



Spreadsheet functions

How to use logic functions in Sheets

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“Logic is not a body of doctrine, but a
mirror-image of the world. Logic is
transcendental.”

– Ludwig Wittgenstein

Data overview

To investigate how we can use spreadsheet functions in data analytics, we will use two datasets: one on food crops and the other on their subsidies.

1. Average retail market prices of selected food crops, 2014–2018

A Kenyan dataset containing prices for selected food crops during the months of March and September for the years 2014–2018.

2. Food crops subsidies 2014–2018

A dataset indicating the subsidies the Kenyan government provided for all food crops during the months of March and September for the years 2014–2018.



Dataset 1

	A	B	C	D	E	F	G	H	I	J	K
1		2014		2015		2016		2017		2018	
2	Crop	Mar	Sept	Mar	Sept	Mar	Sept	Mar	Sept	Mar	Sept
3	Maize	38.24	35.47	33.19	33.77	33.92	35.10	48.02	43.86	41.32	30.87
4	Beans	77.16	74.67	77.56	77.08	76.74	74.36	93.96	87.46	88.10	70.86
5	Finger Millet	78.90	79.29	83.71	88.86	84.03	84.62	108.59	105.20	107.69	89.73
6	Sorghum	54.07	54.01	55.51	53.60	54.36	52.58	72.65	64.85	73.41	54.68
7	Potatoes	31.20	30.33	34.46	34.11	39.56	38.91	55.96	30.67	41.54	55.51
8	Cabbages	24.67	24.75	38.86	22.17	25.71	31.73	37.54	29.79	32.87	26.28
9	Tomatoes	58.70	68.11	68.09	55.03	70.23	52.60	73.84	79.82	65.29	63.76
10	Bananas	42.50	42.46	37.26	37.46	37.36	41.82	49.18	50.68	45.57	50.81
11											



Dataset 2

	A	B	C	D	E	F	G	H	I	J
1	2014		2015		2016		2017		2018	
2	March	September	March	September	March	September	March	September	March	September
3	10.00%	8.00%	11.00%	11.00%	15.00%	22.00%	20.00%	0.00%	0.00%	25.00%
4										

The IF and IFS functions

IF is used to return one value if a logical expression evaluates to **TRUE** and another if it evaluates to **FALSE**. **IFS** evaluates **multiple conditions** and returns a value that corresponds to the **first TRUE** condition.

```
=IF(logical_expression, value_if_true, value_if_false)
```

```
=IFS(condition1, value1, [condition2, value2, ...])
```

- **logical_expression** – An expression or cell reference containing an expression that represents some logical value (**TRUE** or **FALSE**).
- **value_if_true** – The value the function returns if **logical_expression** is **TRUE**.
- **value_if_false** – [OPTIONAL] The value the function returns if **logical_expression** is **FALSE**.
- **condition1** – The first condition to be evaluated. This can be a boolean, a number, or a reference to any of those.
- **value1** – The returned value if **condition1** is **TRUE**.
- **[condition2, value2, ...]** – Additional conditions and values if the previous ones are evaluated as **FALSE**.

The IF and IFS functions

Example use:

- 01.** For March 2014 prices **less than KSh 50**, categorize as “cheap”. **Otherwise**, categorize as “expensive.”

Our task is to separate our list of food crops into two categories based on their prices. Food crops that are less than KSh 50 we will tag as “cheap”, while those equal to or more than KSh 50 will be tagged as “expensive”.

01.

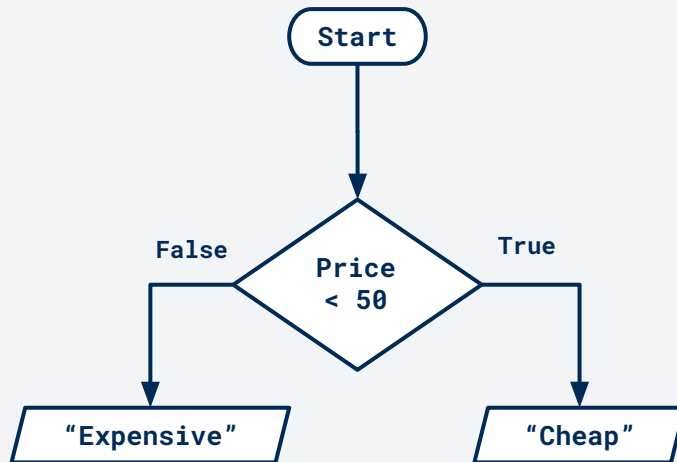
If **price** < 50

– Output = “Cheap”

Else

– Output = “Expensive”

01.



The IF and IFS functions

Example use:

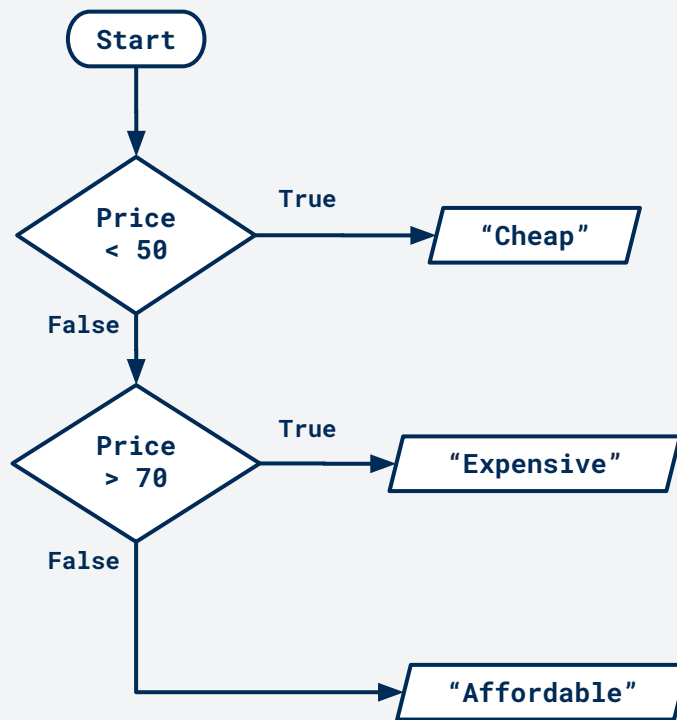
- 02.** For March 2014 prices **less than KSh 50**, categorize as “cheap”, **more than KSh 70**, categorize as “expensive” and **the rest**, categorize as “affordable”.

Our second task has three categories, which means that we will have to expand the pseudocode for our **If** statement by adding an **Else if**.

02.

```
If price < 50
- Output = "Cheap"
Else if price > 70
- Output = "Expensive"
Else
- Output = "Affordable"
```

02.



The IF and IFS functions

Example use:

01. Since the first task has only **two conditions** (“cheap” or “expensive”), we will use an **IF function** which evaluates Boolean expressions.
02. The second task has **more than two conditions** (“cheap”, “affordable”, or “expensive”) and will therefore be better evaluated with an **IFS function**.

D3	\downarrow	\mathcal{F}_X	=IF(B3<50, "Cheap", "Expensive")
E3	\downarrow	\mathcal{F}_X	=IFS(B3<50, "Cheap", B3>70, "Expensive", B3<70, "Affordable")

	A	B	C	D	E	F
1	Original average retail prices					
2	Crop	March	September	< 50 >	< 50, > 70 <	
3	Maize	38.24	01.	Cheap	Cheap	02.
4	Beans	77.16	74.67	Expensive	Expensive	
5	Finger Millet	78.90	79.29	Expensive	Expensive	
6	Sorghum	54.07	54.01	Expensive	Affordable	
7	Potatoes	31.20	30.33	Cheap	Cheap	
8	Cabbages	24.67	24.75	Cheap	Cheap	
9	Tomatoes	58.70	68.11	Expensive	Affordable	
10	Bananas	42.50	42.46	Cheap	Cheap	

+	☰	2014	2015	2016	2017	2018	Subs...
---	---	------	------	------	------	------	---------

01. Enter the formula `=IF(B3<50, "Cheap", "Expensive")` on cell D3.
02. Enter the formula `=IFS(B3<50, "Cheap", B3>70, "Expensive", B3<70, "Affordable")` on cell E3.

The alternative IF functions

IFERROR and **IFNA** functions are used to catch and handle errors in a formula.

```
=IFERROR(value, [value_if_error])
```

```
=IFNA(value, value_if_na)
```

- **value** – The value to return if **value** itself is not an error (**IFERROR**) or the value to check if it is an #N/A error (**IFNA**).
- **[value_if_error]** – [OPTIONAL] The value returned if **value** is an error.
- **value_if_na** – The value to return if **value** is an #N/A error.

IFERROR function returns the first argument if it is not an error value; otherwise, it returns the second argument if present or a blank if the second argument is absent.

IFNA function evaluates a value and returns the specified value if the value is an #N/A error.

The alternative IF functions

Example use:

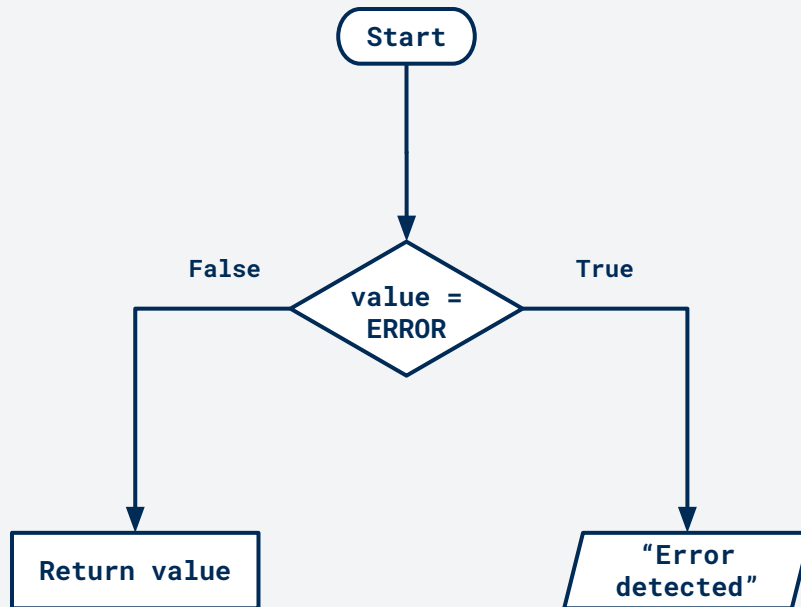
01. Detect price values that have an **error**.

