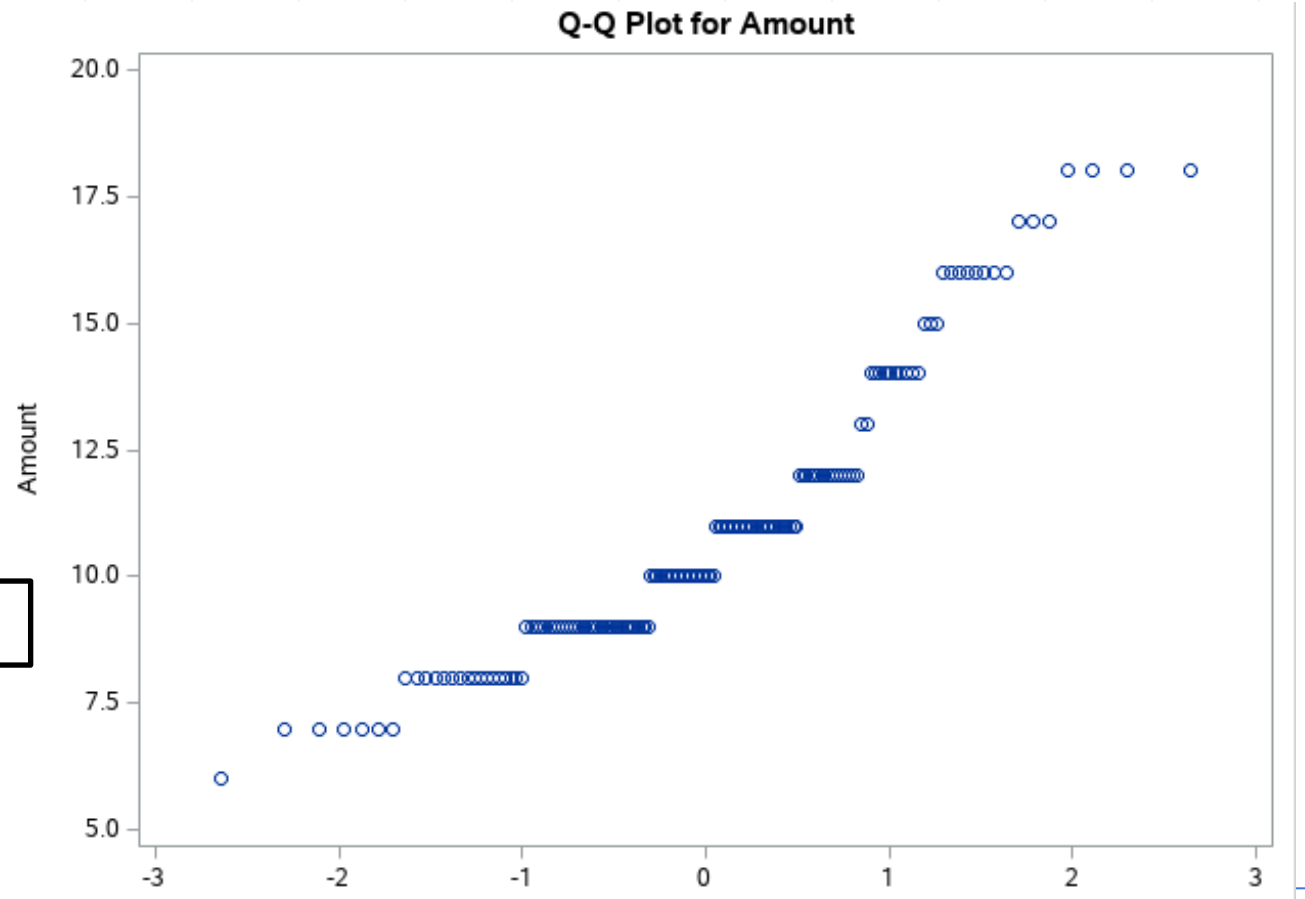
- Excel 2020 (Microsoft Corp)
  - Data organization, such as data entering and cleaning

- SAS University Edition (SAS Institute)
  - Statistical analysis, such as constructing graphs and tables

Test of Normality

- QQ plot
- Data focus on the center
- A nearly 45° straight line

DATA ARE NORMALLY DISTRIBUTED



(Graph 1)

One-way classification model

- Identify the fixed effects in our treatments
  - Each treatment is categorized with a single factor
  - An insight into the different population means from others

- Model: $Y_{ij} = \mu_i + \varepsilon_{ij}$ established
  - Fact: data are normally distributed

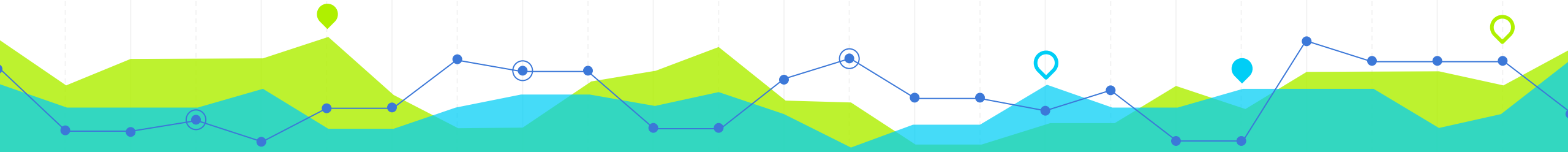
- We rewrite into $Y_{ij} = \mu + \alpha_i + \varepsilon_{ij}$
  - μ_i is the ground means
  - α_i indicates the fixed effects

Why not other methods?

