# CAPITAL BUDGETING RISK ANALYSIS

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## DECISIONS UNDER RISK AND UNCERTAINTY

RISK
- Unknown outcome in the future which can be attributed to the probability of the event

UNCERTAINTY
- Unknown outcome in the future which can not be attributed to the probability of event

# SOURCES OF RISK AND UNCERTAINTY

Development of demand, prices and costs

No. of similar investments

Bias of individuals towards pessimism or optimism, or by factors which should not be considered

Changing economic environment that invalidates the past experience

Misinterpretation of data

Incorrect analysis

Dependence on management skills

Inflexibility of the investment

Asset obsolescence




# METHODS FOR ANALYSIS OF RISK AND UNCERTAINTY

**INTUITIVE APPROACH**

Qualitative/Subjective

Payback period adjusted to risk

Discount rate adjusted to risk

Cash flow adjusted to risk

**ANALYTICAL APPROACH**

Probabilistic distribution

Decision trees

NPV break even-point

Sensitivity analysis

Scenario analysis

Monte Carlo simulation

Decision theory

# SENSITIVITY ANALYSIS

OTOBAI COMPANY, OSAKA, JAPAN (BREALEY ET AL., 2008, P. 271-283)

**1. Assumptions (inputs, no formulas)**

| | |
|---|---|
| Investment | ¥15 000 |
| Life span (years) | 10 |
| Scooter market size | 1 000 000 |
| Market share | 10% |
| Price | ¥375 000 |
| Variable unit cost | ¥300 000 |
| Fixed expenses | ¥3 000 |
| Income tax rate | 50% |

**2. Cash flow model (no data, formulas only)**

| | | *millions of yen* |
|---|---|---|
| | Year 0 | Years 1-10 |
| Investment | ¥15 000 | |
| Revenue | | ¥37 500 |
| Variable costs | | ¥30 000 |
| Contribution margin | | ¥7 500 |
| Fixed expenses | | ¥3 000 |
| Depreciation | | ¥1 500 |
| Profit before taxes | | ¥3 000 |
| Income tax | | ¥1 500 |
| NOPAT | | ¥1 500 |
| Operating cash flow | | ¥3 000 |

**3. Output (no data, formulas only)**

**NPV**

| | |
|---|---|
| Cost of capital | 10% |
| PV | ¥18 434 |
| NPV | ¥3 434 |





# OTOBAI COMPANY - SENSITIVITY ANALYSIS

| | Pessimistic | Expected | Optimistic |
|---|---|---|---|
| Variable | | NPV | |
| Market size | 900 000 | 1 000 000 | 1 100 000 |
| | ¥1 129 | ¥3 434 | ¥5 738 |
| | | | |
| | | NPV | |
| Market share | 4% | 10% | 16% |
| | -¥10 392 | ¥3 434 | ¥17 259 |
| | | | |
| | | NPV | |
| Unit price (yen) | ¥350 000 | ¥375 000 | ¥380 000 |
| | -¥4 247 | ¥3 434 | ¥4 970 |
| | | | |
| Unit variable cost | | NPV | |
| | ¥360 000 | ¥300 000 | ¥275 000 |
| | -¥15 000 | ¥3 434 | ¥11 114 |
| | | | |
| | | NPV | |
| Fixed cost | ¥4 000 | ¥3 000 | ¥2 000 |
| | ¥361 | ¥3 434 | ¥6 506 |

# SENSITIVITY ANALYSIS

See **Data Table Analysis** in EXCEL

- One way
- Two ways

| NPV | | Market share | | | |
|---|---|---|---|---|---|
| | | 8% | 10% | 12% | 14% |
| Unit price | ¥350 000 | -¥7 319 | -¥4 247 | -¥1 175 | ¥1 898 |
| | ¥357 500 | -¥5 476 | -¥1 943 | ¥1 590 | ¥5 123 |
| | ¥365 000 | -¥3 633 | ¥361 | ¥4 355 | ¥8 349 |
| | ¥372 500 | -¥1 789 | ¥2 666 | ¥7 120 | ¥11 575 |
| | ¥380 000 | ¥54 | ¥4 970 | ¥9 885 | ¥14 801 |




# LOOK FOR UNIDENTIFIED VARIABLES IN THE MODEL

- Patent problems to be resolved yet?
- Is there enough power service stations to recharge the scooter batteries?
  - Does the company need to do additional investments in power stations?
  - Does this have a potential impact lowering the assumed demand?

