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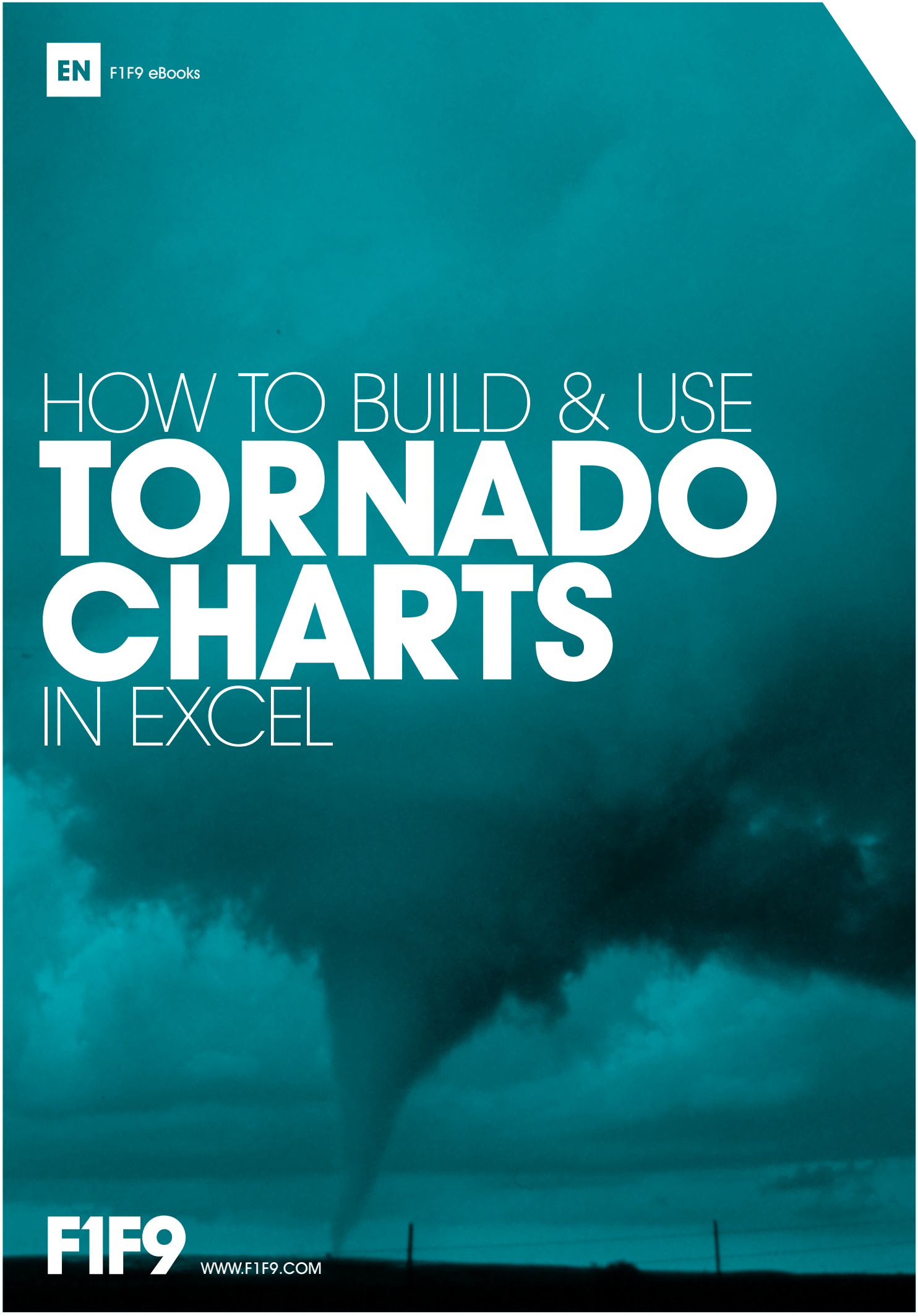
HOW TO BUILD & USE TORNADO CHARTS IN EXCEL



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CONTENTS

DESPITE OUR BEST EFFORTS, OUR ABILITY TO PREDICT THE FUTURE IS LIMITED.

THE VARIABLES IN ANY ANALYSIS HAVE A RANGE OF VALUES WITH DIFFERENT PROBABILITIES OF HAPPENING AT ANY TIME.

EN

ABOUT F1F9

F1F9 provides financial modelling and business forecasting support to blue chip clients and medium-sized corporates. We also teach financial modelling skills to companies around the world. Our clients have access to high quality, low-cost modelling support delivered by over 40 professional modellers.

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F1F9 ENERGY & NATURAL RESOURCES TEAM

F1F9's dedicated Energy & Natural Resources modelling team is led by Daniel Prinsloo. Daniel has more than 20 years of Energy & Natural Resources experience. With a strong technical background in chemical and process engineering and a further qualification in computer science, Daniel has worked in a number of major commercial functions and gained extensive experience in strategy development, project evaluation, business development and commercial agreements.

Daniel's commercial negotiation and valuation experience covers Algeria, Australia, China, Iran, Latvia, Lithuania, Malaysia, Netherlands, Nigeria, Qatar, Russia, South Africa, Tanzania and the United Kingdom. He has a proven ability in the development of multibillion dollar energy investment opportunities and providing the financial models used to support these investments while ensuring high standards of quality control are maintained.

DANIEL PRINSLOO
DIRECTOR, ENERGY & NATURAL RESOURCES

WHAT IS A TORNADO CHART?

A tornado chart is a type of bar chart that is used as a graphical means of displaying the results of a deterministic analysis to show the most important input variables.

It indicates how much each variable contributes to the swing in a specific metric when all other variables are at their base value.

These charts show the results of single factor sensitivity analysis, i.e. outcomes displayed by changing one variable at a time. The variables are positioned on the chart vertically, rather than horizontally, in such a way that the largest swing appears at the top of the chart, the second largest appears second from the top and so on, with the lowest swing appearing at the bottom of the chart. Hence, the final chart visually resembles either one half of, or a complete, tornado.

Tornado charts display the result of single variable sensitivity analysis, i.e. outcomes displayed by changing each variable one at a time.

Tornado charts are also known as "tornado diagrams", "tornado plots" or "sensitivity charts".

WHY BUILD A TORNADO CHART?

While forecasting, the key question that needs to be answered is: *Is the forecast precise enough to make a confident decision?* If the answer is no, then you need to gather more information. The tornado chart is one of the most useful and easy-to-understand methods to assess confidence in a forecast.

