

Non-crossing neural network quantile regression estimation for driving data with telematics

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About the speaker

- **Xenxo Vidal-Llana** – *Researcher, Universitat de Barcelona*
 - *Mathematician and Actuary. PhD in Risk Analysis.*
 - *Former Senior Non-Life Pricing Actuary at Allianz Spain.*
 - *Development and Implementation of Machine Learning Models for Risk Analysis in Finance, Insurance and Energy.*



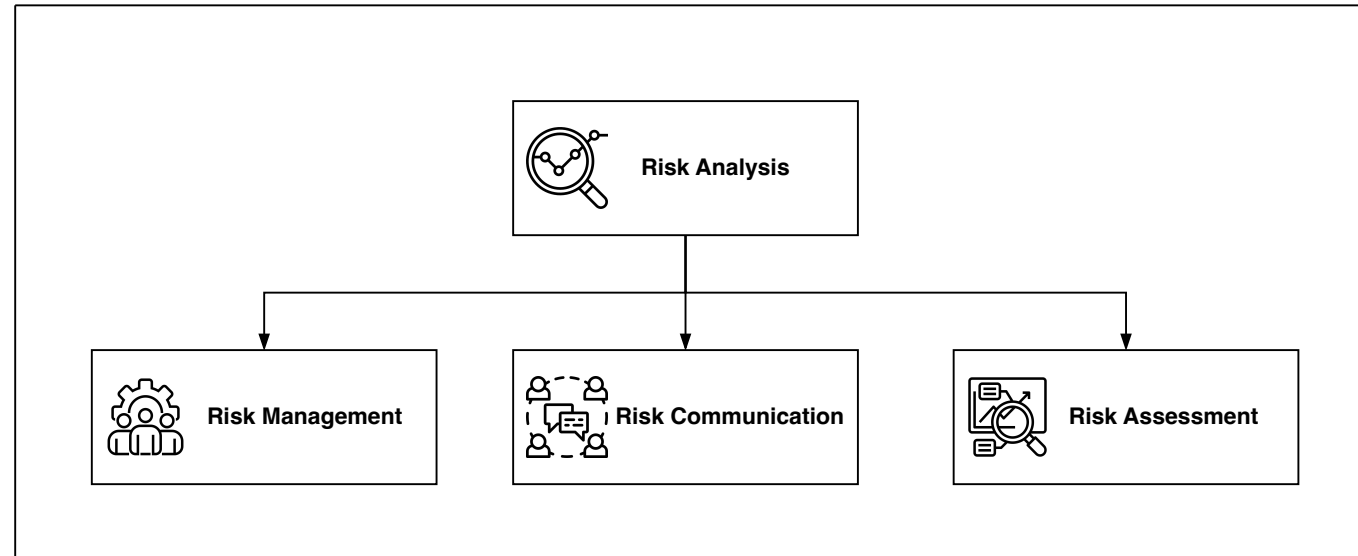
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- Founded in 1450
 - Ranked #1 University in Spain (2023 CWUR Ranking)
 - #47 in Europe
 - #134 Worldwide



UNIVERSITAT DE
BARCELONA

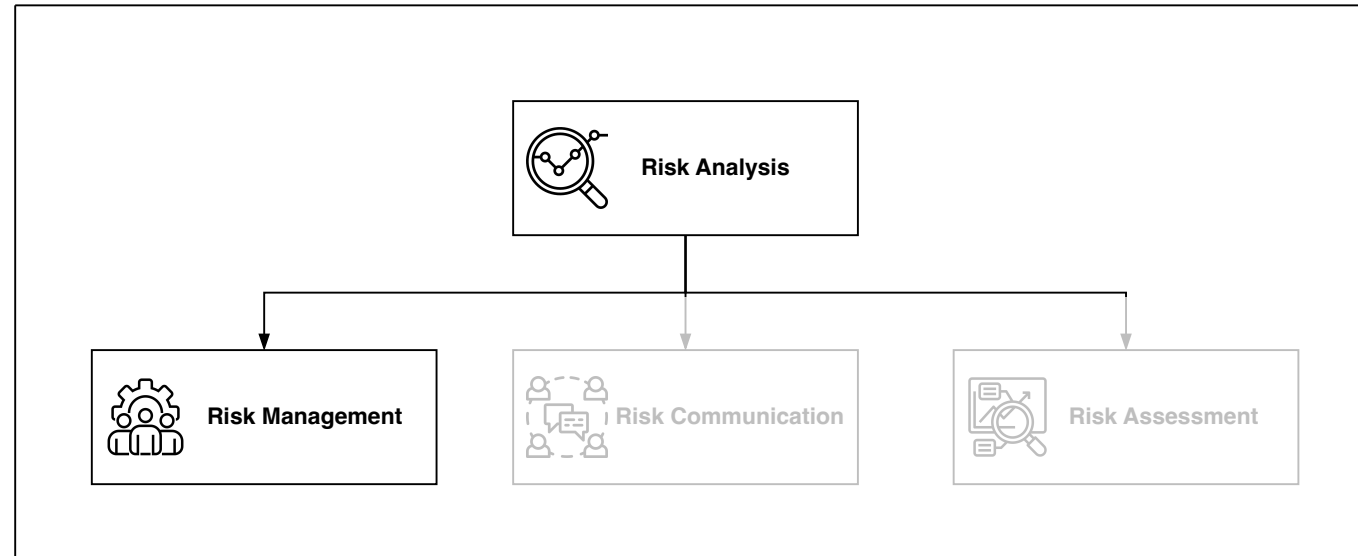
What is Risk Analysis?

- Examination of a situation involving exposure to danger, in order to prevent and mitigate distress events.



What is Risk Analysis?