If value = **ERROR**

- Output = "Error detected"

Else

- Return value



The alternative IF functions

Example use:

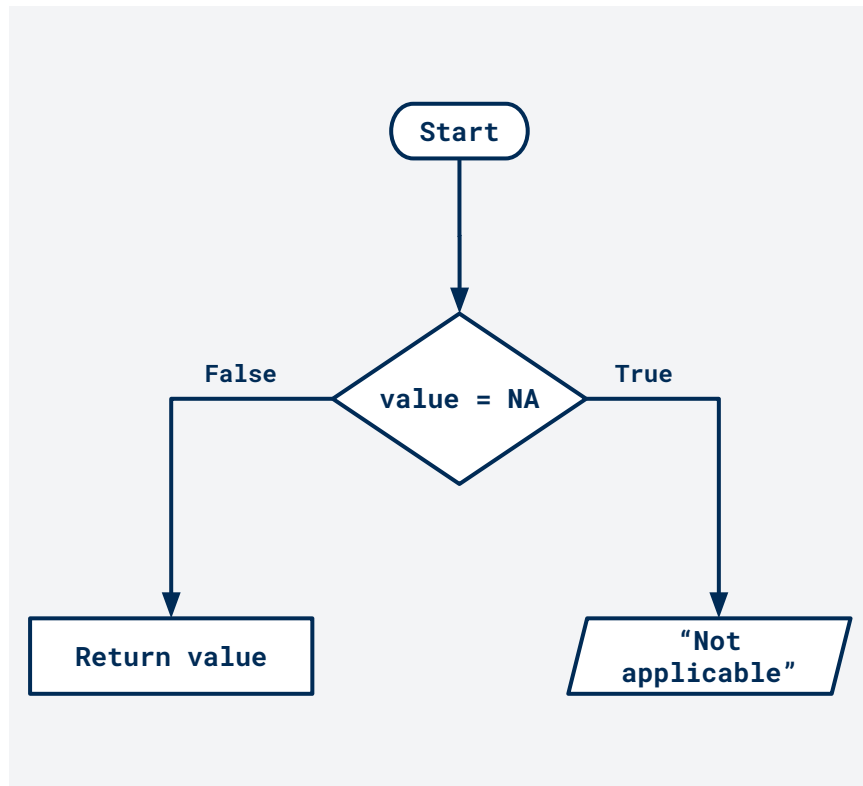
02. Detect price values that have values that are **not applicable**.

If value = NA

- Output = "Not applicable"

Else

- Return value



The alternative IF functions

Example use:

01. **IFERROR** can detect any type of error and will therefore detect **#N/A** errors among other errors.
02. **IFNA**, however, only detects **#N/A** errors and will not pick up on any other types of errors.

01. Enter the formula `=IFERROR(B3:C10, "Error detected.")` in cell D3 and press **ENTER**.

02. Enter the formula `=IFNA(B3:C10, "Not applicable.")` in cell D3 and press **ENTER**.

D3				<code>=IFERROR(B3:C10, "Error detected.")</code>	01.
	A	B	C	D	E
1	Original average retail prices				
2	Crop	March	September	Detected errors	
3	Maize	38.24	35.47	38.24	35.47
4	Beans	77.16	74.67	77.16	74.67
5	Finger Millet	78.90	#N/A	78.9	Error detected.
6	Sorghum	54.07	54.01	54.07	54.01
7	Potatoes	#DIV/0!	30.33	Error detected.	30.33
8	Cabbages	24.67	24.75	24.67	24.75
9	Tomatoes	58.70	68.11	58.7	68.11
10	Bananas	#ERROR!	42.46	Error detected.	42.46

D3				<code>=IFNA(B3:C10, "Not applicable.")</code>	02.
	A	B	C	D	E
1	Original average retail prices				
2	Crop	March	September	Detected NAs	
3	Maize	38.24	35.47	38.24	35.47
4	Beans	77.16	74.67	77.16	74.67
5	Finger Millet	78.90	#N/A	78.9	Not applicable.
6	Sorghum	54.07	54.01	54.07	54.01
7	Potatoes	#DIV/0!	30.33	#DIV/0!	30.33
8	Cabbages	24.67	24.75	24.67	24.75
9	Tomatoes	58.70	68.11	58.7	68.11
10	Bananas	#ERROR!	42.46	#ERROR!	42.46

The alternative IF functions

SUMIF is used to **add up** the value of cells within a range that meet **a certain condition** while **SUMIFS** **adds up** the value of cells within a range that meet **multiple conditions**.

```
=SUMIF(range, criterion, [sum_range])
```

```
=SUMIFS(sum_range,criteria_range1,criterion1,[criteria_range2,criterion2,...])
```

- **range** – The range that is tested against the **criterion**.
- **criterion** – The pattern or test to apply to **range**.
- **sum_range** – [OPTIONAL for **SUMIF** if different from **range**] The range to be summed.
- **criteria_range1** – The range to check against **criterion1**.
- **criterion1** – The pattern or test to apply to **criteria_range1**.
- **criteria_range2, criterion2, ...** – [OPTIONAL] Additional ranges and criteria to check.

The alternative IF functions

Example use:

01. **Sum up** the prices of all food crops that were **more than KSh 50** in March 2014.

