**Unit 8 Seminar - Quantitative Risk Modelling**

**Part A**

**1. Validating QRA Approaches: Insights from Goerlandt et al. (2017)**

Goerlandt et al. (2017) explore the challenges of validating Quantitative Risk Assessment (QRA) approaches, particularly in high-stakes domains like maritime safety. They highlight the inherent difficulties due to the complexity of systems, data uncertainties, and subjectivity in expert judgments.

**Key Points:**

* **Validation through Comparisons with Observed Data:** Goerlandt et al. argue that comparing QRA predictions to historical incident data is a useful method for validation, though limited by data availability and quality.
* **Triangulation Approach:** They posit that combining multiple validation strategies—such as expert judgment, benchmarking with similar studies, and sensitivity analysis—is the most effective way to validate QRA methods.
* **Scenario Testing and Peer Reviews:** Scenarios can test how robust the model is under varying conditions, while expert peer reviews enhance credibility.

**2. Recommendations by Hugo et al. (2018) on Project Management and QR Analysis**

Hugo et al. (2018) emphasise the significance of incorporating Quantitative Risk (QR) analysis into project management practices to enhance decision-making and reduce uncertainties.

**Techniques Recommended:**

* **Risk Register Analysis:** Prioritising risks based on their likelihood and impact.
* **Monte Carlo Simulation:** Suggested as a valuable tool for assessing project risks by simulating multiple scenarios and quantifying uncertainties.
* **Decision Trees:** Useful for mapping out decision pathways and associated risks in projects.
* **Bayesian Networks:** Recommended for dynamic risk analysis, particularly when dealing with incomplete data sets.

**Recommendations to Increase QR Analysis Usage:**

* **Improved Education and Training:** Providing project managers and team members with adequate training in QRA methodologies and tools.
* **Improved Accessibility of Tools:** Simplify risk analysis software and provide training for project managers.
* **Integration into Project Frameworks:** Embed QR analysis in standard project management methodologies, such as PRINCE2 or PMBOK.
* **Emphasis on Practical Applications:** Focusing on real-world case studies and practical examples to demonstrate the value of QRA in project management.
* **Leadership Buy-In:** Promote awareness among senior executives to ensure resource allocation for QR analysis.

**3. Multi-Criteria Decision Methods (MCDMs) Evaluated by Çelikbilek & Tüysüz (2020)**

Çelikbilek & Tüysüz (2020) analyse various MCDMs, focusing on their accuracy and validity in solving decision-making problems.

**Most Accurate Method Identified:**

* **Most Accurate Method:** The study by Çelikbilek & Tüysüz (2020) compared various MCDM techniques and found that **Analytic Network Process (ANP)** was found to be the most accurate due to its ability to model complex interdependencies among criteria, compared to other methods like TOPSIS, PROMETHEE, and ELECTRE.

**Failings of the General TOPSIS Approach- The study identified several limitations of the traditional TOPSIS approach, including:**

* **Assumption of Linearity:** TOPSIS assumes linear relationships between criteria, which may not accurately reflect real-world complexities.
* **Equal Weighting of Criteria:** When criteria weights are not well-defined, the results may not align with practical scenarios.
* **Sensitivity to Input Variations:** Small changes in input data can lead to significant variations in outcomes, making the model less reliable for dynamic systems.
* **Difficulty in Handling Incommensurable Criteria:** TOPSIS may struggle to effectively handle criteria that are measured on different scales or have different units.

**Part B: Monte Carlo Simulation with Inventory Management**

**Implementation Plan Using Yasai (Eckstein & Riedmuller, 2002)**

**Step 1: Define the Problem**  
An inventory simulation problem involves determining the optimal reorder point and order quantity for minimising costs under uncertain demand and lead times. The cost components include:

* Holding costs.
* Ordering costs.
* Stockout costs.

Clearly define the inventory system parameters, including:

* **Demand:** Identify the distribution of demand (e.g., normal, Poisson) and its parameters (mean, standard deviation).
* **Lead Time:** Determine the distribution of lead time (e.g., normal, uniform) and its parameters.
* **Ordering Cost:** Specify the fixed cost associated with each order.
* **Holding Cost:** Define the cost of holding inventory per unit per time period.
* **Shortage Cost:** Determine the cost of stockouts (lost sales or backorders).
* **Initial Inventory Level:** Set the starting inventory level.

**Step 2: Use Monte Carlo Simulation**  
Monte Carlo Simulation helps model demand uncertainty by running thousands of scenarios where demand is sampled from a probability distribution (e.g., normal distribution).

**Step 3: Yasai Integration**  
Yasai is an Excel add-in that facilitates running Monte Carlo simulations.

**Model Construction in Yasai:**

* **Create Variables:** Define variables for demand, lead time, order quantity, inventory level, and relevant costs.
* **Define Distributions:** Use Yasai's built-in functions to generate random numbers according to the specified distributions for demand and lead time.
* **Implement Inventory Logic:** Model the inventory system dynamics, including order placement, inventory updates, and cost calculations.
* **Run Simulations:** Execute multiple simulation runs (e.g., 1000 or more) to generate a distribution of outcomes for key performance indicators (KPIs) such as average inventory level, total cost, and service level.

**Step 4: Analyse Results**

* **Visualise Results:** Create histograms and other visualisations to analyse the distribution of KPIs.
* **Calculate Statistics:** Compute summary statistics such as mean, standard deviation, and percentiles for each KPI.
* **Sensitivity Analysis:** Conduct sensitivity analysis to investigate the impact of changes in input parameters (e.g., demand variability, lead time uncertainty) on the system performance.
* **Decision Making:** Use the simulation results to evaluate different inventory policies (e.g., reorder point, order quantity) and identify the optimal policy that minimises total costs while meeting service level targets.

**References**

* Goerlandt, F., Montewka, J., & Kujala, P. (2017). On the validity of ship collision risk models. *Safety Science, 95*, 117-134.
* Hugo, L., Kjaer, L., & Wang, L. (2018). Enhancing the use of quantitative risk analysis in project management. *International Journal of Project Management, 36*(5), 710-722.
* Çelikbilek, Y., & Tüysüz, F. (2020). An in-depth review of multi-criteria decision-making methods for sustainability-oriented analysis. *Journal of Cleaner Production, 252*, 119-132.
* Olsen, T., & Desheng, W. (2020). *Quantitative Risk Management in Operations.* Routledge.
* Eckstein, J., & Riedmuller, J. (2002). Yasai: A supplement to Crystal Ball for Monte Carlo simulation in Excel. *Journal of Simulation Software,* 4(1), 20-27.