- Multiple linear regression
  - Requires a precise design matrix
  - Tedious full-scale matrix multiplication

Level of significance

- Set to be 5%
  - Good enough for our experiment



Results

Information we obtained in statistical analysis

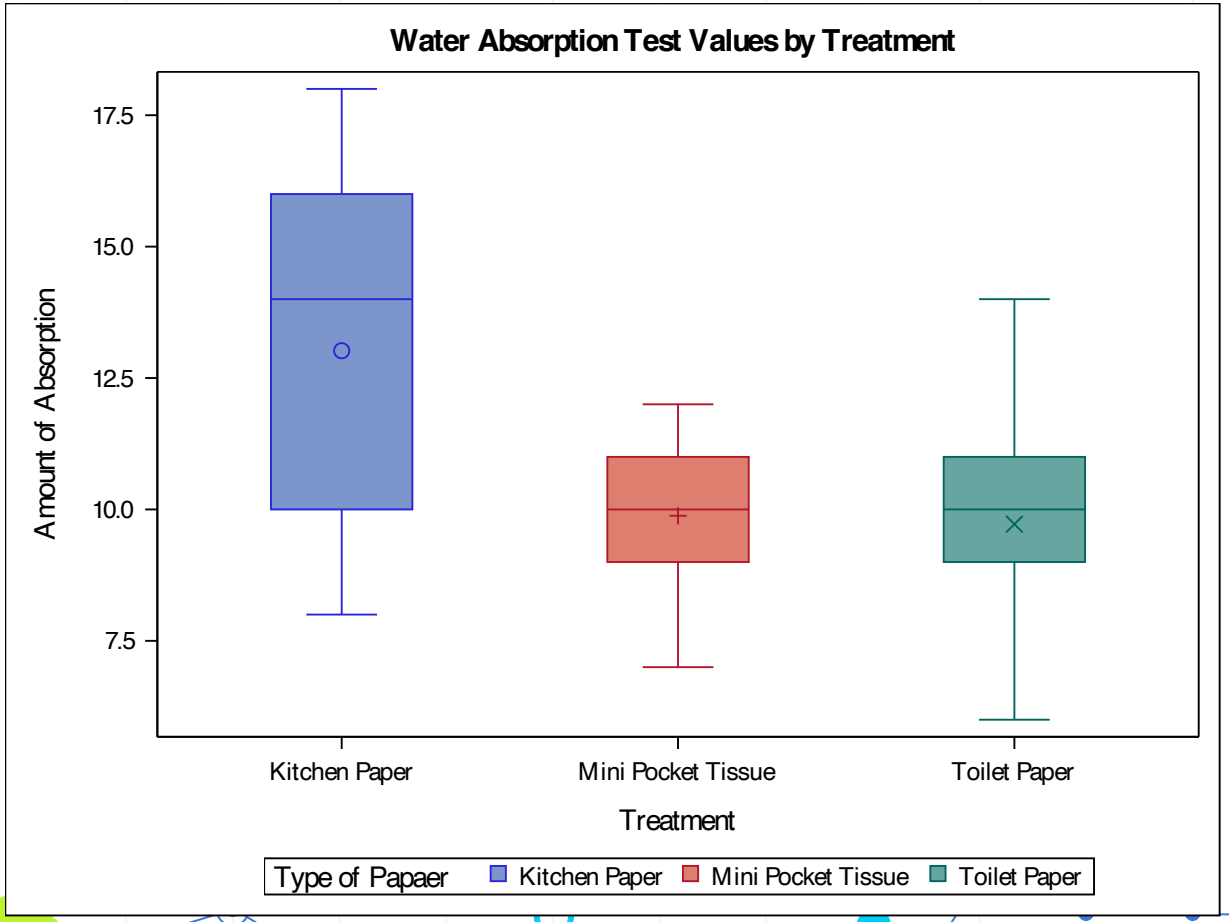
Summary Statistics

Analysis Variable: Amount							
Level of Type	N	Mean	Std Error	Minimum	Maximum	Lower 95% CL for Mean	Upper 95% CL for Mean
Kitchen Paper	50	13.02	0.46	8.00	18.00	12.10	13.94
Mini Pocket Tissue	50	9.88	0.21	7.00	12.00	9.46	10.30
Toilet Paper	50	9.72	0.22	6.00	14.00	9.28	10.16

(Table 1)

Summary Statistics (con't)

- Kitchen paper absorbs more
  - Large variation
- The amount of absorption is similar among mini pocket tissue and toilet paper



(Graph 2)