**The greatest risks often lie in the unknown unknowns ("unk-unks")**

# THE VALUE OF ADDITIONAL INFORMATION

- You can check whether you can resolve some of the uncertainty previously identified, before the company spends 15 billions of yens.
- What if the production is forecasting an extra 20.000 yen per unit because the people from production are worried about the risk on the use of a specific machine?

$$100.000\ units \times ¥20.000/unit \times (1-0{,}5)$$

$$Impact\ in\ NPV = \sum_{i=1}^{10} \frac{¥\ 1b}{(1+0{,}1)^i} = ¥6{,}14b$$

- This would destroy the value of the scooter project: +¥ 3,43b – ¥ 6,14b = - ¥ 2,71b
- Is that possible to do something to minimize this risk? For example
- What if you know that the chance of this risk to occur is 1 in 10 and you need to invest ¥10 million to test the machine?

$$-¥\ 10M + 0{,}1 \times ¥\ 6{,}14b = +¥\ 604M$$

- The value of additional information about market size is small as the project is acceptable even under pessimistic assumptions



# LIMITS TO SENSITIVITY ANALYSIS

- **Advantages**

- Forces managers to identify the underlying risk drivers
- Indicates where additional information is most useful
- Helps to expose confuse or inappropriate forecasts

**Limitations**

- It always give some ambiguous results. What does optimistic and pessimistic means?
- the underlying input variables are likely to be interrelated. Example: market share penetration and unit price, or unit price and unit cost
- as a consequence you cannot push one-at-a-time sensitivity analysis too far

## SCENARIO ANALYSIS

If the input variables are interrelated it may help to consider some alternative plausible scenarios, such as rise or decline in oil prices, improve versus deterioration of purchasing power, etc.

It allows to look at different but consistent combinations of variables




## SCENARIO ANALYSIS

Scenarios can be based in most varied factors such as:

- Macro-economics (inflation, GDP growth, unemployment, etc.)
- Political (change of government, no change in government policy, etc.)
- Industry based (level of competition, innovation, etc.)
- Company (growth, sales gross margin, restructuring costs and savings, etc.)

See **Tools/Scenarios** in EXCEL

# SCENARIO ANALYSIS – OTOBAI IN EXCEL

| Scenario Summary | Current Values: | Base Case | Optimistic | Pessimist |
|---|---|---|---|---|
| **Changing Cells:** | | | | |
| **Investment** | ¥15 000 | ¥15 000 | ¥12 000 | ¥17 000 |
| **Life_Span** | 10 | 10 | 10 | 10 |
| **Market_Size** | 1 000 000 | 1 000 000 | 1 100 000 | 900 000 |
| **Market_Share** | 10,00% | 10,00% | 12,00% | 8,00% |
| **Price** | ¥375 000 | ¥375 000 | ¥385 000 | ¥360 000 |
| **Variable_Unit_Cost** | ¥300 000 | ¥300 000 | ¥285 000 | ¥320 000 |
| **Fixed_Expenses** | ¥3 000 | ¥3 000 | ¥2 800 | ¥3 200 |
| **Income_Taxes** | 50% | 50% | 50% | 50% |
| **Result Cells:** | | | | |
| **Net_Present_Value** | ¥3 434 | ¥3 434 | ¥23 638 | -¥12 760 |

Notes: Current Values column represents values of changing cells at time Scenario Summary Report was created. Changing cells for each scenario are highlighted in gray.