Input $\{p_1, \dots, p_n\}$

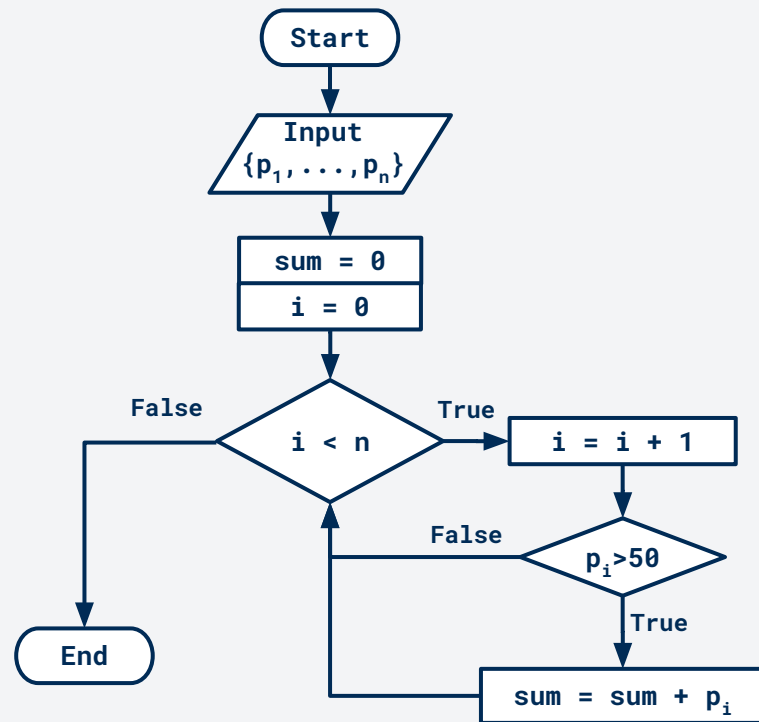
sum = 0

i = 0

While $i < n$ do

- $i = i + 1$
- If $p_i > 50$
- - $\text{sum} = \text{sum} + p_i$

Let the set of prices in March 2014 be represented by $\{p_1, \dots, p_n\}$ where n is the number of prices in the list.



The alternative IF functions

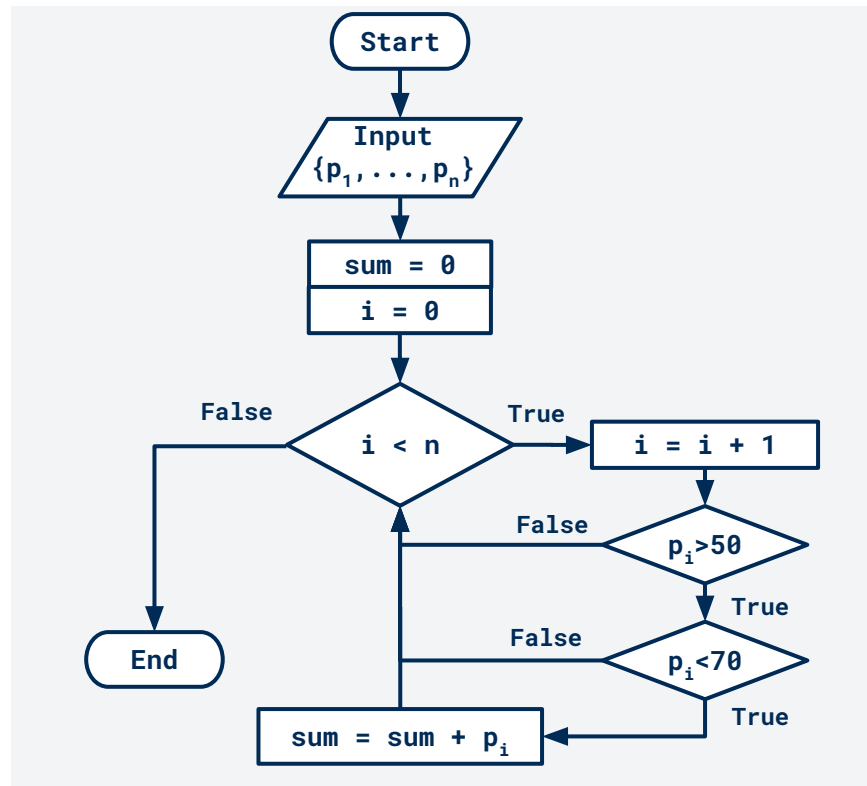
Example use:

- 02. Sum up** the prices of all food crops that were **more than KSh 50** but **less than KSh 70** in March 2014.

```
Input  $\{p_1, \dots, p_n\}$   
sum = 0  
i = 0
```

```
While  $i < n$  do  
-  $i = i + 1$   
- If  $p_i > 50$   
- - If  $p_i < 70$   
- - -  $sum = sum + p_i$ 
```

Let the set of prices in March 2014 be represented by $\{p_1, \dots, p_n\}$ where n is the number of prices in the list.



The alternative IF functions

Example use:

Our **SUMIF's range** will be the same as the **sum_range** and, therefore, **sum_range** will not be included in our function.

SUMIFS will use the same range of cells for both **criteria_range1** and **criteria_range2** as well as **sum_range**.

01. Enter the formula **=SUMIF(B3:B10, ">50")** in cell E3 and press **ENTER**.

02. Enter the formula **=SUMIFS(B3:B10,B3:B10,">50",B3:B10,"<70")** in cell E6 and press **ENTER**.

E3

fx

=SUMIF(B3:B10, ">50")

01.

E6

fx

=SUMIFS(B3:B10,B3:B10,">50",B3:B10,"<70")

02.

