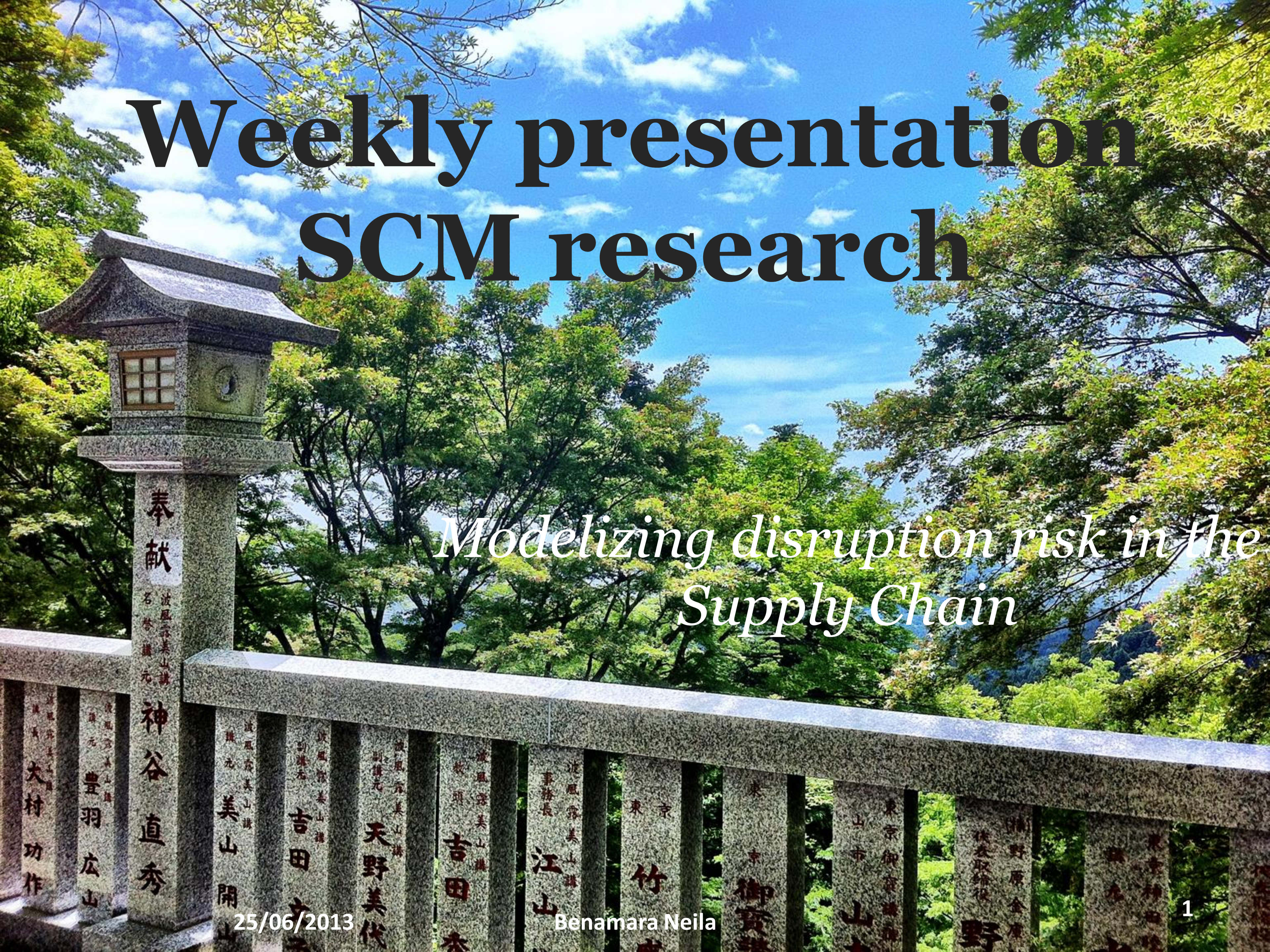


Weekly presentation SCM research

Modelizing disruption risk in the Supply Chain

Project

Build a supply chain design model risk management oriented

Consider disruption rates to select the best options as to minimize the entire Supply Chain disruption probability

Single sourcing/ Dual sourcing

Then implement it in the Graves model, with disruption rate as a supplementary option's parameter

Model

- *ON/OFF cycles*

- *Each option characterized by the parameters*

$$(\lambda, \psi)$$

disruption rate *recovery rate*

- *Expected duration of a ON cycle is 1/λ and OFF cycle 1/ ψ*

- *Duration of the cycles exponentially distributed*

Single sourcing

- *<u>Assumption</u>: at most one option can be disrupted*
- *The Supply Chain thus becomes disrupted as well (everything stops, no profit during this period)*
- *1 option j selected for each stage i*

Single sourcing

- *Equations reference*

$$P(A \cap B) = P(A|B)P(B)$$

$$P(A \cup B) = P(A) + P(B)$$

(exclusive events)