# DEVELOPMENT OF SCENARIOS

1) Selection of critical variables

2) Selection of values for the variables in each scenario

3) Calculation of PV for each scenario

4) Analysis of value in each scenario

5) Decide on the asset valuation (or equity valuation) given the value of each scenario. You may attribute probabilities to each scenario and obtain a weighted valuation

## SCENARIO ANALYSIS LIMITATIONS

Scenarios are discrete - Optimistic, Most probable, Pessimistic

Complexity of analysis grows very quickly with the increase of critical variables (e.g.: 15 variables x 3 scenarios => 45 Expected values)

There is no optimal recommendation on how to use the results




## NPV BREAK-EVEN VS. ACCOUNTING BREAK-EVEN

Use **Goal Seek** in EXCEL searching NPV = 0 changing the cell of volume

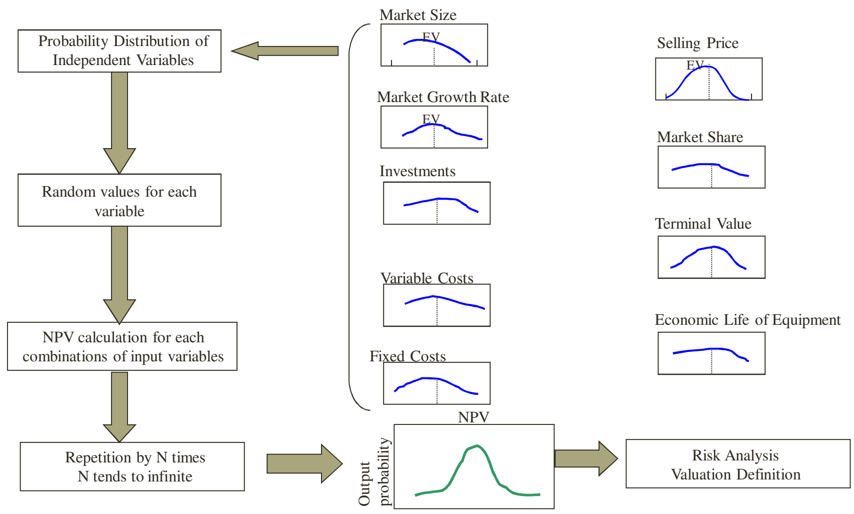
Units: 85 098

Calculation of accounting break even:

$$\text{BEP} = \frac{¥\,4.500\ M}{¥\,75.000} = 60.000\ units$$

Why the accounting and NPV break even are different?