Using a tornado chart, you can assess how much the forecast might change if things go better or worse than anticipated.

You can also assess which uncertainties have the greatest impact on the forecast —those are the very inputs you should research further if the forecast precision needs to be tightened up.

Tornado charts provide insight into how a decision problem, i.e. outcome (such as IRR, NPV, etc.), can vary if the future looks different for a suite of single input assumptions. The objective of plotting a tornado chart (sensitivity analysis) is to:

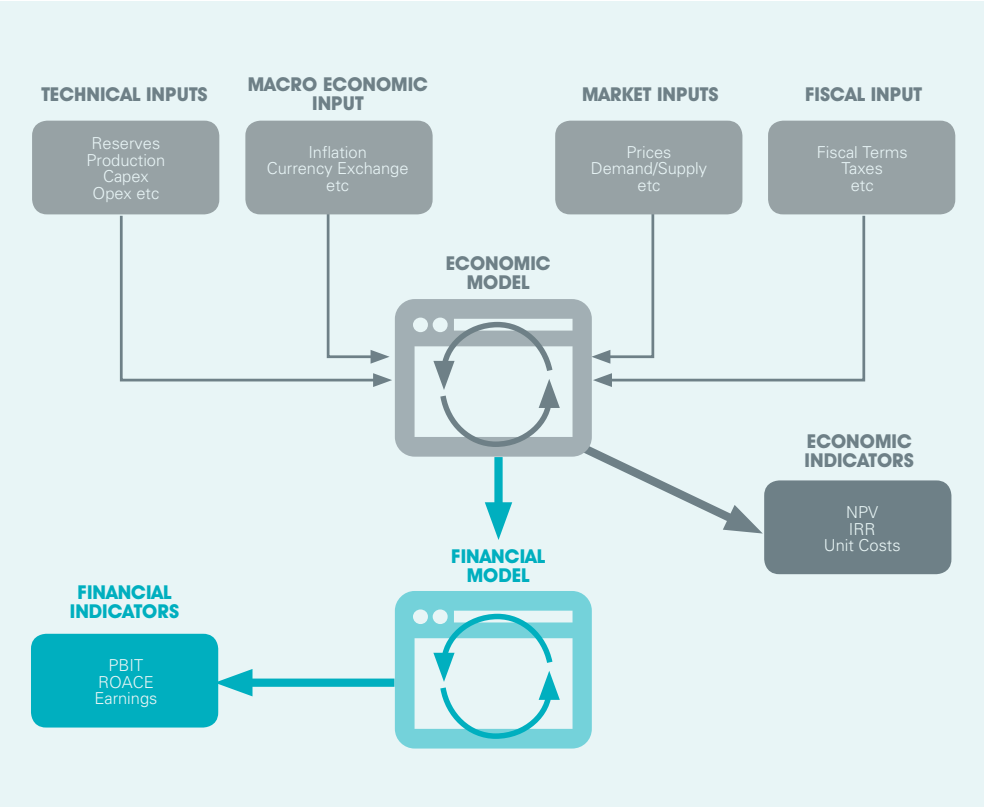
- Identify those input variables or assumptions that are most critical to the value metric (decision problem). These are then carried forward to probabilistic (and decision tree) analysis.
- Determine which variables to focus on for gathering detailed information and which variables may be estimated with less detailed information.
- Create insight into the decision problem and observe whether the magnitude and direction of the outcome is sensible.

We know that, despite our best efforts, our ability to predict the future is limited and that each variable in our analysis has a range of values with different probabilities of happening at any time in the future.

HOW TO BUILD A TORNADO CHART

STEP 1: BUILD THE DETERMINISTIC MODEL

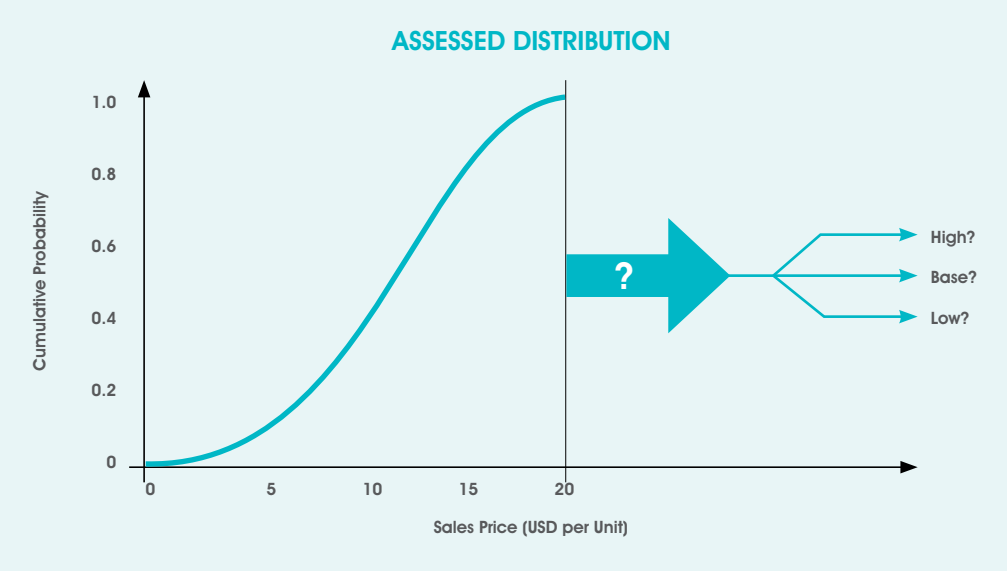
Build your decision model (MS Excel), which uses the input parameters to be used in sensitivity analysis.



Software packages exist that automate these calculations and plot the tornado chart, e.g. Oracle Crystal Ball, @Risk etc

STEP 2: ASSESS THE RANGES

Estimate the range of values (low, base, high) to assess for each "potentially" significant variable.



STEP 3: SELECT THE VALUE METRIC

Select the value metric(s) of interest in supporting each decision alternative.

