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Exploring the kiwifruit cool chain with Artificial Intelligence

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Zespri™ KIWIFRUIT

eResearch NZ
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Outline

- The Kiwifruit Cold Chain
- Insights using AI
  - Data Visualisation
    - UMAP
    - Bayesian Networks
  - Predicting Fruit Quality
    - Importance analysis
    - Encoding Temperature information
- Conclusions

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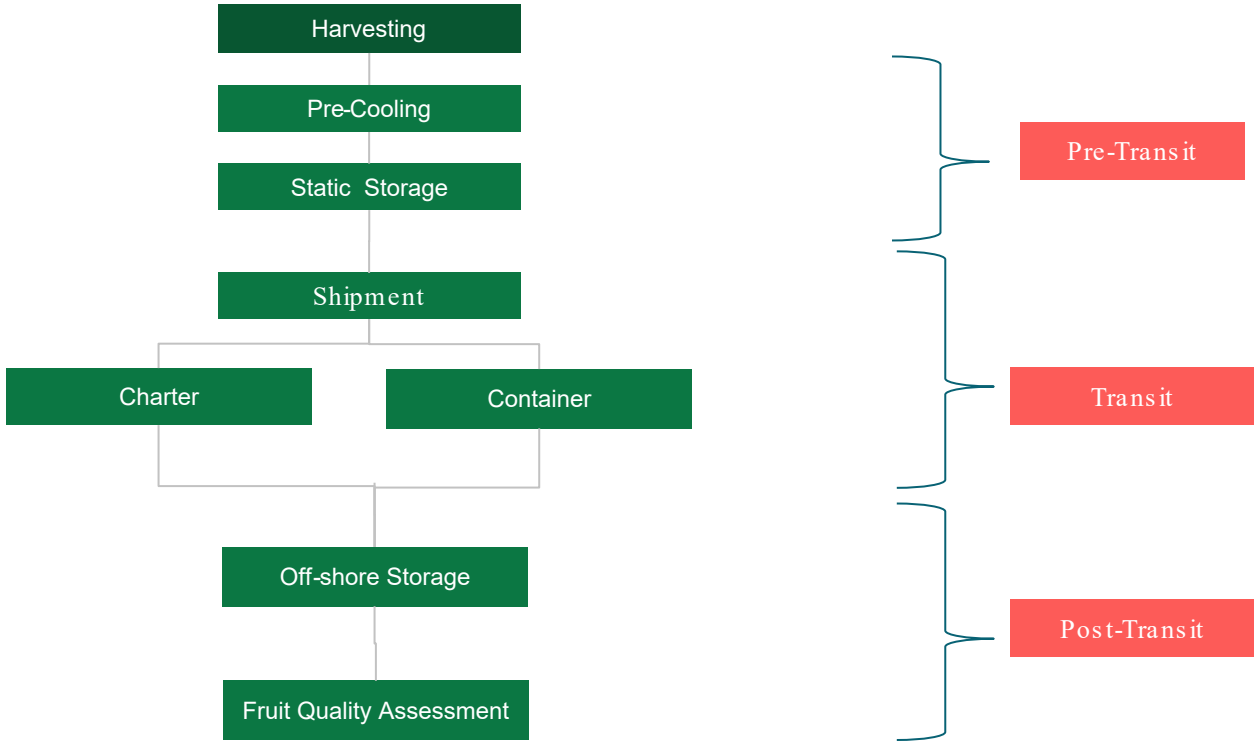
Kiwifruit Cool Chain, Simplified