	A	B	C	D	E		
1	Original average retail prices						
2	Crop	March	September	SUMIF: March prices>50			
3	Maize	38.24	35.47	01.	268.83		
4	Beans	77.16	74.67	SUMIFS: March 50<price<70			
5	Finger Millet	78.90	79.29				
6	Sorghum	54.07	54.01	02.	112.77		
7	Potatoes	31.20	30.33				
8	Cabbages	24.67	24.75				
9	Tomatoes	58.70	68.11				
10	Bananas	42.50	42.46				
11							
	+	2014	2015	2016	2017	2018	Subsidies

The alternative IF functions

COUNTIF function **counts cells** in a range that meet **a single condition** while **COUNTIFS** function **counts cells** in a range that meet **multiple conditions**.

```
=COUNTIF(range, criterion)
```

```
=COUNTIFS(criteria_range1,criterion1,[criteria_range2,...],[criterion2,...])
```

- **range** – The range that is tested against **criterion**.
- **criterion** – The pattern or test to apply to **range**.
- **criteria_range1** – The range to check against **criterion1**.
- **criterion1** – The pattern or test to apply to **criteria_range1**.
- **criteria_range2, criterion2...** – [OPTIONAL] Additional ranges and criteria to check.

The alternative IF functions

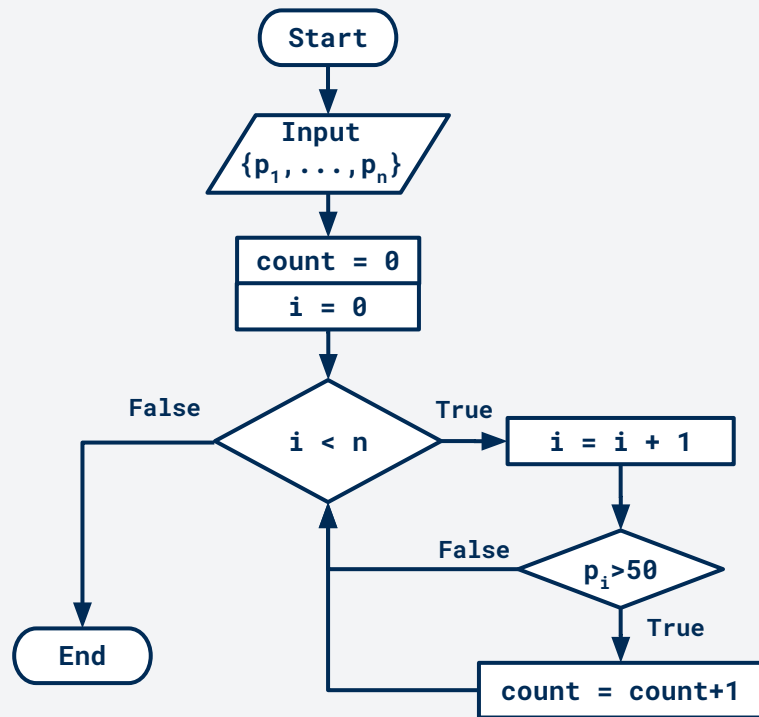
Example use:

01. **Count** the number of cells containing food crop prices that were **more than KSh 50** in March 2014.

```
Input {p1, ..., pn}  
count = 0  
i = 0
```

```
While i < n do  
- i = i + 1  
- If pi > 50  
- - count = count + 1
```

We see that our *logic* remains the same as per our sum example.



The alternative IF functions

Example use:

- 02. Count** the number of cells containing food crop prices that were **more than KSh 50** but **less than KSh 70** in March 2014.

Input $\{p_1, \dots, p_n\}$

count = 0

i = 0

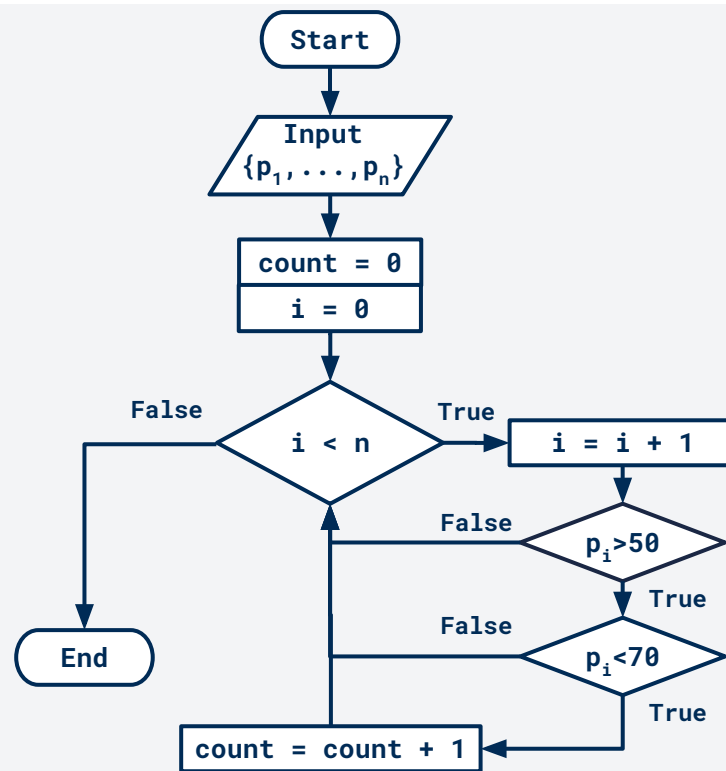
While $i < n$ do

- $i = i + 1$

- If $p_i > 50$

- - If $p_i < 70$

- - - count = count + 1



The alternative IF functions

Example use:

The **range** on **COUNTIF** as well as **criteria_range1** and **criteria_range2** on **COUNTIFS** will be the column that contains prices for the month of **March**.