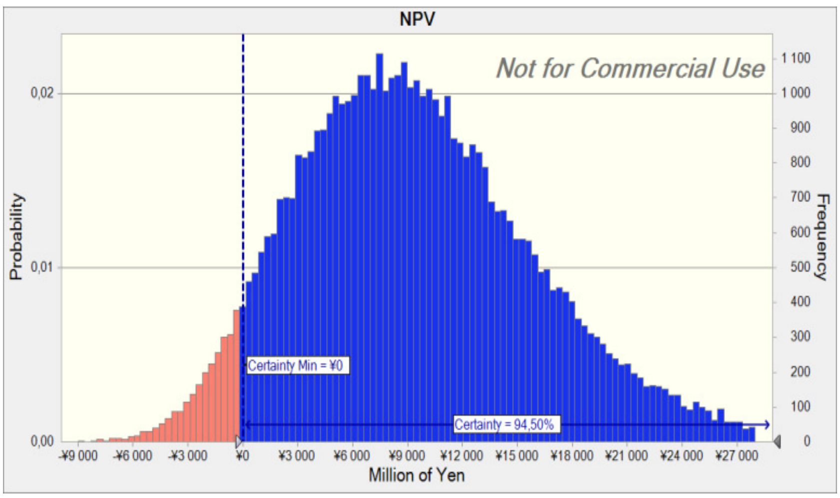
# MONTE CARLO SIMULATION



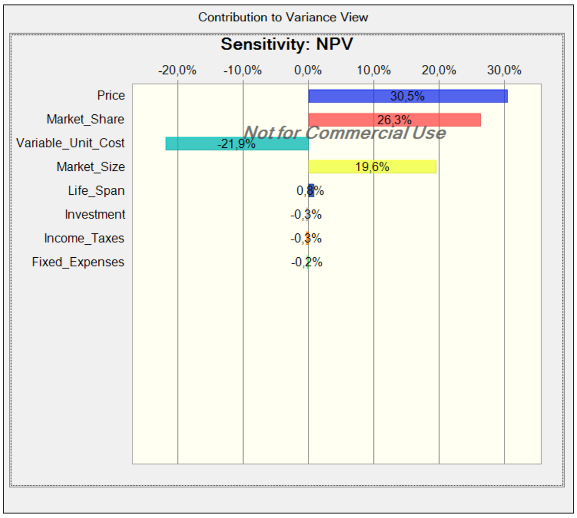




# OTOBAY COMPANY – CRYSTAL BALL – MONTE CARLO SIMULATION

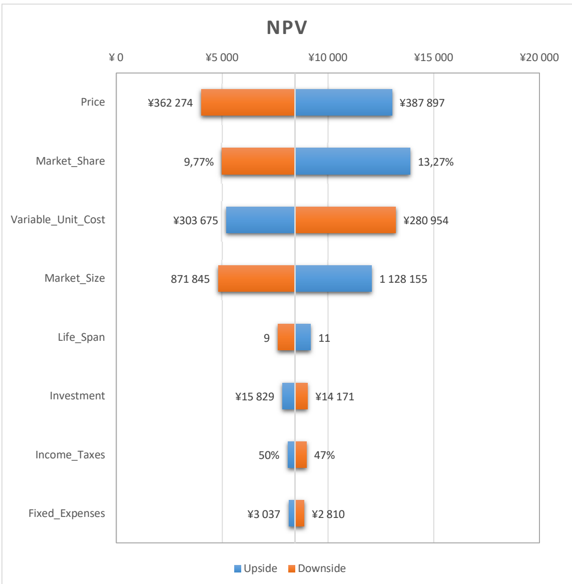


# SENSITIVITY ANALYSIS – OTOBAI – CRYSTAL BALL






# TORNADO ANALYSIS – OTOBAI CASE



# WHICH DISTRIBUTIONS SHOULD YOU USE?

Standard Crystal Ball® 2000 — DECISIONEERING — Professional Crystal Ball® 2000

## Which distributions should I use?

Selecting a distribution for an assumption is one of the most challenging steps in creating a Crystal Ball model. Crystal Ball has 17 possible discrete and continuous distributions you can use to describe an assumption, including a custom distribution, which can be a combination of continuous and discrete ranges.

- A **continuous** distribution assumes all values in the range are possible, so any range contains an infinite number of possible values. These distributions are smooth, solid curves.
- A **discrete** probability distribution describes distinct, finite, commonly integer values. These distributions look like different-height columns set next to each other.

The first step in selecting a probability distribution is to use any available data. In the absence of data, use your understanding of the physics or conditions of the variable to help select a distribution. Finally, apply reasonable limits to a simple distribution.

| Distribution | Conditions | Applications | Examples |
|---|---|---|---|
| Normal | • The mean value is most likely<br>• It is symmetrical about the mean<br>• It is more likely to be close to the mean than far away | Natural phenomena. | People's heights, reproduction rates, inflation |
| Lognormal | • Upper limit is unlimited but values cannot fall below zero<br>• Distribution is positively skewed, with most values near lower limit<br>• Natural logarithm of the distribution is a normal distribution | Situations where values are positively skewed, but *cannot* be negative. | Real estate prices, stock prices, pay scales, oil reservoir size |