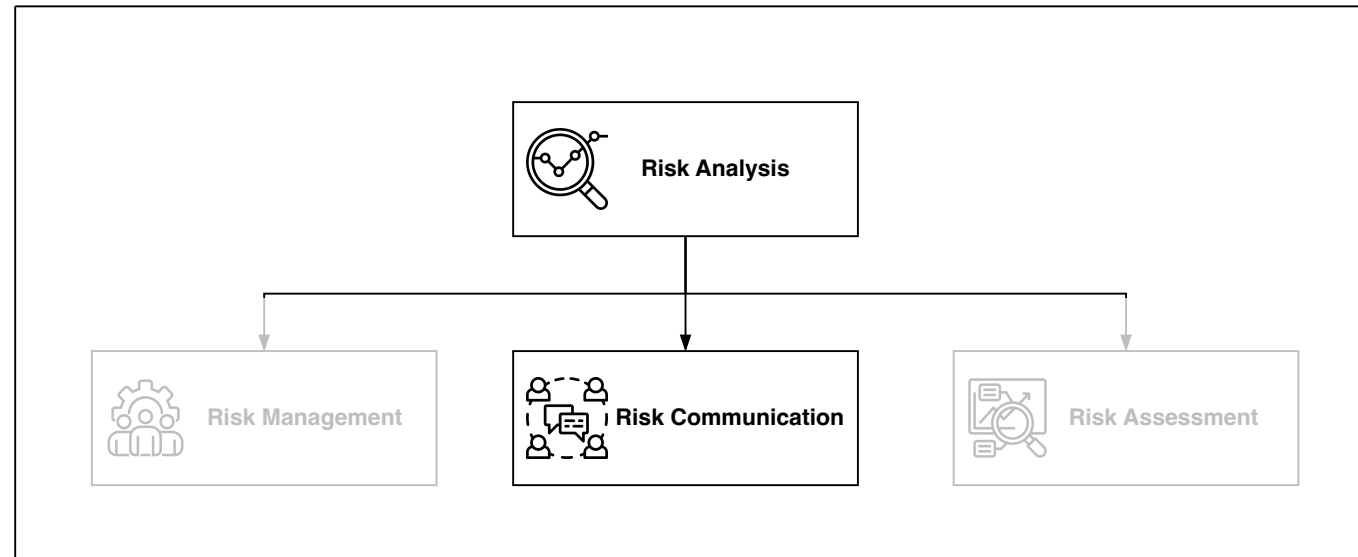
- Examination of a situation involving exposure to danger, in order to prevent and mitigate distress events.



- Creating policies and decisions to prevent disruptions.

What is Risk Analysis?

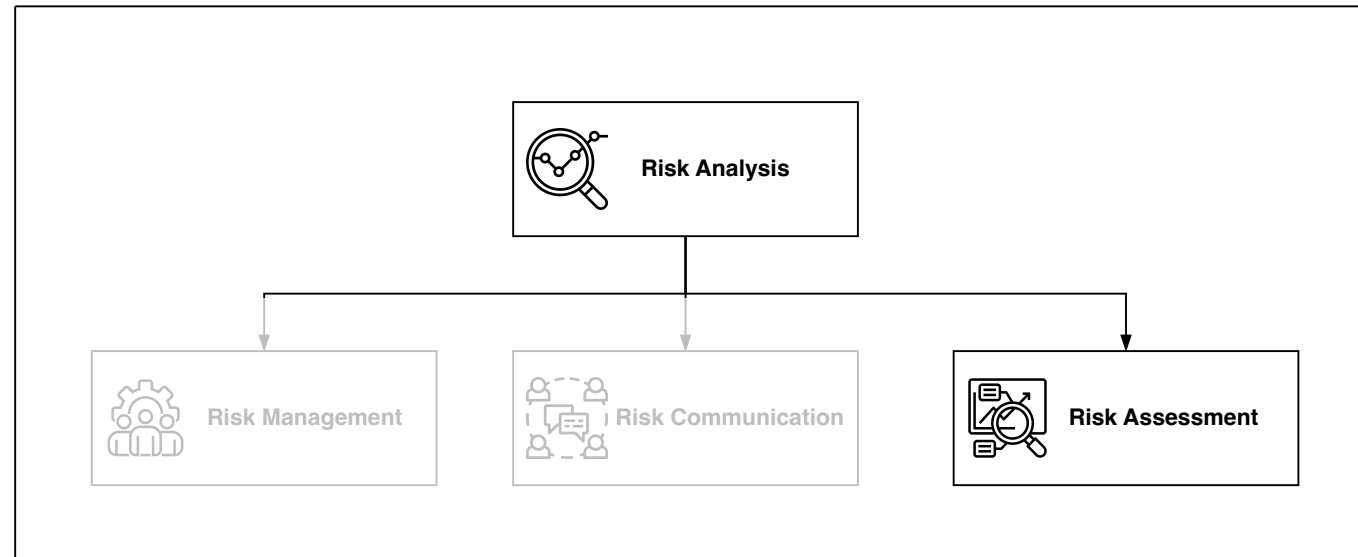
- Examination of a situation involving exposure to danger, in order to prevent and mitigate distress events.



- Exchange of information regarding a previously identified risk.

What is Risk Analysis?

- Examination of a situation involving exposure to danger, in order to prevent and mitigate distress events.

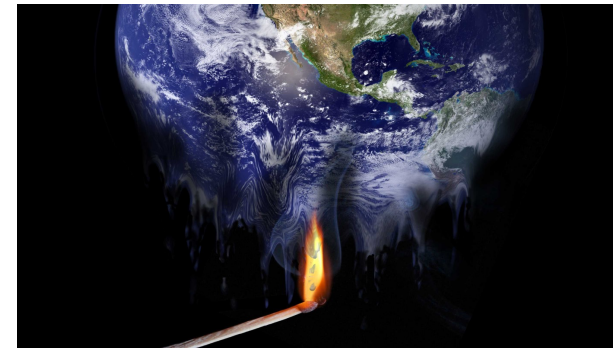


- Hazard identification and quantification of **Actuarial Risks**.

Actuarial Risks: phenomenon subject to uncertainty with respect to one or more of the variables: occurrence, timing, and severity.

Importance of correct assessment of Actuarial Risks

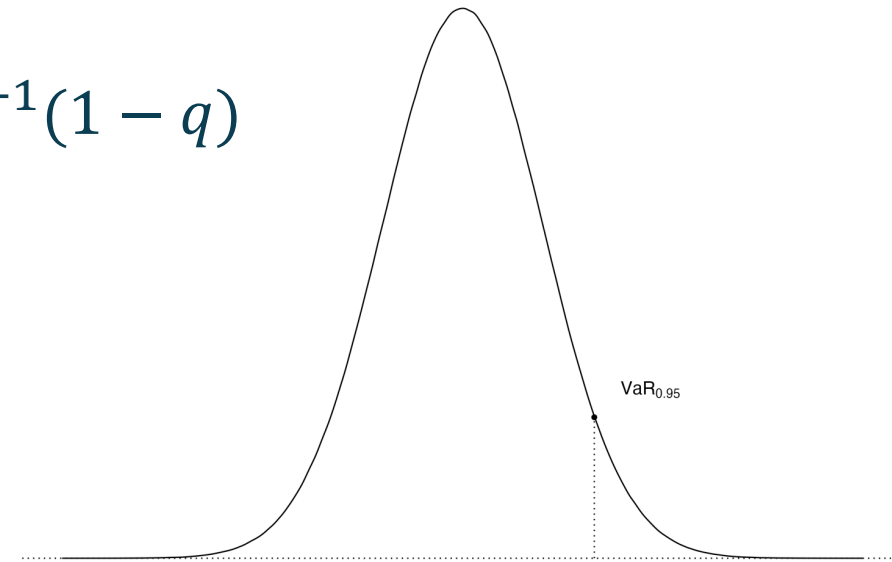
- There is an increasing amount of disruptive events
 - Turmoil events (crises + conflicts).
 - Global warming.
 - Cybersecurity.
- Benefits for a correct Analysis of risk
 - Ensure a healthy financial development.
 - Reduced exposure to losses.
 - Enhanced stakeholder confidence.