Our statements will be **exclusive** of the given **price boundaries** since we want to count values that are **more than** KSh 50 for the first problem and **more than** KSh 50 and **less than** KSh 70 for the second problem.

01. Enter the formula `=COUNTIF(B3:B10, ">50")` in cell E3 and press **ENTER**.

02. Enter the formula `=COUNTIFS(B3:B10, ">50", B3:B10, "<70")` in cell E6 and press **ENTER**.

E3	▼	<i>fx</i>	=COUNTIF(B3:B10, ">50")	01.	
E6	▼	<i>fx</i>	=COUNTIFS(B3:B10, ">50", B3:B10, "<70")	02.	
	A	B	C	D	E
1	Original average retail prices				
2	Crop	March	September		COUNTIF: March prices>50
3	Maize	38.24	35.47	01.	4
4	Beans	77.16	74.67		
5	Finger Millet	78.90	79.29		COUNTIFS: March 50<price<70
6	Sorghum	54.07	54.01	02.	2
7	Potatoes	31.20	30.33		
8	Cabbages	24.67	24.75		
9	Tomatoes	58.70	68.11		
10	Bananas	42.50	42.46		
11					
+ ≡ 2014 ▼ 2015 ▼ 2016 ▼ 2017 ▼ 2018 ▼ Subsidies ▼					

The SWITCH function

SWITCH evaluates a **logical expression** and **matches** it with **one of the cases** available. It then returns the **value** defined in that **case block**. If there is no matching case, it returns the **default** value.

```
=SWITCH(expression, case1, value1, [case2_or_default, ...], [value2, ...])
```

- **expression** – The value(s) to be evaluated.
- **case1** – The first case to be checked against **expression**.
- **value1** – The corresponding value to be returned when **case1** matches **expression**.
- **case2_or_default...** – [OPTIONAL] Additional cases to try if the previous ones don't match **expression**, or an optional default value to be returned if none of the cases match **expression**.
- **value2...** – [OPTIONAL] Additional values to be returned if their corresponding cases match **expression**.

The SWITCH function

Example use:

Let's say we want to **categorize** the food crops. We will list cases with the least number of items first and let the default have the most number of items.

Based on our list of food crops, our categories are **Legume**, **Vegetable**, **Fruit**, and **Grain**.

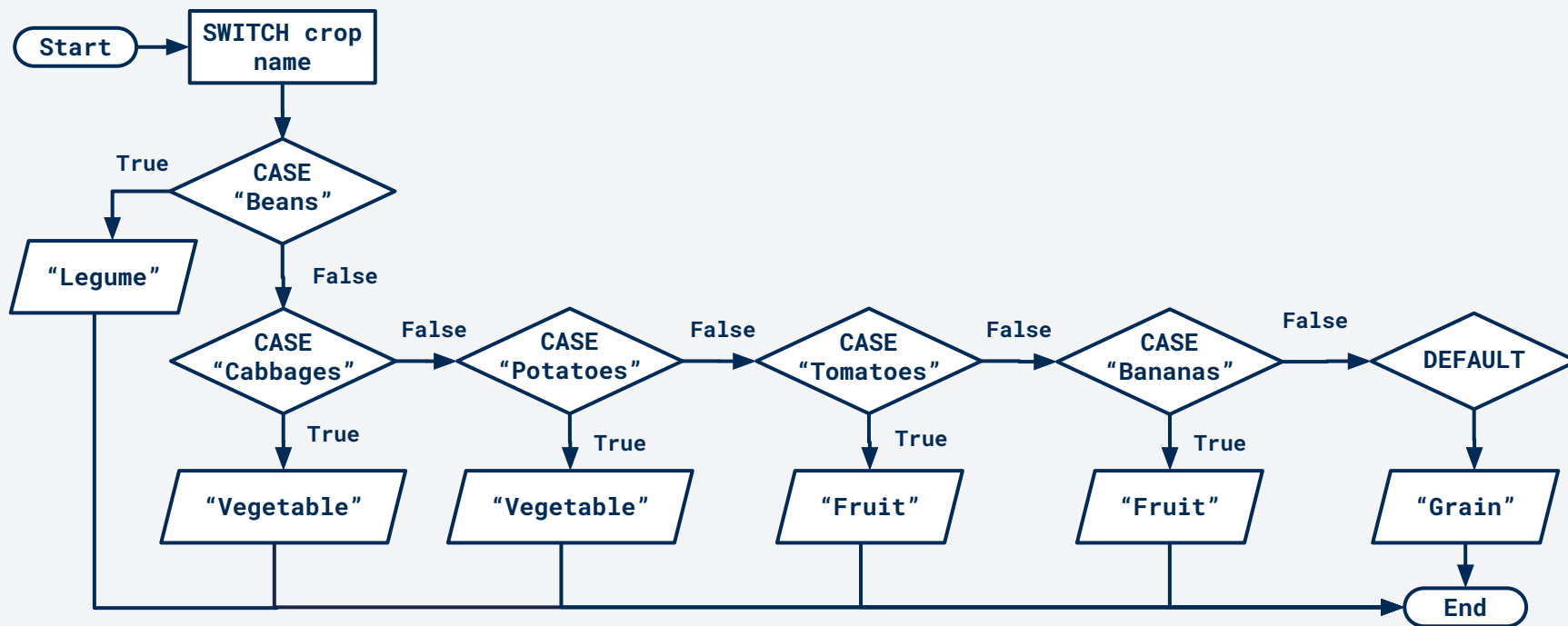
1. **Legume** has *one* crop: **beans**.
2. **Vegetable** has *two* crops: **cabbages** and **potatoes**.
3. **Fruit** has *two* crops: **tomatoes** and **bananas**.
4. **Grain** has *three* crops: **maize**, **sorghum**, and **finger millet**.

