Section 1

The Structure of the Courses, the Delphi Method, the Purpose of MCS and its Background

Lecture 2

The Delphi Method - A Manual Simulation

The Purpose of this Lecture is to introduce the modern Delphi Method for estimation

It is really a “manual” way of conducting Monte Carlo Simulation . . .

Zeus, the Chief God of the Greeks, let out 2 eagles, one from the East and one from the West.
Where they met was called Delphi

The Temple of Apollo was the center of the Delphi Oracle
It was the home of Apollo's Priestess, Pythia . . .

The Modern **Delphi Method**

1) This is a method used for **Judgmental Forecasting**
2) It can be used in brainstorming meetings or when polling larger groups
3) It consolidates the views of **Experts** on a specific subject

Here is an example of the Delphi Method

Greek Myth
(1600 BCE to 300 BCE)

The Delphi Method at the **Institute of Engineering and Technology (IET)**, UK (1977)

Late 70s – The Rise of Microcomputers

A conference took place in London (1977) organized by IET in London

A group of engineers (say 237 for example), attended a whole day of lectures

A survey was conducted to poll their estimates of when various technological predictions will arise

Workout 1: The Delphi Method Survey

Each engineer was given a questionnaire with 10 questions
Each question asked **the engineer to indicate the future month when the event would happen**

Examples:
"When do you think we will have color monitors?" OR
"When do you think small companies will have computers?"

Engineers would mark the months on their cards

A Sample Card to be Filled by Each Engineer

The rows define the Questions

The columns indicate the month the Engineer selected

	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12
Question 1							✓					
Question 2										✓		
Question 3								✓				
Question 4									✓			
Question 5				✓								
Question 6					✓				✓			
Question 7											✓	

Let us say Question 3 asked :
"When will business users have color monitors?"

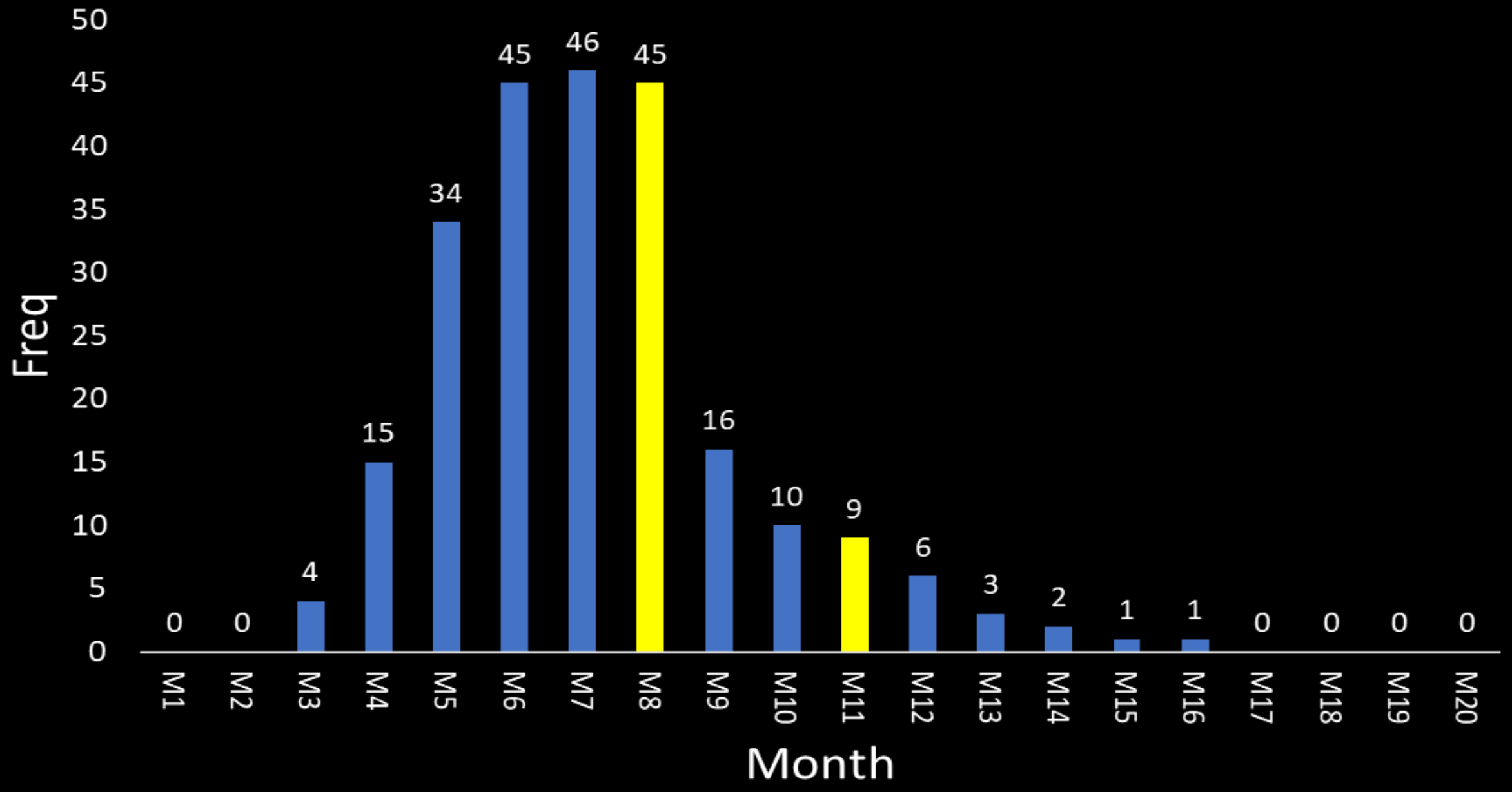
237 engineers responded
IET counted the number of responses received for each month
We call this count: "the frequency"