STEP 4: CALCULATE THE SWING

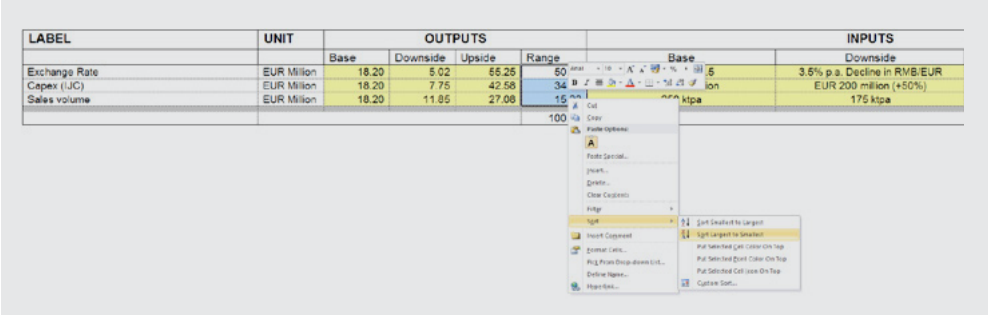
- By varying each variable, one at a time, within its specified range of values while holding all other variables at their base value, the effect of this variable on the value metric can be observed.
- Record the change in the value metric.
- Repeat for each variable the swing / range between high and low.

LABEL	UNIT	OUTPUTS			
		Base	Downside	Upside	Range
Exchange Rate	EUR Million	18.20	5.02	55.25	50.23
Capex (IJC)	EUR Million	18.20	7.75	42.58	34.83
Sales volume	EUR Million	18.20	11.85	27.08	15.23
					100.29

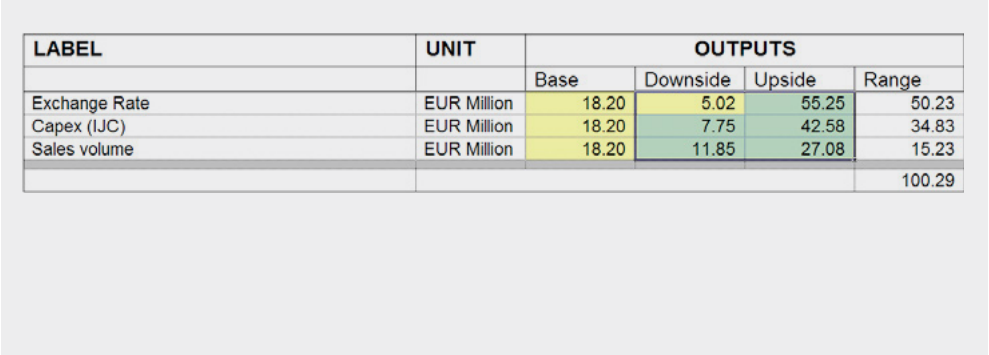
INPUTS		
Base	Downside	Upside
Long term 6.5	3.5% p.a. Decline in RMB/EUR	3.5% p.a. increase in RMB/EUR
EUR 135 million	EUR 200 million (+50%)	EUR 100 million (-25%)
250 ktpa	175 ktpa	275 ktpa

STEP 5: PLOT THE TORNADO CHART

Arrange the variables in descending order of the width of the tornado bars so that the variable with the largest swing is at the top.

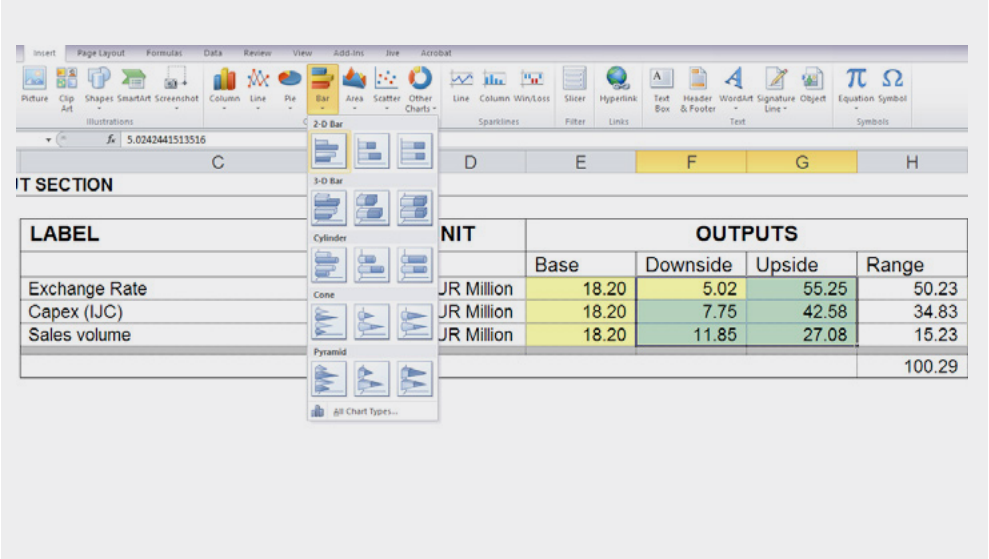


Select the upside and downside values of all the variables.

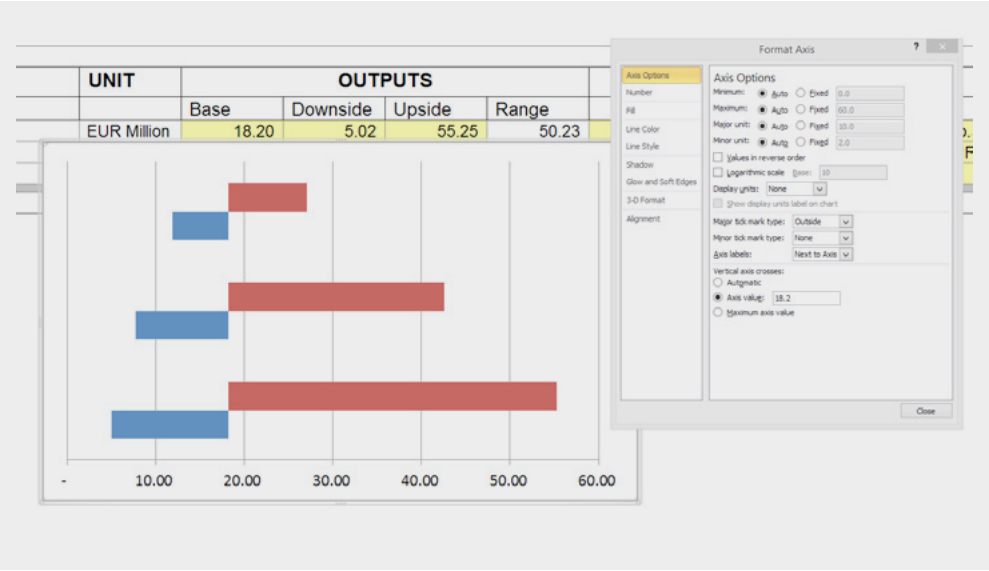


LABEL	UNIT	OUTPUTS			
		Base	Downside	Upside	Range
Exchange Rate	EUR Million	18.20	5.02	55.25	50.23
Capex (IJC)	EUR Million	18.20	7.75	42.58	34.83
Sales volume	EUR Million	18.20	11.85	27.08	15.23
					100.29