- *Functionnal equation:*

$P(SC{=}OFF) = P(\cup_i (Xi = OFF \cap_{j \neq i} Xj = ON)$

We consider every disruption scenario possible $=$

$\sum_i P(Xi = OFF / \cap_{j \neq i} Xj = ON) *$

$P(\cap_{j \neq i} Xj = ON)$

$= \sum_i P(Xi = OFF) * \prod_{j \neq i} P(Xj = ON)$

$= \sum_i P(Xi = OFF) * \prod_{j \neq i} (1 - P(Xj = OFF))$

Single sourcing

- Probability that the node i would get disrupted after t times

$$\phi(t) = \frac{\lambda}{\lambda + \psi}\left(1 - e^{-(\lambda+\psi)t}\right)$$

using 2-state continuous Markov chain theory and Chapman-Kolmogorov equation

- At time 0

$$P(X=OFF) = \frac{\lambda}{\lambda+\psi}$$

$$\min_{(\lambda i,\psi i)} \sum_{i} \frac{\lambda i}{\lambda i + \psi i} \prod_{j \neq i} \left(1 - \frac{\lambda i}{\lambda i + \psi i}\right)$$

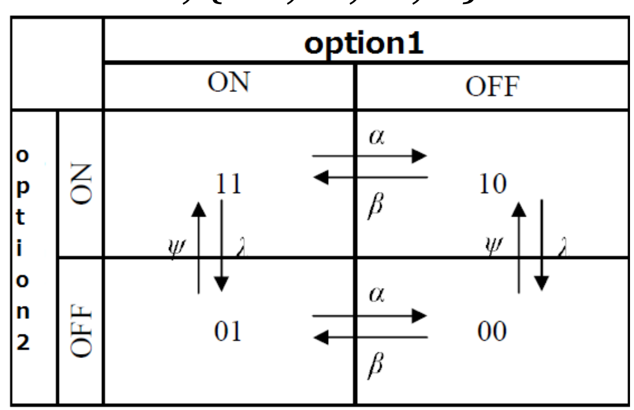
Dual sourcing

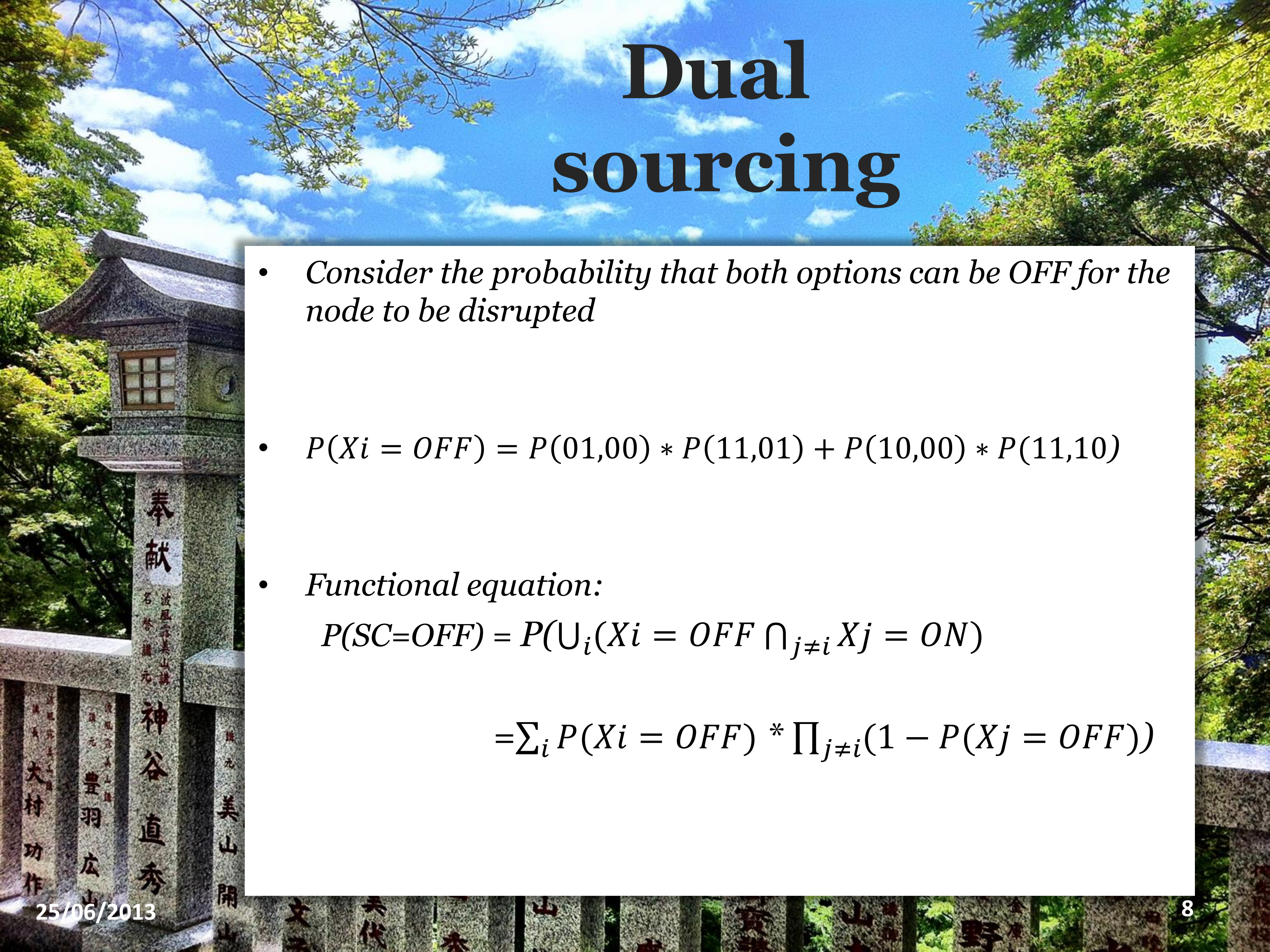
- *<u>Assumption</u>: at most one node can be disrupted,which happens only when both options are disrupted*