Value at Risk (VaR)

- The stock market crash of 1987 putted quantitative finance into question.
- The Value at Risk flourished to study extreme events.
- Represents the value that a random variable is not expected to exceed with a certain probability.

- $VaR_q(Y) = \inf\{y \in \mathbb{R} \mid F_Y(y) > q\} = F_Y^{-1}(1 - q)$



Estimation of VaR

- Assuming a distribution
- Quantile Regression (Cross-sectional data) (Koenker and Basset, 1987).
- CAViaR (time-series) (Engle and Manganelli, 2015).
- Monotone Composite Quantile Regression Neural Network (multiple quantiles) (Cannon, 2018).

Movement into Conditional Tail Expectation

A revised version of this standard was published in January 2019. <https://www.bis.org/bcbs/publ/d457.pdf>

Basel Committee
on Banking Supervision

STANDARDS

Minimum capital
requirements for
market risk

January 2016

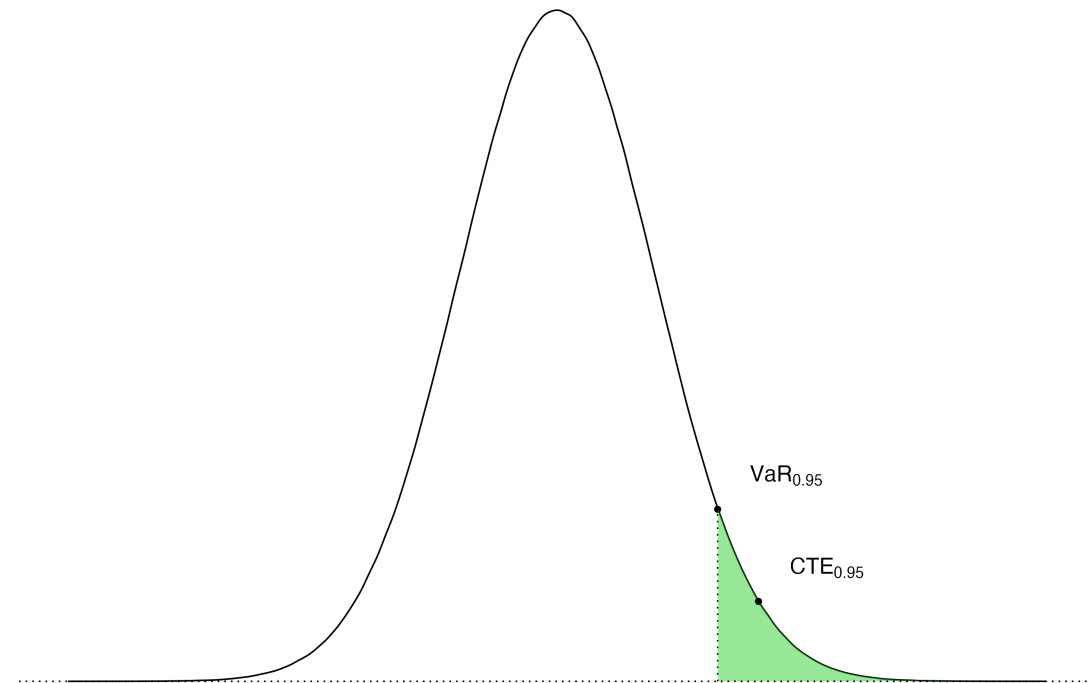


BANK FOR INTERNATIONAL SETTLEMENTS

- Also called **Expected Shortfall (ES)** and **Tail Value at Risk (TVaR)**.
- A **shift** from Value-at-Risk (VaR) to Conditional Tail Expectation (CTE) as a measure of risk under stress.
- Use of ES will help to ensure a **more prudent capture of “tail risk”** and capital adequacy during periods of significant financial market stress.

Conditional Tail Expectation

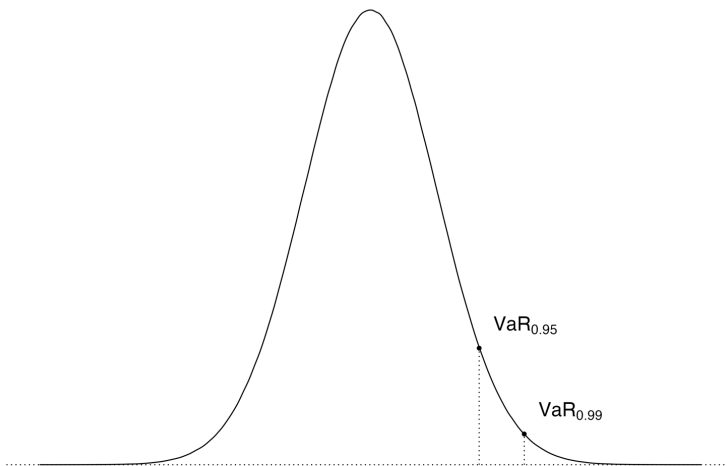
- Also known as Tail Value at Risk or Expected Shortfall.
- Expected value of an unlikely distress.
- Basel III: Provides a better perspective of unlikely distresses.
- $CTE_q(Y) = E[Y|Y \geq VaR_q(Y)]$