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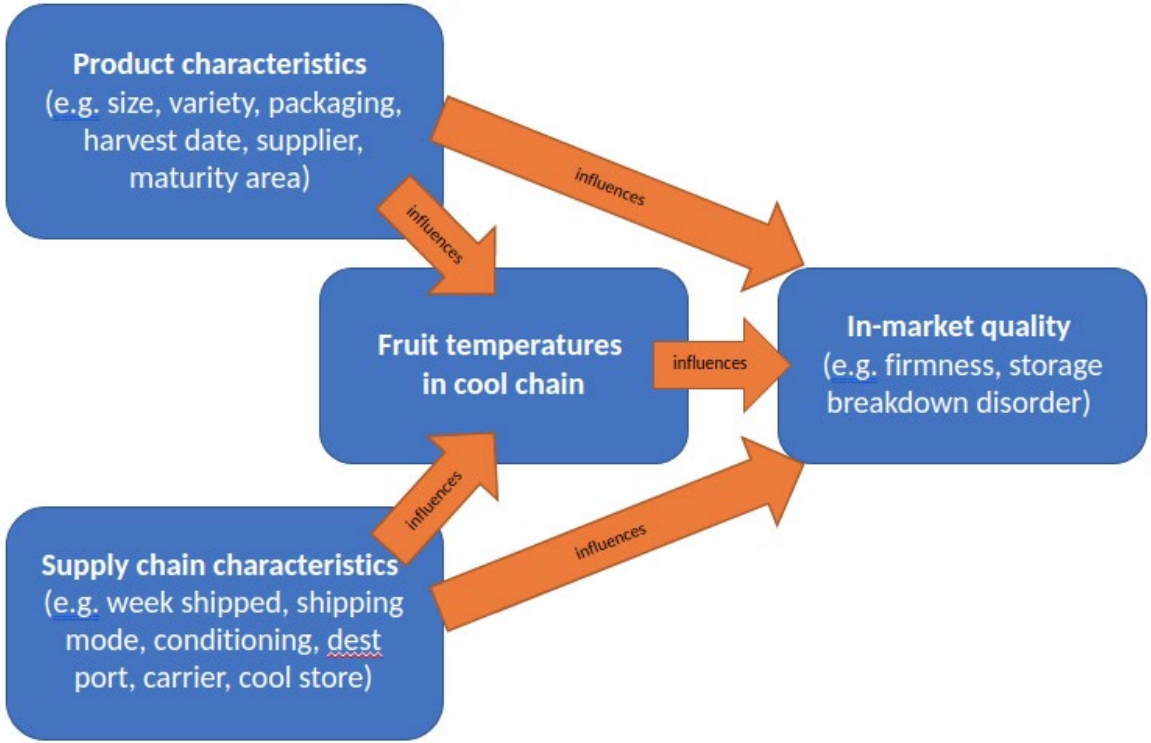

- 3 Seasons (2018-2020)
- ~40,000 pallets/year tracked with temperature loggers
- Fruit quality assessment on ~¼ of pallets tracked
- **~40 variables**

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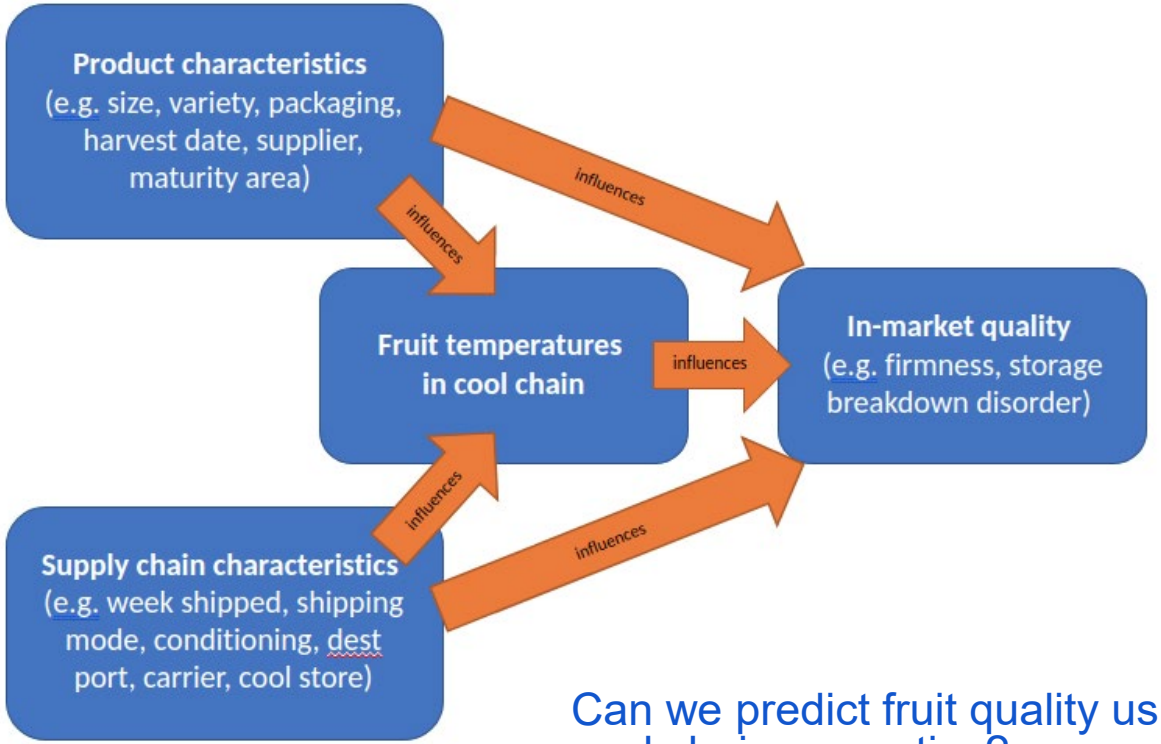

Can we predict fruit quality using cool chain properties?