Examples:
45 engineers answered "M8" and
9 engineers answered "M11"
And so on . . .

The Freq Column was charted as a Bar Chart (or Histogram)

Month	Freq
M1	0
M2	0
M3	4
M4	15
M5	34
M6	45
M7	46
M8	45
M9	16
M10	10
M11	9
M12	6
M13	3
M14	2
M15	1
M16	1
M17	0
M18	0
M19	0
M20	0
Total	**237**

Q3: Frequency Chart for 20 Months



Then, IET calculated the **Cumulative Frequency**

The **Cum Freq** column sums the responses for each month before and including that month

Example: M8 shows a cumulative frequency = 189
= 0 + 0 + 4 + 15 + 34 + 45 + 46 + 45 = 189

We can read the entries in this column as follows:
189 engineers out of 237 believe users will have Color Monitors **up to and including** M8

Month	Freq	Cum Freq
M1	0	0
M2	0	0
M3	4	4
M4	15	19
M5	34	53
M6	45	98
M7	46	144
M8	45	189
M9	16	205
M10	10	215
M11	9	224
M12	6	230
M13	3	233
M14	2	235
M15	1	236
M16	1	237
M17	0	237
M18	0	237
M19	0	237
M20	0	237

Finally, they calculated the Cum Freq %, (our Objective)

The Cum Freq % is the proportion of the Cum Freq out of the total count

Cum Freq % = Cum Freq / 237

Example: M8 shows 189 / 237 = 0.80 = 80%

We read this as follows:

80% of the engineers believe users will have Color Monitors by M8 or earlier

Month	Freq	Cum Freq	Cum Freq %
M1	0	0	0.00
M2	0	0	0.00
M3	4	4	0.02
M4	15	19	0.08
M5	34	53	0.22
M6	45	98	0.41
M7	46	144	0.61
M8	45	189	0.80
M9	16	205	0.86
M10	10	215	0.91
M11	9	224	0.95
M12	6	230	0.97
M13	3	233	0.98
M14	2	235	0.99
M15	1	236	1.00
M16	1	237	1.00
M17	0	237	1.00
M18	0	237	1.00
M19	0	237	1.00
M20	0	237	1.00
Total	**237**		

The Cumulative Frequency % is often called Relative Cumulative Frequency

The Cumulative Frequency % is at the heart of Monte Carlo Simulation analysis . . .