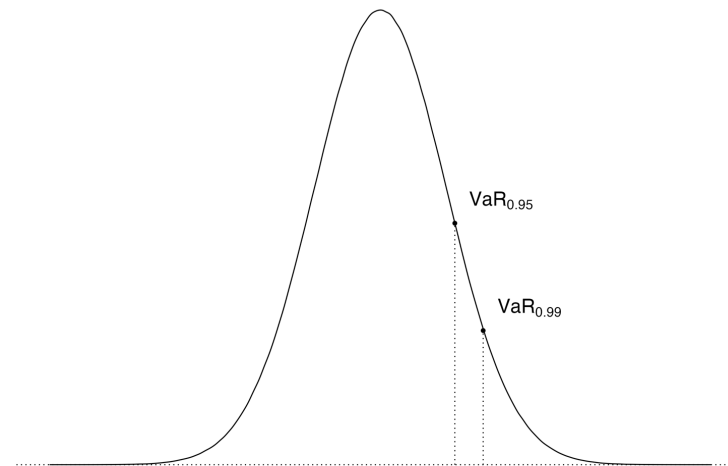
Back to reality

- We are actuaries in an insurance company quantifying risk of drivers.
- We estimate a model to predict quantiles 0.95 and 0.99 of the expected claim loss of each policy. These are the results:

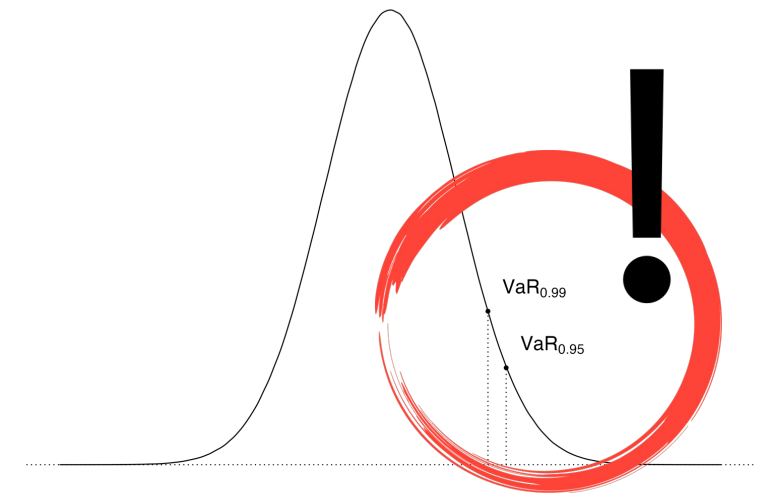
DRIVER 1



DRIVER 2



DRIVER 3

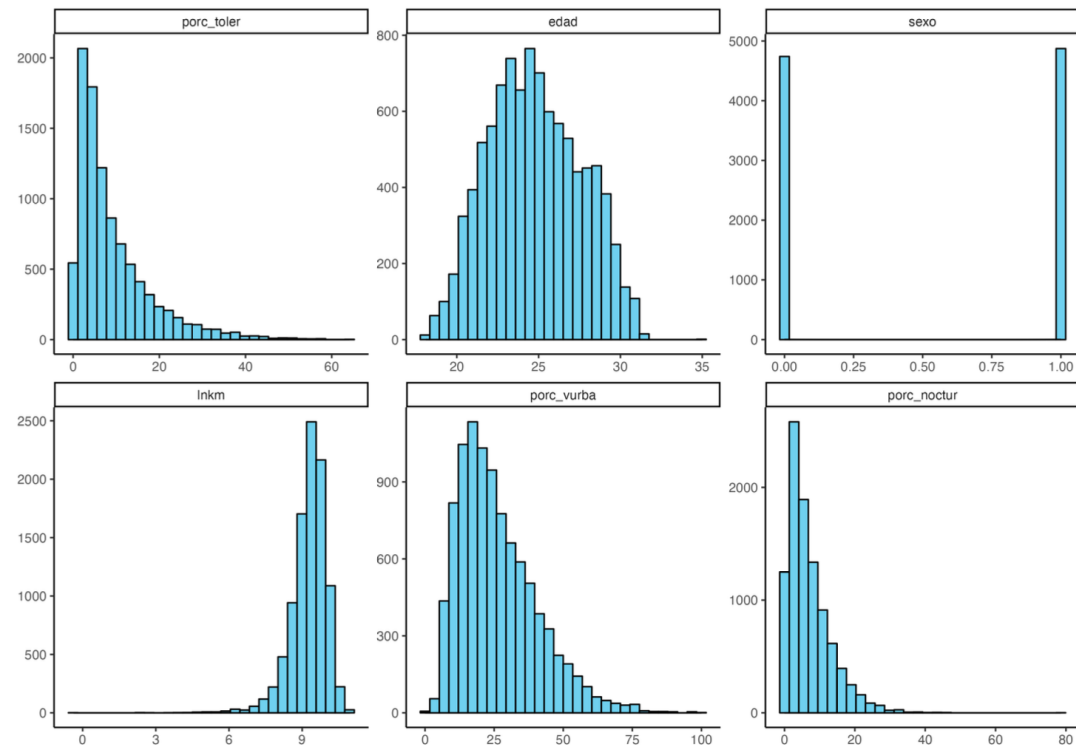


The crossing issue

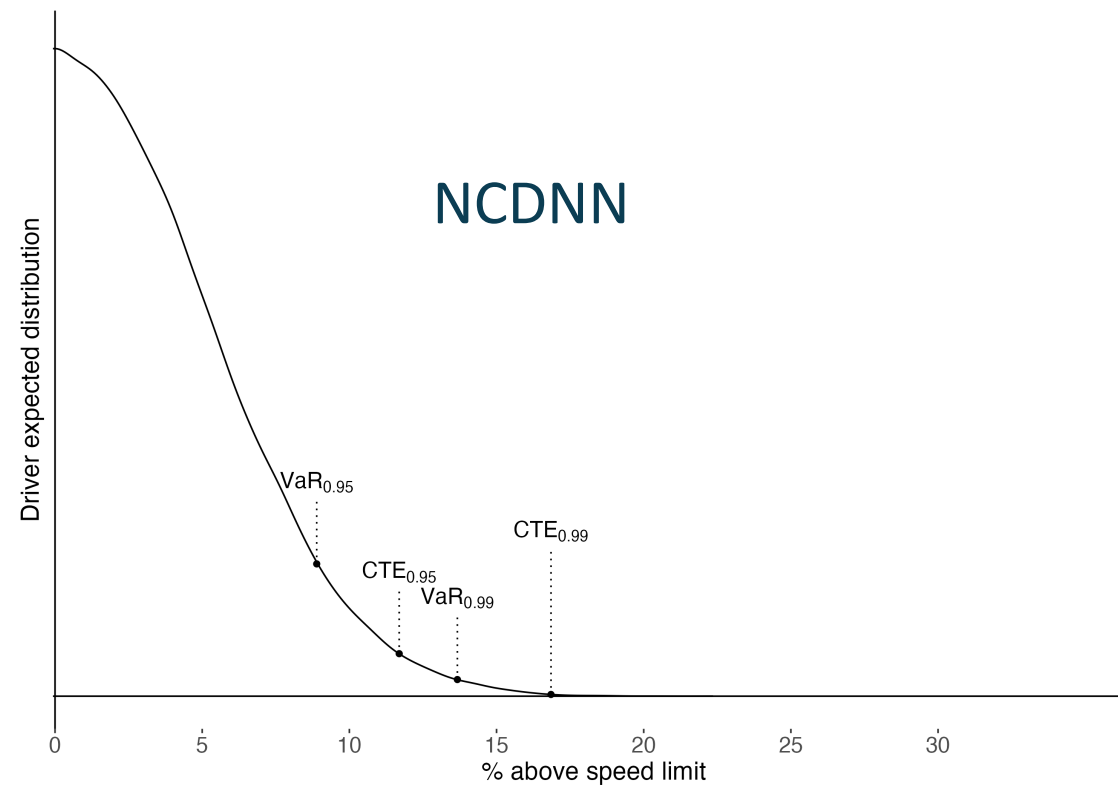
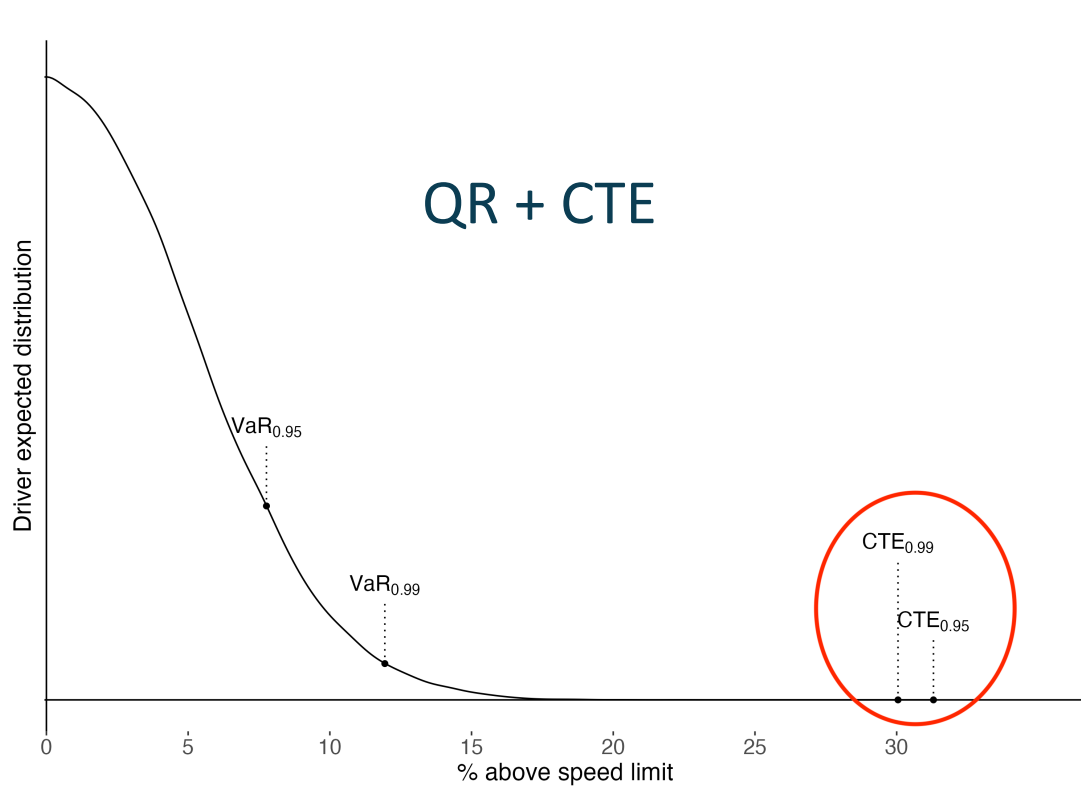
- The actuary did nothing wrong! **Crossing happens with standard quantile regression algorithms.**
- Has been studied for different VaRs, and for one VaR and one CTE at a time.
- But, there is the motivation to move from VaR to CTE and estimate different quantile levels, where crossing has not been addressed.
- We present the **Non-Crossing Dual Neural Network (NCDNN)**, an algorithm capable of estimating VaR and CTE for different quantile levels without crossing.

Telematic information

- Aggregation of yearly driver behavior of ~10,000 drivers from a Spanish insurance firm.
- % km above speed limit.