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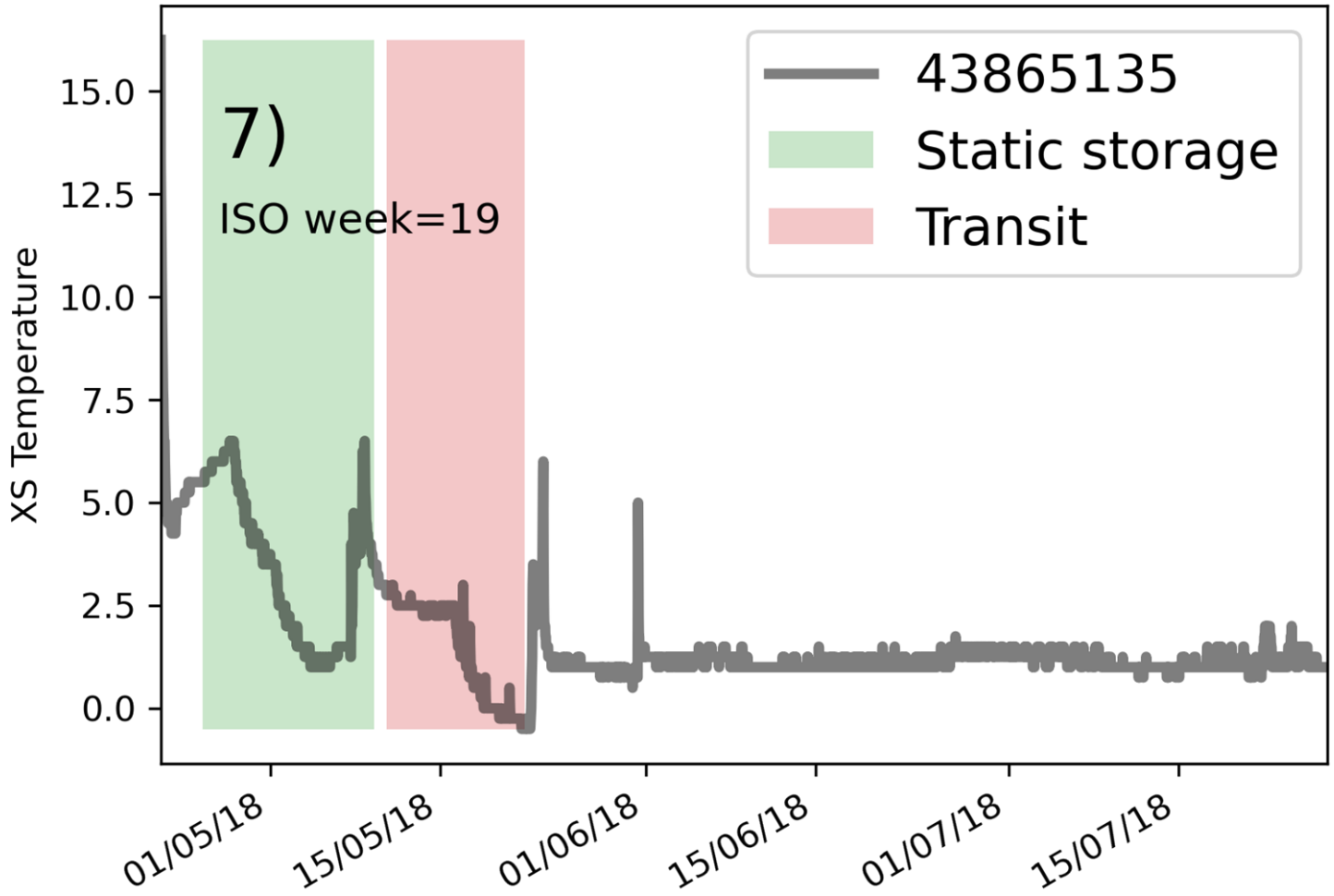