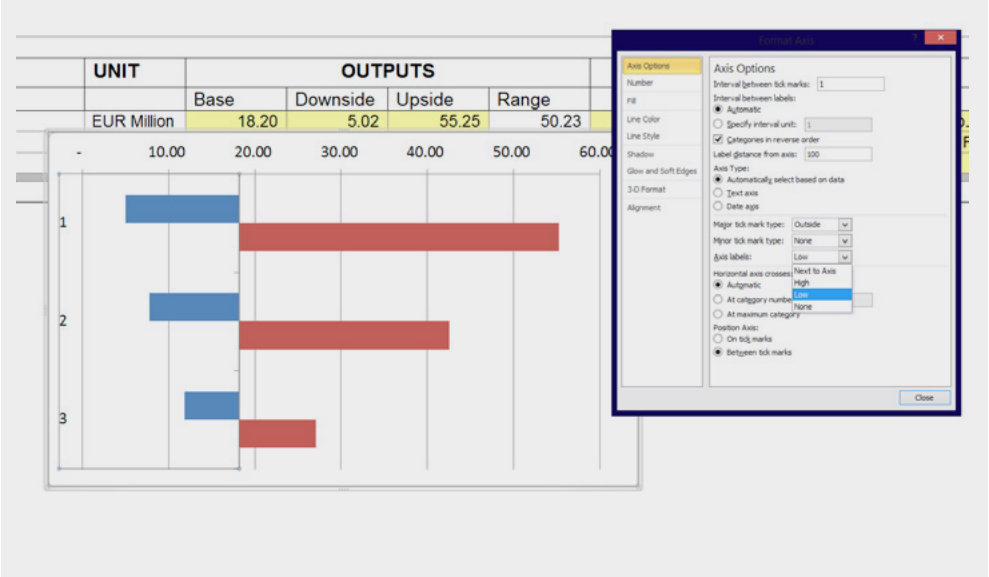
Insert a bar graph (2D clustered).



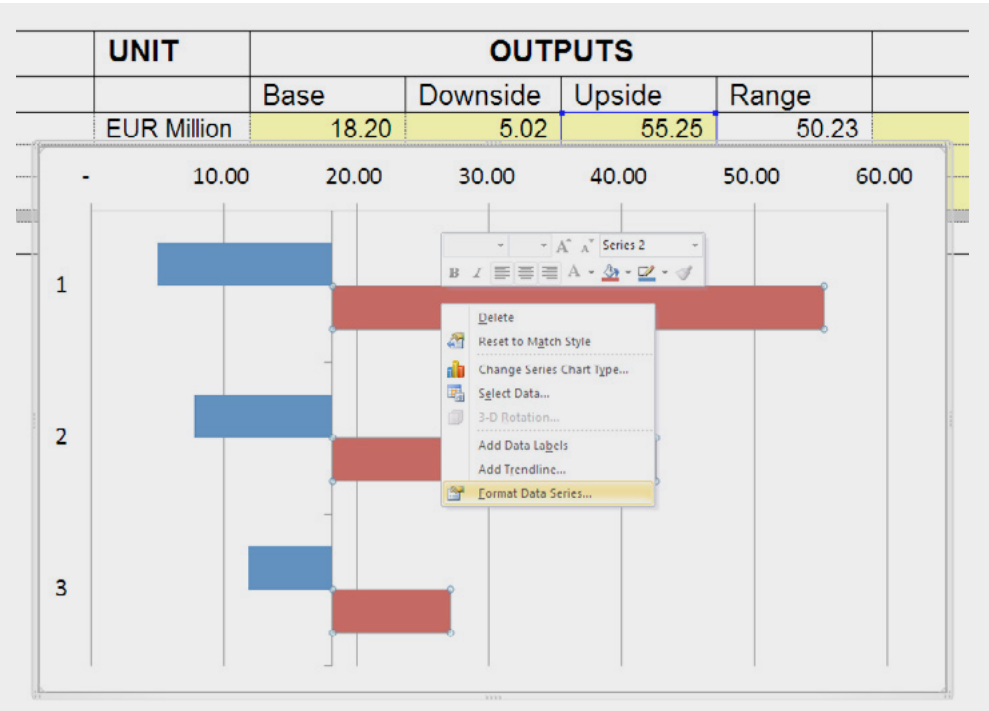
Select the horizontal (X) axis and go to "Format Axis". Under the "Axis Options" tab, update the base metric value in "Axis Value" under the "Vertical axis crosses" section.

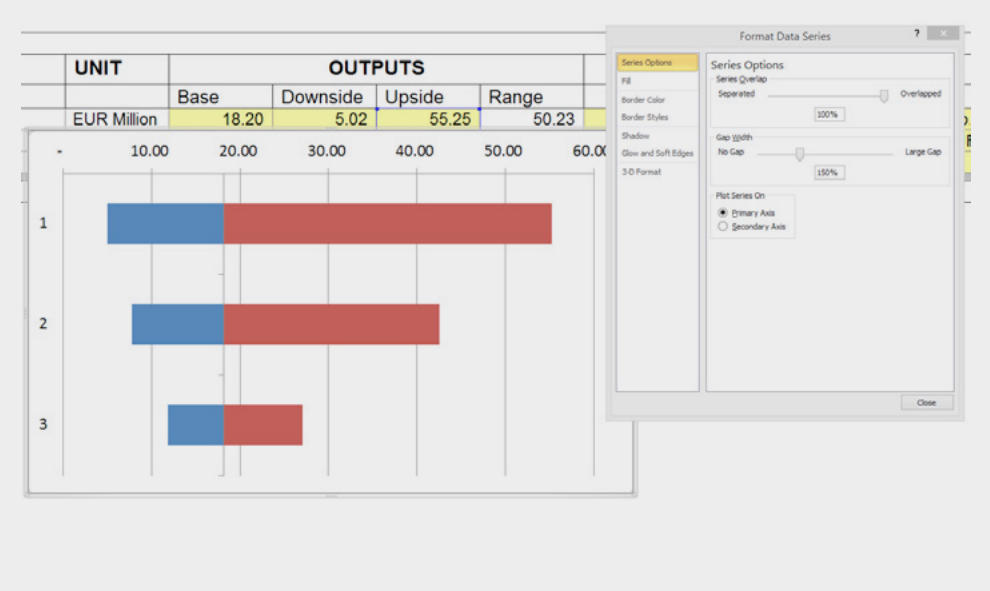


Select the vertical (Y) axis and go to “Format Axis”.
Under the “Axis Options” tab:
• Check “Categories in reverse order”.
• Select “Low” option from the dropdown under “Axis Label”.