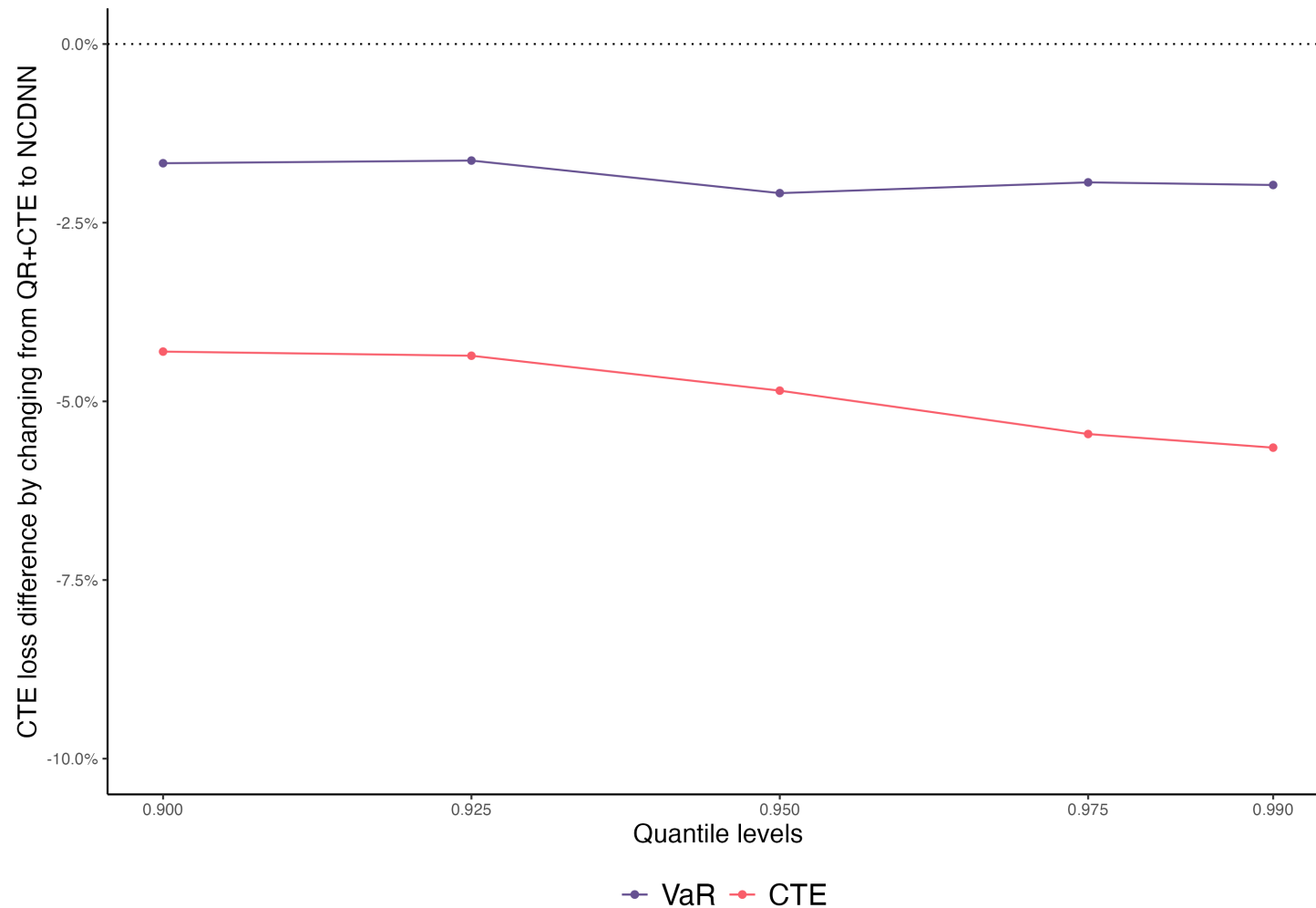
Crossing example



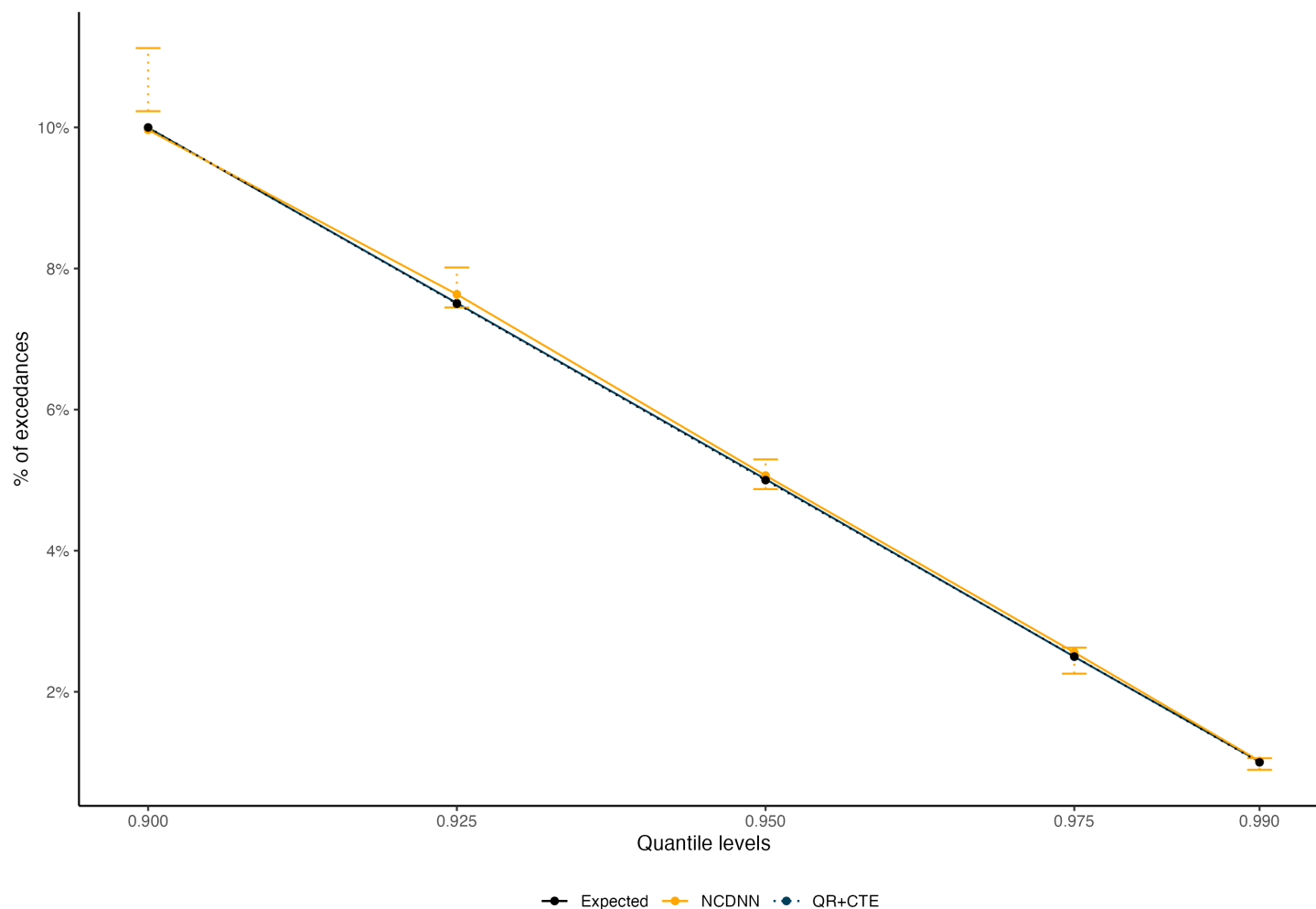
Crossings one quantile level at a time

$q_i - q_{i+1}$	0.9 - 0.925	0.925 - 0.95	0.95 - 0-975	0.975 - 0.99
$VaR_{q_i} > VaR_{q_{i+1}}$	3 (0%)	1 (0%)	2 (0%)	2 (0%)
$CTE_{q_i} > CTE_{q_{i+1}}$	0 (0%)	541 (6%)	1,560 (16%)	176 (2%)