- *The Supply Chain thus can be disrupted in this case (minimize this probability)*

- *2 options (λi,ψi) and (αi,βi) selected for each stage i*

- *4 state Markov Chain, {00,01,10,11}*





Dual sourcing

- *Consider the probability that both options can be OFF for the node to be disrupted*

- $P(Xi = OFF) = P(01{,}00) * P(11{,}01) + P(10{,}00) * P(11{,}10)$

- *Functional equation:*

$$P(SC{=}OFF) = P(\cup_i (Xi = OFF \cap_{j \neq i} Xj = ON)$$

$$= \sum_i P(Xi = OFF) * \prod_{j \neq i} (1 - P(Xj = OFF))$$

Dual sourcing

$$\min_{\substack{(\lambda i,\psi i)\\(\alpha i,\beta i)}} \sum_{i} x[i] \prod_{j\neq i} (1 - x[j])$$

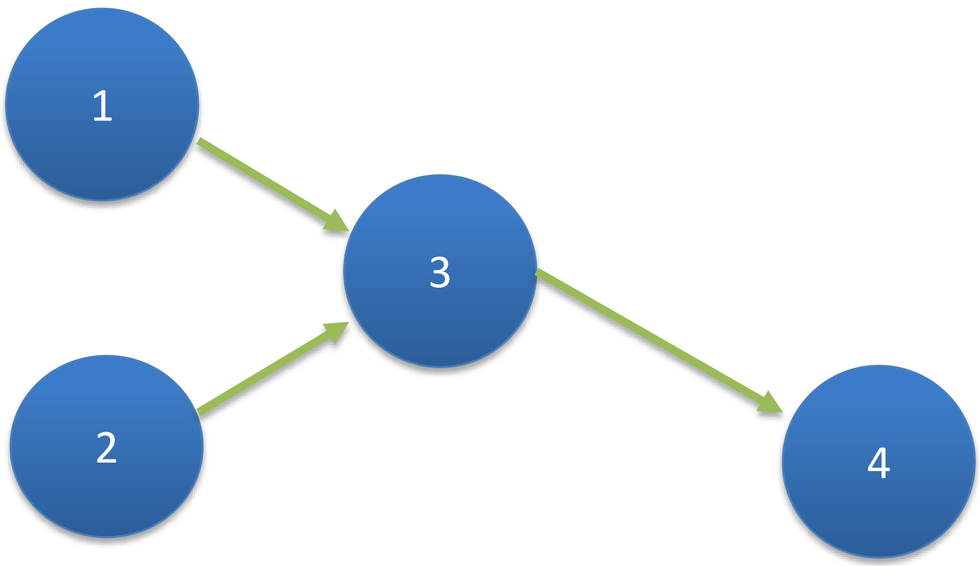
With:

$$x[i] = \alpha i \lambda i \left[\frac{1}{(\alpha i + \psi i)(\lambda i + \psi i)} + \frac{1}{(\lambda i + \beta i)(\alpha i + \beta i)} \right]$$

The probability that node i get disrupted

Simple Simulations

- *Supply Chain network (4 nodes, 4 options at each)*



Simple Simulations

- ***<u>Results : single sourcing</u>***

  - *Using gurobi*

    P(SC = OFF) = 0.11887

    options 3-2-4-2
  - *Best heuristic solution using gurobi*

    P(SC = OFF) = 0.59137

    options 3-4-2-4
  - *Using local optimum by hand*

    P(SC = OFF) = 0.450705

Next Steps

- *Finish debugging the dual sourcing code and analyse the results*

- *Consider disruption at supply chain design phase in Grave's model*

- *Compare with Seiji's results (consider disruptions effect on the operational phase only)*

Thank you for your attention