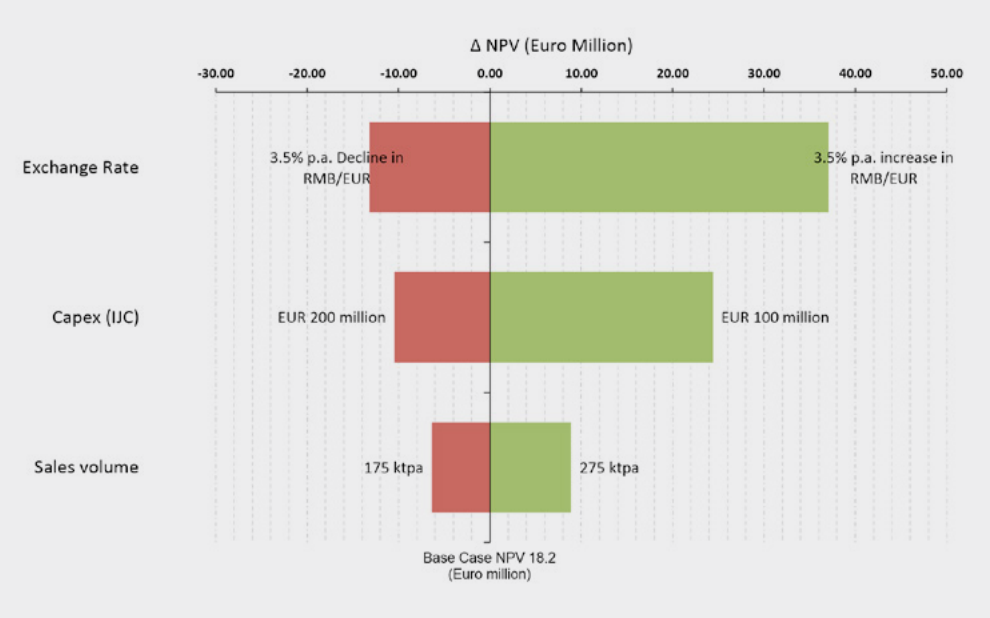


Select either of the two series and then right-click “Format Data Series”, then in “Series Options” change “Series Overlap” to 100%.





Finally, add the required formatting and data labels to fine tune the tornado charts.



TIPS & PITFALLS

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TIPS

Incremental changes?

A delta or difference tornado shows the impact that variables have on the difference of a value metric, for example a change in oil price of USD 10 per bbl. Senior management find this a very useful "gut-feel" measure for their "back of an envelope" calculations. A practical benefit of plotting a delta tornado chart is that it eliminates the need for changing the vertical axis cross point manually.

Over-arching variables

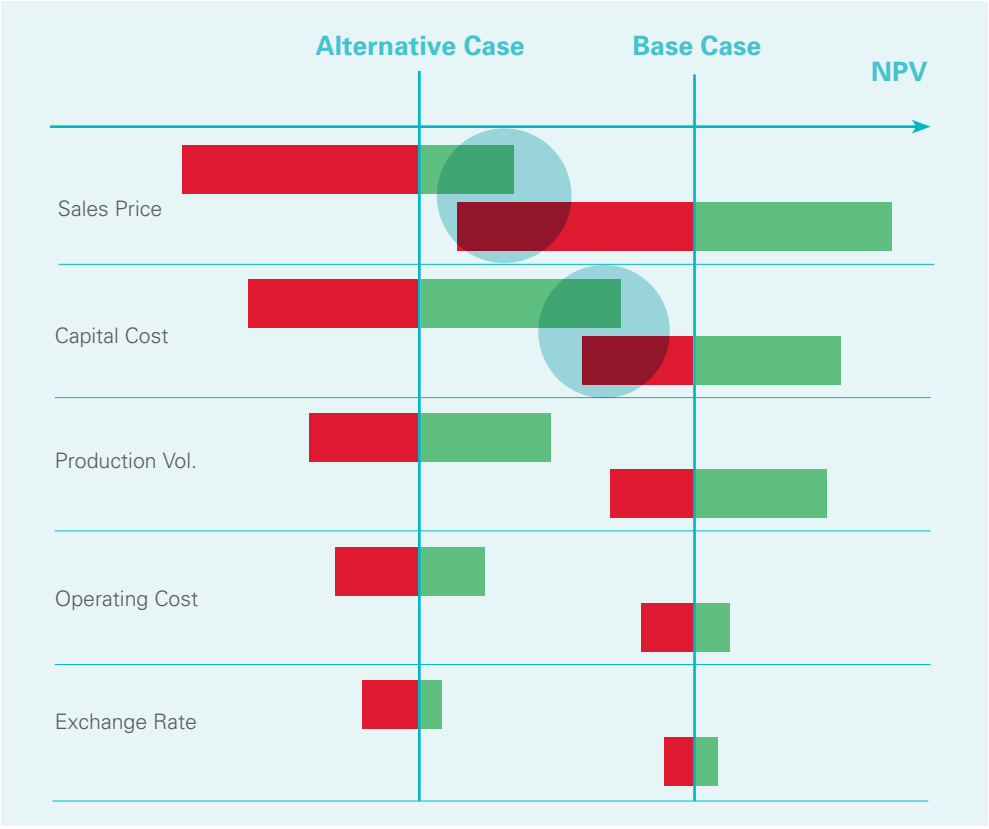
Variables that have an over-arching influence on the shape of the tornado chart (typically outside of your control) should be plotted as different scenarios. For example, the oil or metal price in a natural resource project will often create the perception that all other variables are insignificant. These variables are mostly common to all your strategies.

Which variables can be controlled?

It is important to note that even if a variable is in the top part of a tornado chart, it may not be important to making a decision among alternatives.