Model performance



Model robustness

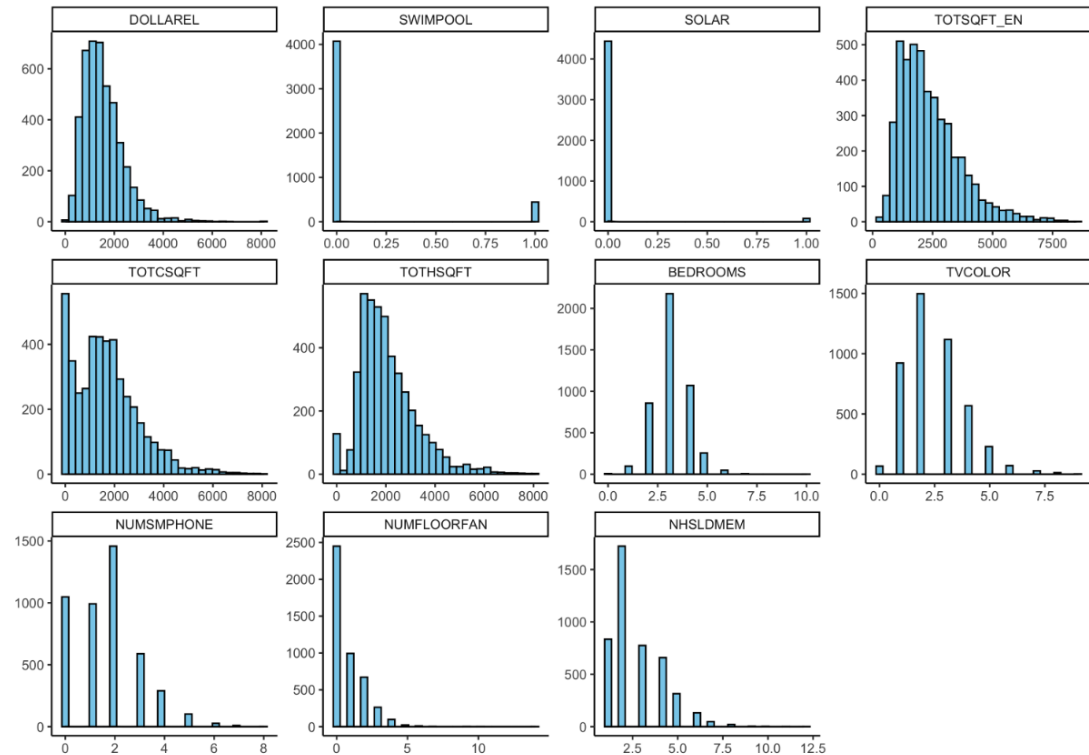


Appendix: Energy Consumption Results

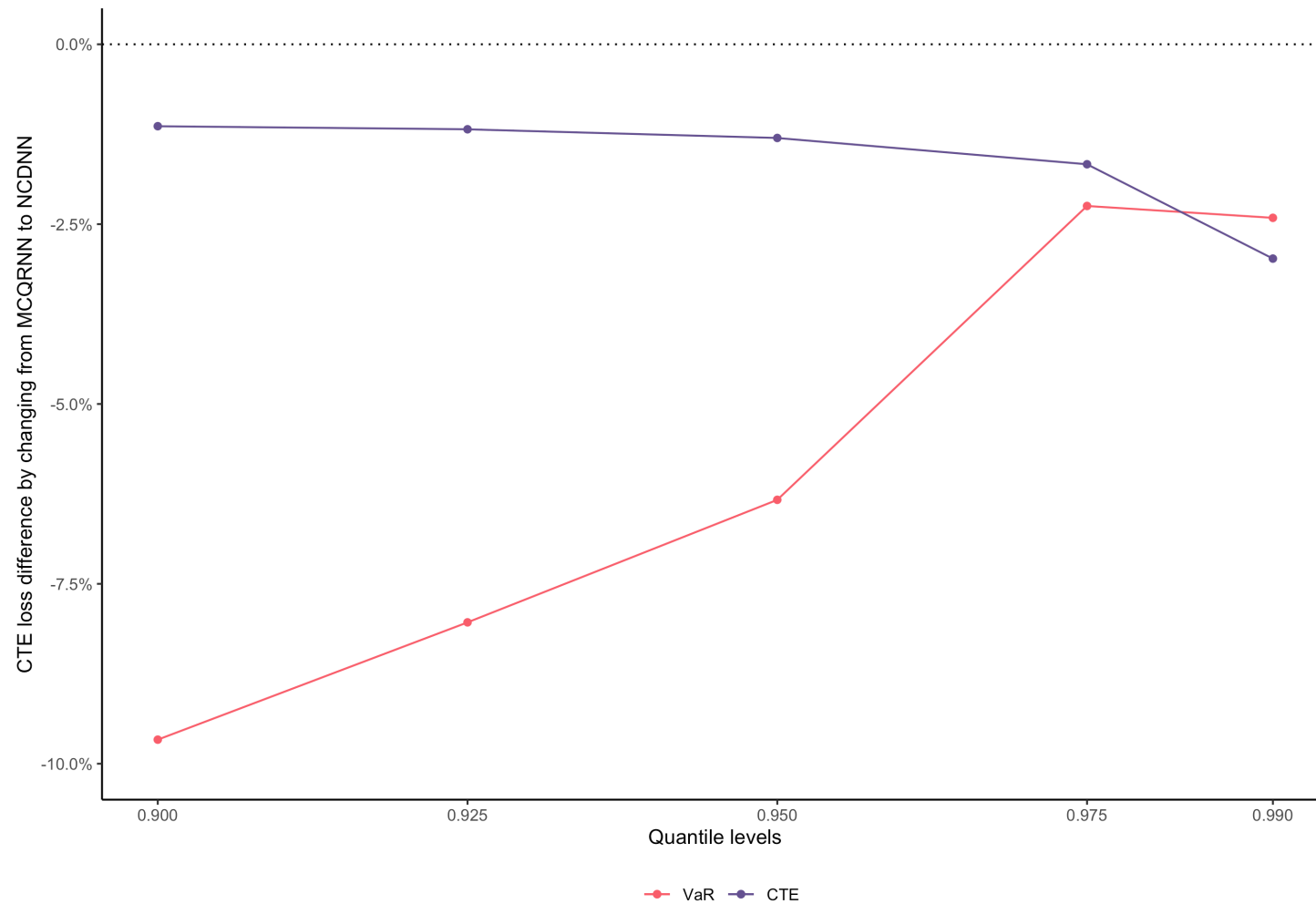


Independent Statistics & Analysis
U.S. Energy Information
Administration

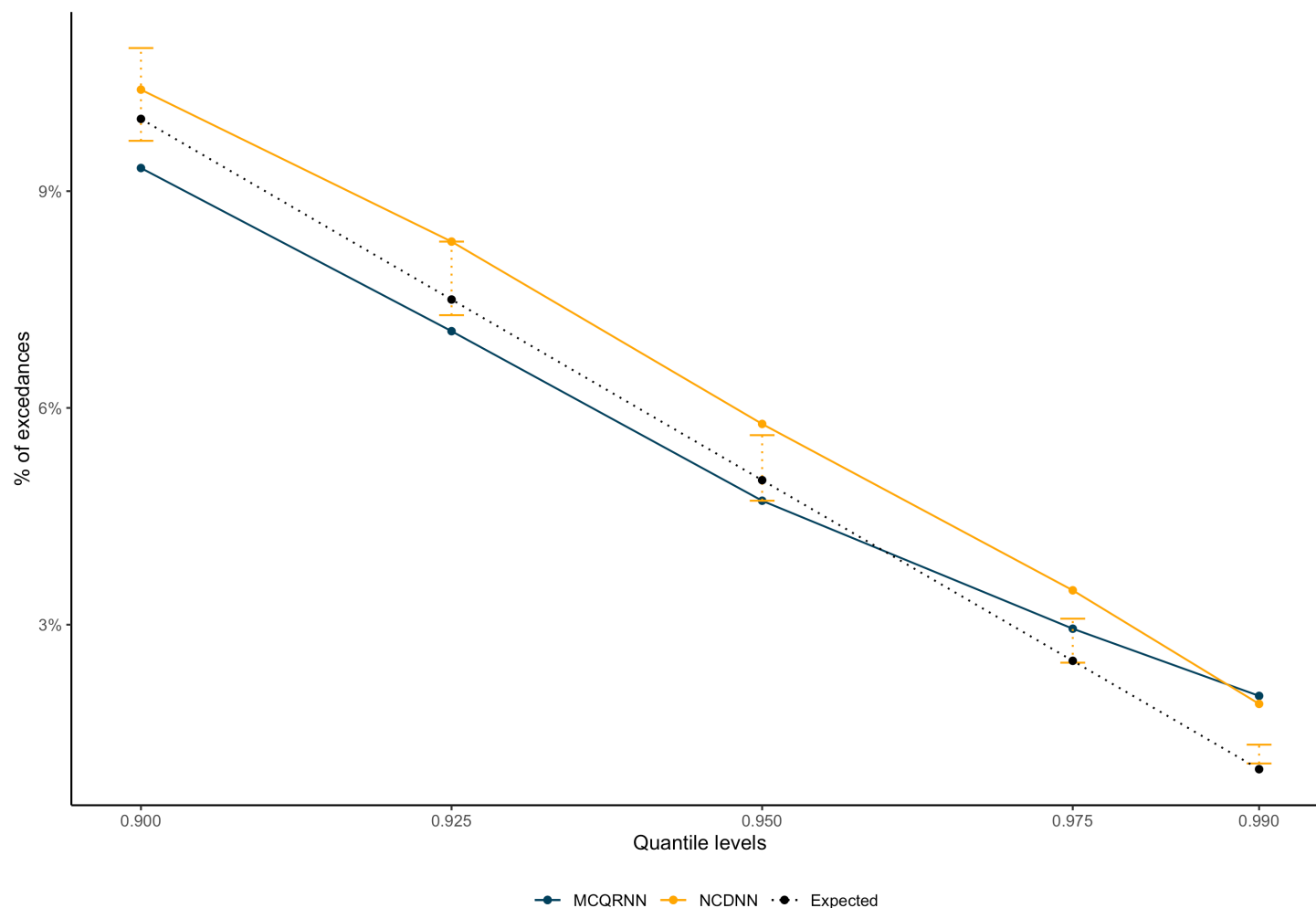
- 2015 poll of 4.5k households.
- Weights allow extrapolation.
- **Cost of electricity.**



Appendix: Model performance



Appendix: Model robustness



Recap and Conclusions

- Risk Analysis needs the **estimation of extreme quantiles** for assessing potential losses.
- Applicable in **insurance, finance** and **energy**.
- Value-at-Risk (VaR) and Conditional Tail Expectations (CTE) are motivated to be estimated for different quantile levels, but **the crossing issue creates unfeasible results**.
- Algorithms such as **Non-Crossing Dual Neural Network** allow the actuary to **overcome the crossing issue** while improving performance against other tested models.



NCDNN Repository for experimentation

The screenshot shows the GitHub interface for the repository 'JuanJoseVidal / ncdnn'. The repository is public and has 0 stars, 0 forks, and 1 watcher. The main branch is 'main'. The repository contains several files and folders: 'aux_code', 'data', 'nn', 'README.md', 'environment.yml', and 'main.py'. The most recent commit is by Juan José Vidal Llana and Juan José Vidal Llana, dated Mar 27, with 2 commits. The README.md file is open, showing the title 'Non-Crossing Dual Neural Network' and a description: 'This is a repository in regards of the article "Non-Crossing Dual Neural Network: Joint Value at Risk and Conditional Tail Expectation estimations with Non-Crossing Conditions" (Working Paper)'. The right sidebar shows the 'About' section with no description, website, or topics provided, and the 'Releases' and 'Packages' sections, both indicating no published items.

File/Folder	Commit Message	Time
aux_code	Initial commit	2 months ago
data	Initial commit	2 months ago
nn	Initial commit	2 months ago
README.md	Modify README to add acknowledgements and correct stuff	2 months ago
environment.yml	Initial commit	2 months ago
main.py	Initial commit	2 months ago

Bibliography

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- Cannon, A. J. (2018). Non-crossing nonlinear regression quantiles by monotone composite quantile regression neural network, with application to rainfall extremes. *Stochastic Environmental Research and Risk Assessment*, 32(11):3207– 3225.
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- Vidal-Llana, X., Salort Sánchez, C., Coia, V., and Guillén, M. (2022b). Non- crossing dual neural network: Joint value at risk and conditional tail expectation estimations with non-crossing conditions. *Documents de Treball (IREA)*, 2022(15):1.

Thank you!

Hope you liked the presentation. For further questions do not hesitate to contact me via mail on:

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