# WHICH DISTRIBUTIONS SHOULD YOU USE?

| | | | |
|---|---|---|---|
| Gamma | • The possible occurrences in any unit of measurement is not limited<br>• The occurrences are independent<br>• The average number of occurrences is constant from unit to unit | Applied for physical quantities, such as the time between events when the event process is not completely random. | Demand for expected number of units sold during lead time, meteorological processes (pollutant concentrations) |
| Logistic | Conditions and parameters are complex. See: Fishman, G. *Springer Series in Operations Research*. NY: Springer-Verlag, 1996. | Describes growth. | Growth of a population as a function of time, some chemical reactions |
| Pareto | Conditions and parameters are complex. See: Fishman, G. *Springer Series in Operations Research*. NY: Springer-Verlag, 1996. | Analyzes other distributions associated with empirical phenomena. | Investigating distributions associated with city population sizes, size of companies, stock price fluctuations |
| Extreme Value | Conditions and parameters are complex. See: Castillo, Enrique. *Extreme Value Theory in Engineering*. London: Academic Press, 1988. | Describes largest value of a response over time or the breaking strength of materials. | Largest flood flows, rainfall, and earthquakes, aircraft loads and tolerances |
| Neg. Binomial | • Number of trials is not fixed<br>• Trials continue to the *r* th success (trials never less than *r*)<br>• Probability of success is the same from trial to trial | Models the distribution of the number of trials or failures until the *r* th successful occurrence. | Number of sales calls before you close 10 orders |

Tech support: 800-373-5885 (in US) 303-534-1515 (outside US) helpdesk@decisioneering.com

# WHICH DISTRIBUTIONS SHOULD YOU USE?

| | | | |
|---|---|---|---|
| Triangular | • The minimum is fixed<br>• The maximum is fixed<br>• It has a most likely value in this range, which forms a triangle with the minimum and maximum | When you know the minimum, maximum, and most likely values, *popular for when you have limited data.* | Sales estimates, number of cars sold in a week, inventory numbers, marketing costs |
| Uniform | • Minimum is fixed<br>• Maximum is fixed<br>• All values in range are equally likely to occur | When you know the range and all possible values are equally likely. | A real estate appraisal, leak on a pipeline |
| Custom | • Very flexible distribution, used to represent a situation you cannot describe with other distribution types<br>• Can be either continuous or discrete or a combination of both<br>• Used to input an entire set of data points from a range of cells | | |
| ***Less commonly used distributions are listed below and on the back side of the card.*** | | | |
| Binomial | • For each trial, only 2 outcomes are possible; usually, success or failure<br>• The trials are independent<br>• The probability is the same from trial to trial | Describes the number of times an event occurs in a fixed number of trials, also used for Boolean logic (true/false or on/off). | Number of heads in 10 flips of a coin, likelihood of success or failure |
| Poisson | • Number of possible occurrences is not limited<br>• Occurrences are independent<br>• Average number of occurrences is the same from unit to unit | Describes the number of times an event occurs in a given interval (usually time). | Number of telephone calls per minute, number of defects per 100 square yards of material |





# WHICH DISTRIBUTIONS SHOULD YOU USE?

| | | | |
|---|---|---|---|
| Exponential | • The distribution describes the time between occurrences<br>• Distribution is not affected by previous events | Describes events that recur randomly. | Time between incoming phone calls, time between customer arrivals |
| Geometric | • Number of trials is not fixed<br>• Trials continue until the first success<br>• Probability of success is the same from trial to trial | Describes the number of trials until the first successful occurrence. | Number of times you spin a roulette wheel before you win, how many wells to drill before you hit oil |
| Hypergeometric | • Total number of items (population) is fixed<br>• Sample size (number of trials) is a portion of the population<br>• Probability of success changes after each trial | Describes the number of times an event occurs in a fixed number of trials, but trials are dependent on previous results. | Chance of a picked part being defective when selected from a box (without replacing picked parts to the box for the next trial) |
| Weibull | This flexible distribution can assume the properties of other distributions. When shape parameters equal 1, it is identical to Exponential. When equal to 2, it is identical to the Rayleigh. | Fatigue and failure tests or other physical quantities. | Failure time in a reliability study, breaking strength of a material in a control test |
| Beta | • Range is between 0 and a positive value<br>• Shape can be specified with two positive values, alpha and beta | Represents variability over a fixed range, describes empirical data. | Representing the reliability of a company's devices |