Which variables drive the decision between alternatives?

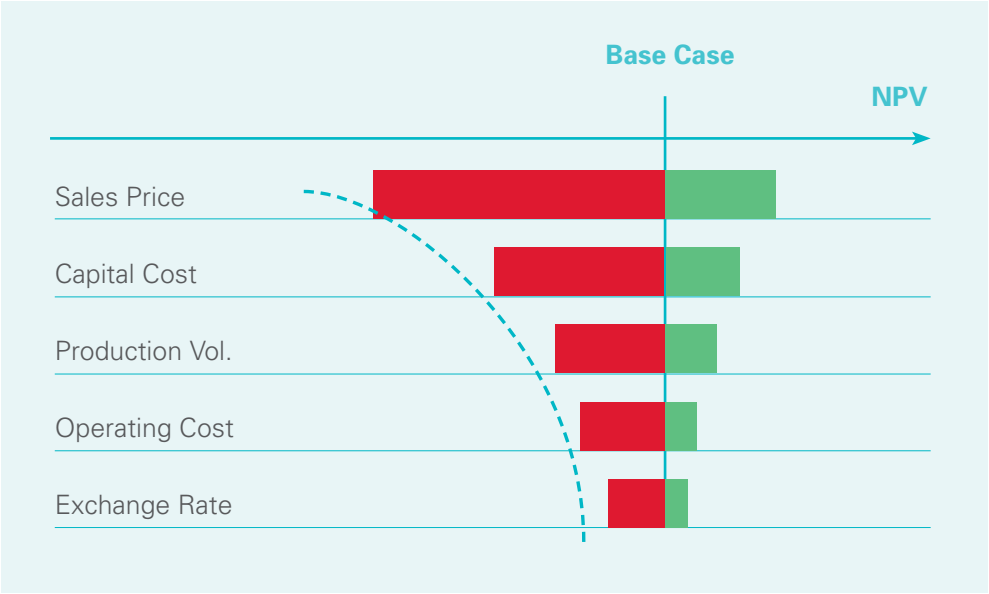
Overlaying two tornados can assist to identify which variables will change the decision outcome, as illustrated below.



Focus on the overlap variables that could change the decison

Upside vs. Downside potential?

The shape of the tornado chart is a good indicator of potential upside or downside.



Check for any skewness

Use as a model-debugging tool?

A tornado chart is a useful debugging tool to visually inspect whether the value metric reacts as expected to a change in a variable. If the result is opposite to what you expect, then it may either be an error in the model, or new insights have been obtained which should be investigated.

PITFALLS

Ranges can be too big or too small usually with a +/- percentage, for example, the typical "± 10%" method.

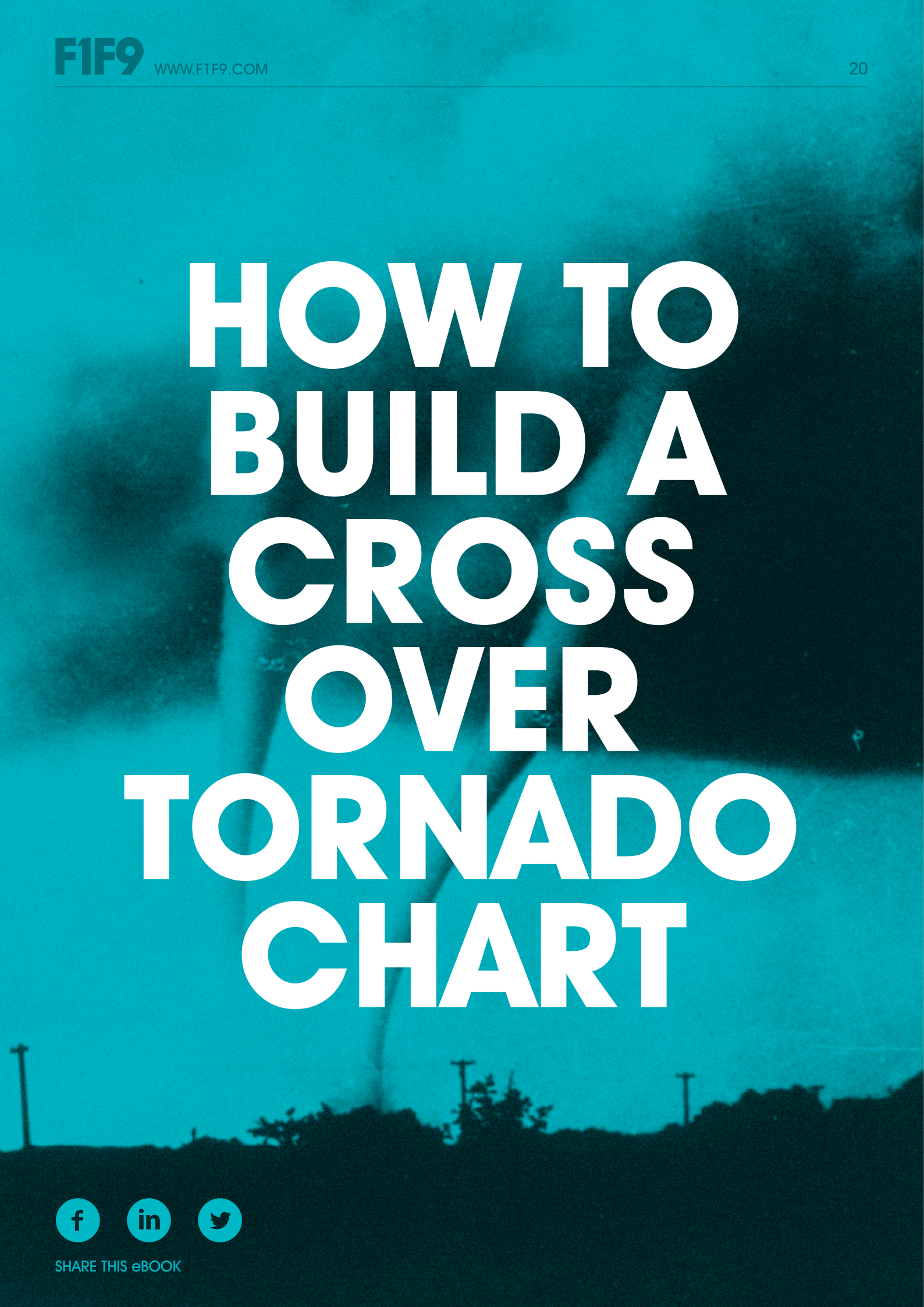
Assuming range symmetry – often uncertainty is asymmetrically distributed, for example, ore grade in a mining project or bias in capital estimation.