Note that **we do not need** to use the **Cum Freq** to get to the **Cum Freq %**

We can calculate it directly from the **Freq** column

Month	Freq	Cum Freq	Cum Freq %
M1	0	0	0.00
M2	0	0	0.00
M3	4	4	0.02
M4	15	19	0.08
M5	34	53	0.22
M6	45	98	0.41
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M16	1	1.00
M17	0	1.00
M18	0	1.00
M19	0	1.00
M20	0	1.00
Total	**237**	

Reading the Cum Freq % . . .

Since the answer of 80% of the engineers (scenarios) to Question 3 was 8 months or earlier . . .

We are 80% confident our estimate is 8 month or less

This confidence can also be expressed as a risk . . .

If someone uses an estimate that is > 8 months . . . there will be a 20% probability that estimate would be wrong

Month	Freq	Cum Freq %
M1	0	0.00
M2	0	0.00
M3	4	0.02
M4	15	0.08
M5	34	0.22
M6	45	0.41
M7	46	0.61
M8	45	0.80
M9	16	0.86
M10	10	0.91
M11	9	0.95
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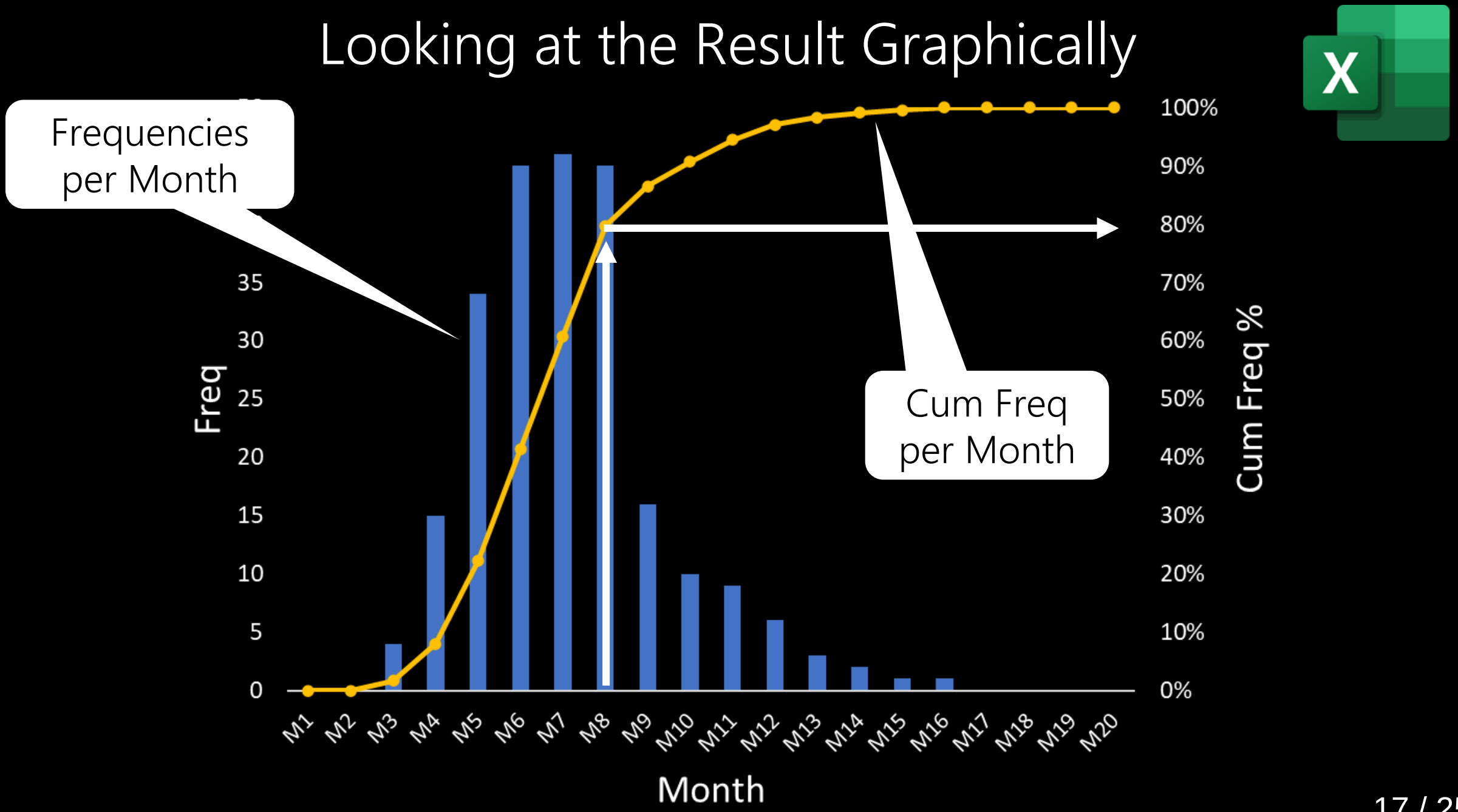
M14	2	0.99
M15	1	1.00
M16	1	1.00
M17	0	1.00
M18	0	1.00
M19	0	1.00
M20	0	1.00
Total	**237**	