Since **Grain** has the most number of crops, we will make it the **default** case.

```
SWITCH crop name
- CASE "Beans"
- - Output = "Legume"
- CASE "Cabbages"
- - Output = "Vegetable"
- CASE "Potatoes"
- - Output = "Vegetable"
- CASE "Tomatoes"
- - Output = "Fruit"
- CASE "Bananas"
- - Output = "Fruit"
- DEFAULT
- - Output = "Grain"
```

The SWITCH function

Example use:



The SWITCH function

D4

=SWITCH(A4:A11, "Beans", "Legume",
"Cabbages", "Vegetable",
fx "Potatoes", "Vegetable",
"Tomatoes", "Fruit",
"Bananas", "Fruit", "Grain")

	A	B	C	D
1	Original average retail prices			
2		KSh per Kg		Food crop category
3	Crop	March	September	
4	Maize	38.24	35.47	Grain
5	Beans	77.16	74.67	Legume
6	Finger Millet	78.90	79.29	Grain
7	Sorghum	54.07	54.01	Grain
8	Potatoes	31.20	30.33	Vegetable
9	Cabbages	24.67	24.75	Vegetable
10	Tomatoes	58.70	68.11	Fruit
11	Bananas	42.50	42.46	Fruit
<div><div><div>+</div><div>≡</div></div><div>2014</div><div>2015</div><div>2016</div><div>2017</div></div>				

Example use:

The **order** in which we list our cases will determine **how long** our **SWITCH** statement will be.

01. Enter the formula `=SWITCH(A4:A11, "Beans", "Legume", "Cabbages", "Vegetable", "Potatoes", "Vegetable", "Tomatoes", "Fruit", "Bananas", "Fruit", "Grain")` in cell D4.
02. Press **Enter**.

Try rewriting the statement below with **"Tubers"** as your default to see the length difference.

SWITCH versus IFS

Both **SWITCH** and **IFS** are logical functions that allow you to perform different actions based on multiple conditions. However, there are some scenarios where you may prefer to use **SWITCH** over **IFS**, or vice versa.

SWITCH is preferred when:

1. You have a **single value or cell** that you want to match with **multiple possible outcomes**.
2. You want to **avoid evaluating unnecessary conditions**. With **IFS**, all conditions are evaluated, even if one of the earlier conditions is true. With **SWITCH**, only the condition that matches the specified value is evaluated, which saves processing time.

IFS is often more flexible than **SWITCH** because it can handle a broader range of conditions and outcomes.

IFS is more flexible than **SWITCH** because:

1. It allows you to evaluate **multiple conditions**, whereas **SWITCH** only allows you to **match a single value with multiple outcomes**. This means that if you have multiple conditions that you need to evaluate, you can use **IFS** to handle all of them.
2. It allows you to **specify different outcomes** based on the conditions that are met. This means that you can use formulas to **calculate outcomes** based on the data in your sheet.

Other logic functions

The **AND** function returns **TRUE** if **all** of the provided arguments **are logically true** and **FALSE** if any of the provided arguments **are logically false**, while the **NOT** function returns the **opposite** of a logical value.

```
=AND(logical_expression1, (logical_expression2, ...])
```

```
=NOT(logical_expression)
```

- **logical_expression/logical_expression1** – An expression that represents some logical value, i.e. TRUE or FALSE, or an expression that can be coerced to a logical value.
- **logical_expression2...** – [OPTIONAL] More expressions that represent logical values.

Examples:

- **=AND(TRUE, FALSE, TRUE)** returns **FALSE**
- **=AND(FALSE, FALSE, FALSE)** returns **FALSE**
- **=AND(TRUE, TRUE, TRUE)** returns **TRUE**
- **=NOT(TRUE)** returns **FALSE**
- **=NOT(FALSE)** returns **TRUE**

Note: The number 0 is logically False; all other numbers (including negative numbers) are logically True.

Other logic functions

The **OR** function returns **TRUE** if **any** argument **is logically true**, and **FALSE** if **all** arguments **are logically false**, while **XOR** returns **TRUE** if an **odd number of arguments are logically true**, and **FALSE otherwise**.

```
=OR(logical_expression1, [logical_expression2, ...])  
=XOR(logical_expression1, [logical_expression2, ...])
```

- **logical_expression1** – An expression that represents some logical value, i.e., TRUE or FALSE, or an expression that can be coerced to a logical value.
- **logical_expression2...** – [OPTIONAL] More expressions that represent logical values.

Examples:

- **=OR(TRUE, FALSE, TRUE)** returns **TRUE**
- **=OR(FALSE, FALSE, FALSE)** returns **FALSE**
- **=OR(TRUE, TRUE, TRUE)** returns **TRUE**
- **=XOR(TRUE, FALSE, TRUE)** returns **FALSE**
- **=XOR(FALSE, FALSE, TRUE)** returns **TRUE**

Other logic functions

Example use:

For 2014, tag all food crops as either **rising price trend** if the price in **September is higher than that in March** or **dropping price trend** if the price in **September is lower than the price in March**.

For this problem, we need to identify a trend for each food crop from March to September based on whether a crop's price went up or down.