Test of fixed effects

$$H_0: \alpha_{kitchen} = \alpha_{tissue} = \alpha_{toilet} = 0 \quad vs \quad H_1: at\ least\ one\ \alpha_i\ is\ NOT\ zero$$

The ANOVA Procedure Dependent Variable: Amount					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	2	346.25	173.13	34.19	<.0001
Error	147	744.34	5.06		
Corrected Total	149	1090.59			

(Table 2)

- The p-value is smaller than 0.05
- Reject H_0 at the 5% level of significance
- The means of different types of paper are differ

EFFECTIVE TREATMENTS IN THE EXPERIMENT

Two tails test for means

$$H_0: \frac{\sigma^2_{toilet}}{\sigma^2_{tissue}} = 1 \quad vs \quad H_1: \frac{\sigma^2_{toilet}}{\sigma^2_{tissue}} \neq 1$$

- The p-value is greater than 0.05
- Not reject H_0 at the 5% level of significance
- Two variances are assumed to be equal

Equality of Variances				
Method	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Folded F	49	49	1.08	0.79

(Table 3)

$$H_0: \mu_{tissue} - \mu_{toilet} = 0 \quad vs \quad H_1: \mu_{tissue} - \mu_{toilet} \neq 0$$

- The p-value is greater than 0.05
- Not reject H_0 at the 5% level of significance
- Insufficient evidence to conclude two means are not different

Method	**Variances**	**DF**	**t Value**	**Pr > |t|**
Pooled	Equal	98	0.53	0.6006

(Table 4)

TWO MEANS ARE NOT DIFFERENT

t-test for means

$$H_0: \frac{\sigma^2_{tissue}}{\sigma^2_{kitchen}} = 1 \quad vs \quad H_1: \frac{\sigma^2_{tissue}}{\sigma^2_{kitchen}} \neq 1$$

- The p-value is less than 0.05
- Reject H_0 at the 5% level of significance
- Two variance are assumed to be unequal

Equality of Variances				
Method	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Folded F	49	49	4.73	<.0001

(Table 5)

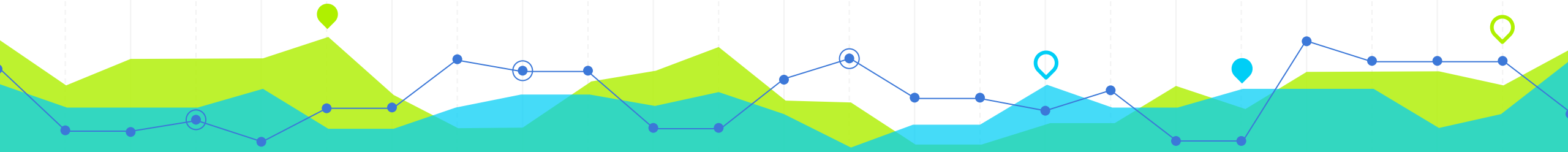
$$H_0: \mu_{kitchen} - \mu_{tissue} \leq 0 \quad vs \quad H_1: \mu_{kitchen} - \mu_{tissue} > 0$$

- The p-value is less than 0.05
- Reject H_0 at the 5% level of significance
- Sufficient evidence to conclude the means of kitchen paper greater than mini pocket paper

Method	Variances	DF	t Value	Pr > t
Satterthwaite	Unequal	68.83	6.21	<.0001

(Table 6)

KITCHEN PAPER ABSORBS MORE WATER



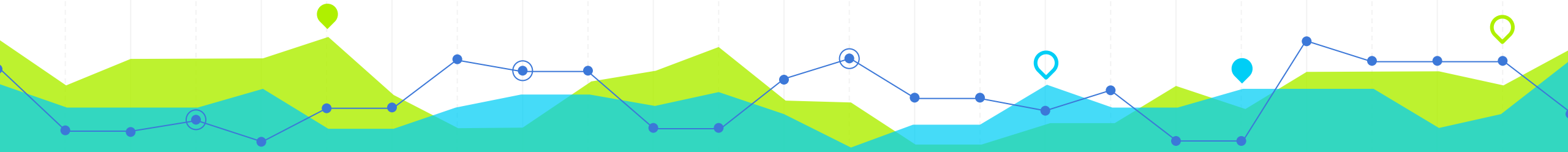
Discussion

Summarize the key points that we found

Discussion

- Fixed effects exist in our treatment
  - Different hydroscopic capacity among different types of paper
- Kitchen paper has the highest hygroscopic capacity
  - Absorbs 13.02g of water on average
- Mini pocket tissue and toilet paper are similar in water absorption
  - Mini pocket paper (9.88g)
  - Toilet paper (9.72g)

KITCHEN PAPER IS BETTER IN ABSORBING WATER



Conclusion

Conclusion

- Relationship between different types of paper towel and absorption of water
  - Winner: Kitchen paper
- Not a perfect pilot
  - Limited budget
    - Not using the precise tools
  - Social situation
    - Not able to buy different paper towels
- Further studies
  - Comprehensive comparing
- Using kitchen paper instead of others when cleaning

Thank you!