Looking at the Result Graphically



Workout 2: Delphi Method Survey (Cost)

Another Estimate . . .

237 Engineers estimated the price of a Color Monitor

The following table shows their responses

Q3 Cost of Monitors: Response of 237 Engineers

354	415	349	374	397	368	412	466	444	435	289	321	455	411	432
367	403	370	317	401	415	394	299	311	396	405	351	450	458	419
440	332	455	458	322	438	363	462	450	360	449	284	404	393	348
432	453	360	488	489	415	384	511	302	324	444	367	450	352	372
344	424	443	438	486	370	397	421	387	406	325	337	378	307	432
311	353	433	410	398	369	425	410	383	454	406	389	371	410	368
405	347	475	409	425	417	373	480	468	448	364	455	409	463	491
397	405	401	354	388	418	390	410	384	359	423	431	384	494	347
368	432	394	357	304	356	390	458	455	310	383	387	327	427	430
295	427	398	366	472	452	457	317	338	422	428	304	432	420	371
367	401	476	312	453	468	457	322	316	377	350	443	305	458	430
421	355	409	500	321	446	404	462	365	338	420	376	473	370	394
398	409	441	318	477	328	369	507	362	307	388	375	323	358	331
506	321	413	391	322	446	361	356	379	499	356	355	461	317	325
413	353	399	410	378	401	347	447	426	472	358	424	333	462	491
302	428	313	355	340	474	380	398	409	393	415	411			

Again, we prepare a frequency table containing the number of responses (or its frequency) for each estimated price