We also have to ensure that the trend is true for both the **original retail prices** and **subsidised retail prices**.

Since we have not been told what to do with crops that don't fall in the category of dropping or rising price trend, we will create a third label called **unidentified trend** to cater for this.

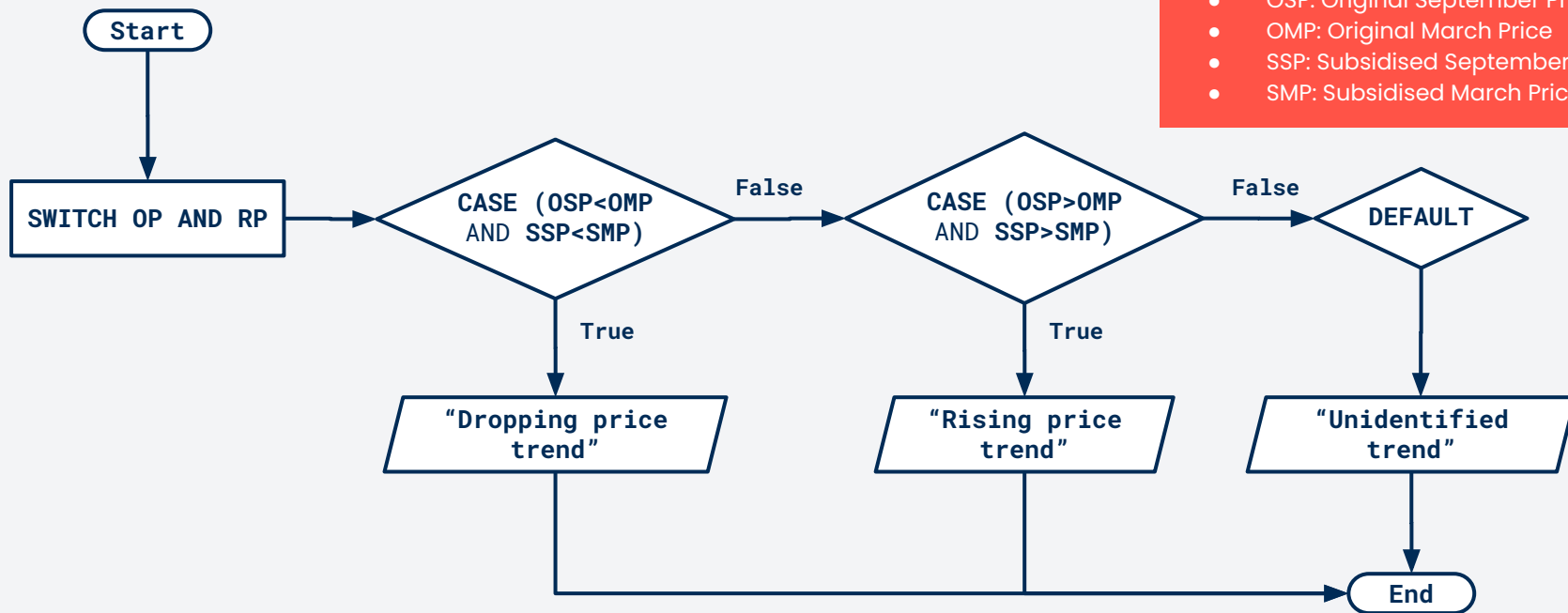
Let **original retail price** in **Sept** be **OSP** and in **March**, **OMP**. Let **the subsidized retail price** in **Sept** be **SSP** and in **March** **SMP**. Also, let all original prices be **OP** and all retail prices be **RP**.

SWITCH **OP** AND **RP**

- CASE(**OSP** < **OMP** AND **SSP** < **SMP**)
 - - Output = "**Dropping price trend**"
- CASE(**OSP** > **OMP** AND **SSP** > **SMP**)
 - - Output = "**Rising price trend**"
- DEFAULT
 - - Output = "**Unidentified trend**"

Other logic functions

Example use:



- OP: Original Prices
- SP: Subsidised Prices
- OSP: Original September Price
- OMP: Original March Price
- SSP: Subsidised September Price
- SMP: Subsidised March Price

Other logic functions

Example use:

Our **SWITCH** function will evaluate prices in both the original and subsidized retail prices, so the **expression** will be an **AND** function. Our first two cases will check for conditions using the original and subsidized tables and will also be **AND** functions. Our default case will be crops that **didn't fit** into either of the first two cases.

01. Enter the formula
`=SWITCH(AND(B3:C10,F3:G10), AND(C3<B3, G3<F3), "Dropping price trend", AND(C3>B3, G3>F3), "Rising price trend", "Unidentified price trend")` on cell J3.
02. Replicate the formula by dragging the fill handle down.

J3	<div> <div>fx</div> <div>=SWITCH(AND(B3:C10,F3:G10), AND(C3<B3, G3<F3), "Dropping price trend", AND(C3>B3, G3>F3), "Rising price trend", "Unidentified price trend")</div> </div>									
	A	B	C	D	E	F	G	H	I	J
1	Original average retail prices				Subsidised average retail prices				Price trend	
2	Crop	March	September		Crop	March	September		Crop	Trend
3	Maize	38.24	35.47		Maize	34.42	32.63		Maize	Dropping price trend
4	Beans	77.16	74.67		Beans	69.44	68.70		Beans	
5	Finger Millet	78.90	79.29		Finger Millet	71.01	72.95		Finger Millet	