Variables – Using the wrong variable, or too many variables - most models will not have more than 6 to 8 key variables that contribute greater than 80% of decision metrics.

Interdependency – Failing to assess the interdependency of variables (examples are project schedule and cost). Note that interdependencies can be built into the model, such as the schedule increase and cost increase; or ore grade and metallurgical recovery.

Metrics – Choosing the wrong decision metric. For example, IRR may not be the best metric for a tornado as the change in the variable may result in a "#N/A" error.

Reflection – Incorrect reflection of bar direction – an increase in revenue input variables results in a positive bar whilst increase in cost variable results in a negative bar.



HOW TO BUILD A CROSS OVER TORNADO CHART

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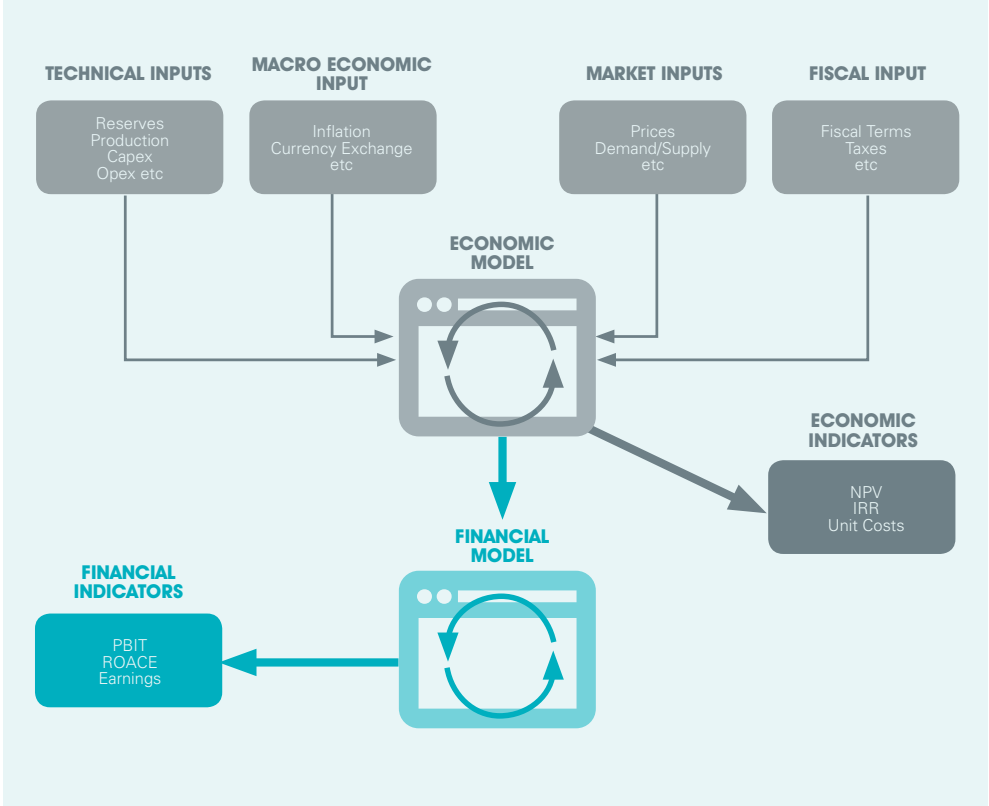
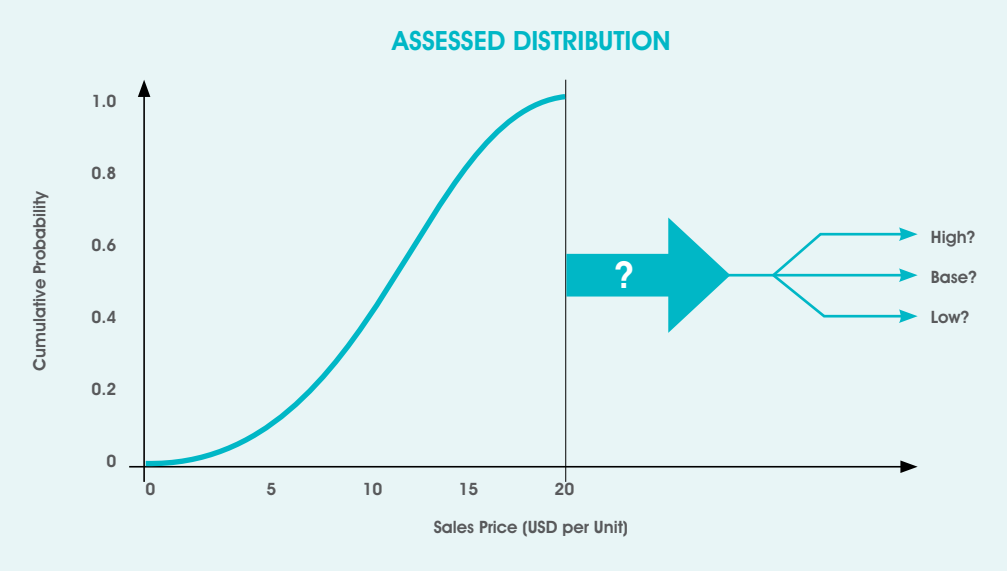
STEP 1: BUILD THE DETERMINISTIC MODEL

Build your decision model (MS Excel) for your alternatives (two cases), which use the variables identified.



STEP 2: ASSESS THE RANGES

Estimate the range of values (low, base, high) to assess for each potentially significant variable for the two cases.



STEP 3: SELECT THE VALUE METRIC

Select the value metric(s) of interest in supporting each decision alternative.

STEP 4: CALCULATE THE SWING

• By varying each variable, one at a time, within its specified range of values while holding all other variables at their base value, the effect of this variable on the value metric can be observed.

• Record the change in the value metric.

• Repeat for each variable the swing / range between high and low.

Note:
While setting the table for your alternative case, leave 2 blank rows before each variable line in your Excel table (to ensure proper spacing between the bars of base case and alternative case in the final crossover chart).