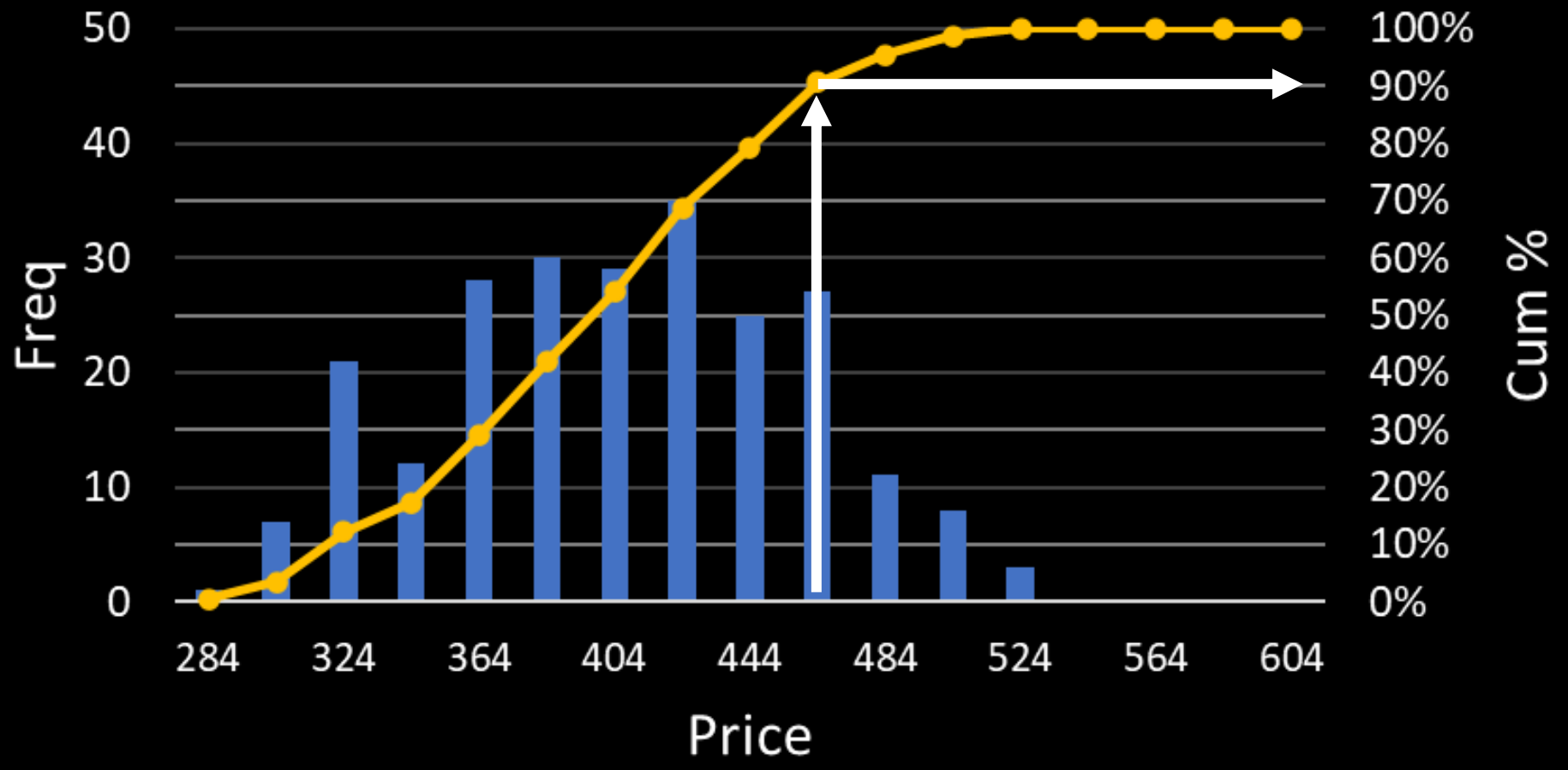
. . . and

The related Cumulative Freq %

We can pick the Price (464) on the Table which gives us a 90% confidence (approx.)

Price	Freq	Cum %
284	1	0.00
304	7	0.03
324	21	0.12
344	12	0.17
364	28	0.29
384	30	0.42
404	29	0.54
424	35	0.69
444	25	0.79
464	27	0.91
484	11	0.95
504	8	0.99
524	3	1.00
544	0	1.00
564	0	1.00
584	0	1.00
604	0	1.00
Total	237	

The **Frequency** and **Cumulative Frequency %** of the Price of a Monitor



Result: Consolidation of the Estimate

The method does not give us a single estimate
It gives us a range measured by the Cumulative Frequency %
(Later, we will see how this range is really a probability)

Our Random Variable X is the Month . . .

X is plotted on the horizontal Axis
Frequency is plotted on the Left Vertical Axis
Cum Frequency % is plotted on the Right Vertical Axis

Benefits

1) The method's first benefit is to give an estimate with a probabilistic confidence
2) It can help us identify extreme estimates or outliers
3) We can state the risk of wrong estimates
4) The large number of responses gives us an objective estimate

Conclusion:

We will learn how to setup these tables and charts soon

We will also extract from the same table many more results:

1) Descriptive Statistics
2) Confidence Intervals of estimates
3) Sensitivity and Influence Analysis
4) Test if the Frequency Chart is a Normal Curve (or another)

Thank you for viewing this lecture.