Base Case

LABEL	UNIT	OUTPUTS				INPUTS				
		Base	Downside	Upside	Range	Base	Downside	Upside	Contribution	Cumulative Contribution
Exchange Rate	EUR Million	18.20	6.02	60.25	54.23	Long term 6.5	3.5% p.a. Decline in RMB/EUR	3.5% p.a. increase in RMB/EUR	52.00%	52.00%
Capex (UC)	EUR Million	18.20	7.75	42.58	34.83	EUR 135 million	EUR 200 million (+50%)	EUR 100 million (-25%)	33.40%	85.40%
Sales volume	EUR Million	18.20	11.85	27.08	15.23	250 ktpa	175 ktpa	275 ktpa	14.60%	100.00%
					104.29					

Alternative Case

LABEL	UNIT	OUTPUTS				INPUTS				
		Base	Downside	Upside	Range	Base	Downside	Upside	Contribution	Cumulative Contribution
Exchange Rate	EUR Million	53.20	35.02	92.25	57.23	Long term 6.5	3.5% p.a. Decline in RMB/EUR	3.5% p.a. increase in RMB/EUR	51.89%	51.89%
									-	51.89%
									-	51.89%
Capex (UC)	EUR Million	53.20	40.75	78.58	37.83	EUR 135 million	EUR 200 million (+50%)	EUR 100 million (-25%)	34.30%	86.19%
									-	86.19%
									-	86.19%
Sales volume	EUR Million	53.20	46.85	62.08	15.23	250 ktpa	175 ktpa	275 ktpa	13.81%	100.00%
					110.29					

STEP 5: PLOT THE TORNADO CHART

- Arrange the variables in descending order of the width of the tornado bars so that the variable with the largest swing is at the top.

- Select the Downside and Upside values of all the variables for base case (1).

- Insert a bar graph (2D clustered).

- Select the graph and go to "Select Data" and Add Downside and Upside values of all the variables for alternative case (2).

- Select the Upside data series for the alternative case (2) and go to "Format Data Series", then under "Series Options" change "Plot Series On" to "Secondary Axis". Repeat the same for the Downside data series for the alternative case (2).

- Select the primary horizontal (X) axis and go to "Format Axis" Under Axis options:

  - Minimum, Maximum values are fixed to cater the NPV values
  - Display units: None
  - Major tick mark type: Outside
  - Minor tick mark type: None
  - Axis labels: Next to axis
  - Vertical axis cross: Update the axis value to the base value of base case (1) (value metric e.g. NPV or IRR)

- Select the primary vertical (Y) axis and go to "Format Axis" under "Axis Options"

  - Check "Categories in reverse order"
  - Major tick mark type: None
  - Minor tick mark type: None
  - Select "Axis label" as low

- Select the secondary horizontal (X) axis and go to "Format Axis" Under Axis options:

  - Minimum, Maximum values are fixed to cater the NPV values (Same as Primary Axis)
  - Display units: None
  - Major tick mark type: None
  - Minor tick mark type: None
  - Axis labels: None
  - Vertical Axis cross: Update Axis value to the base value (Key metric e.g. NPV or IRR)

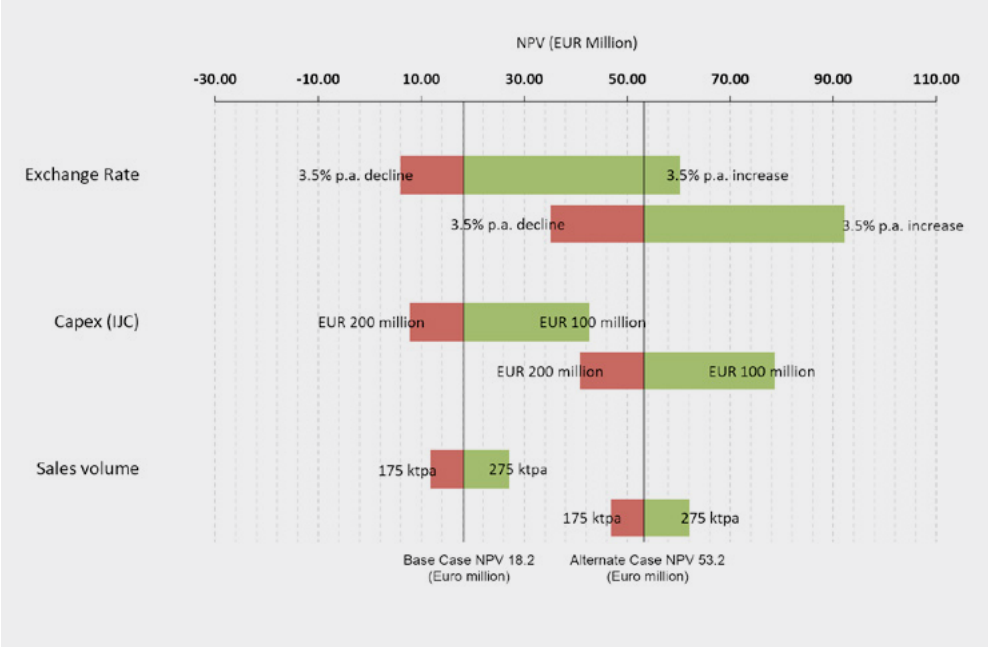
- Select the secondary vertical (Y) axis and go to "Format Axis" under "Axis Options"

  - Tick on "categories in reverse order"
  - Major tick mark type: None
  - Minor tick mark type: None
  - Select "Axis label" as None

- Select a series for the primary axis and then right-click "Format Data Series" then select "Series Options" and change "Series Overlap" to 100% and "Gap Width" to 400%.

- Select a series for the secondary axis and right-click "Format Data Series", then in "Series Options" change "Series Overlap" to 100% and "Gap Width" to 100%.

- Finally, add the required formatting and data labels to fine tune the tornado diagrams.



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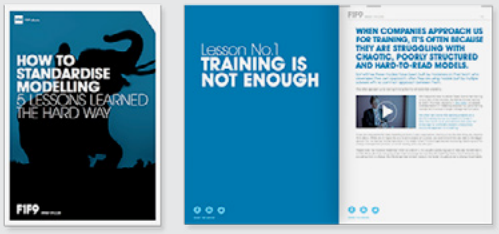

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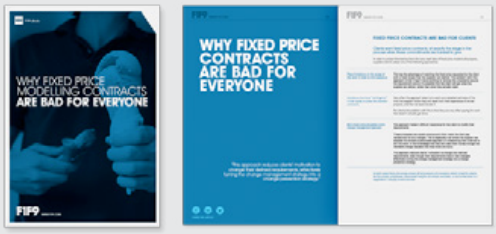

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