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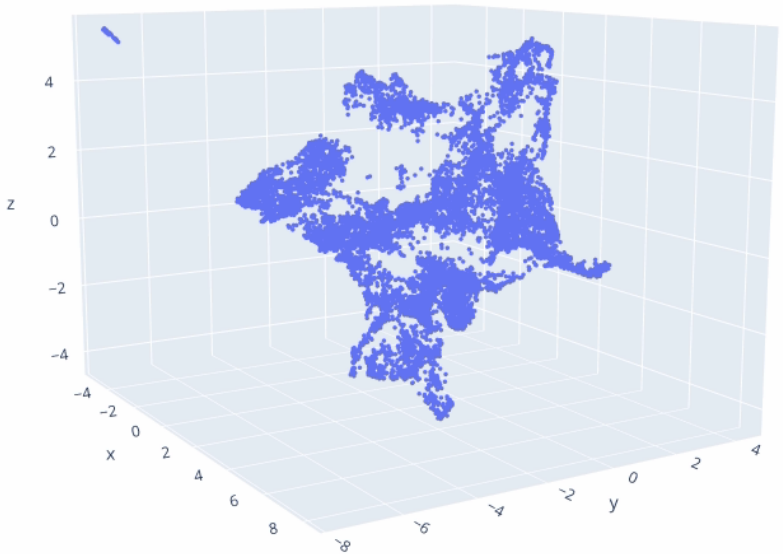
Revealing Data Structure with Dimensionality Reduction: UMAP

From over ~40 dimensions to 3



Cool chain properties of kiwifruit pallets exhibits structure

- Full dataset exhibit structure with some clear groups
- Similarity

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Revealing Data Structure with Dimensionality Reduction: UMAP

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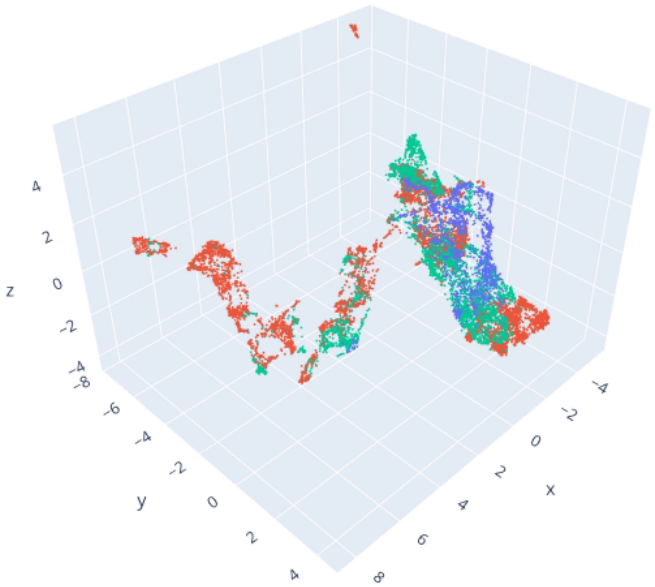

Cool chain properties of kiwifruit pallets exhibits structure

- Full dataset exhibit structure with some clear groups
- Period in the season key to understand pallet properties
  - Early Season
  - Mid Season
  - Late Season

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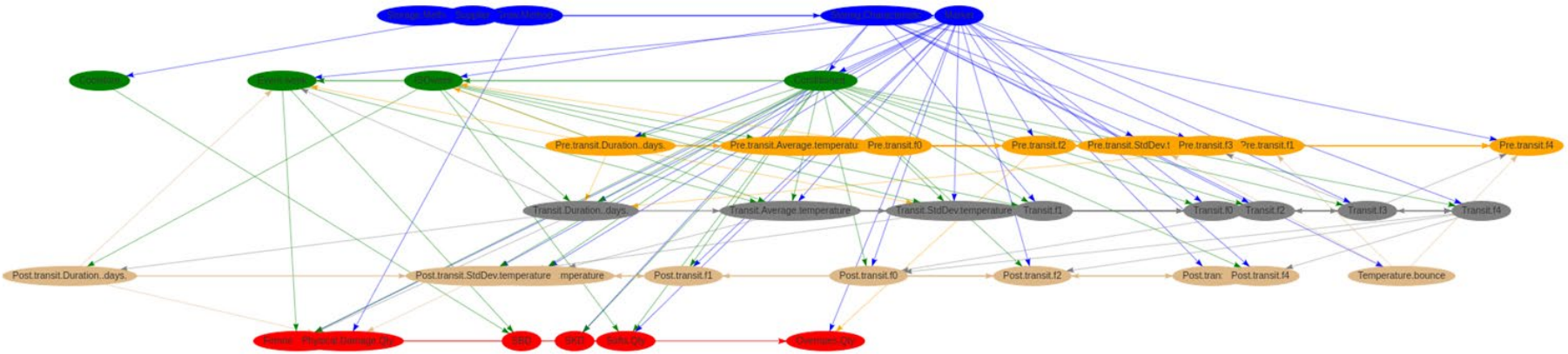
Discovering causal links in dataset:

Bayesian Networks

Model conditional dependence -> Causation $P(V) = \prod P(V_i|\pi(V_i))$



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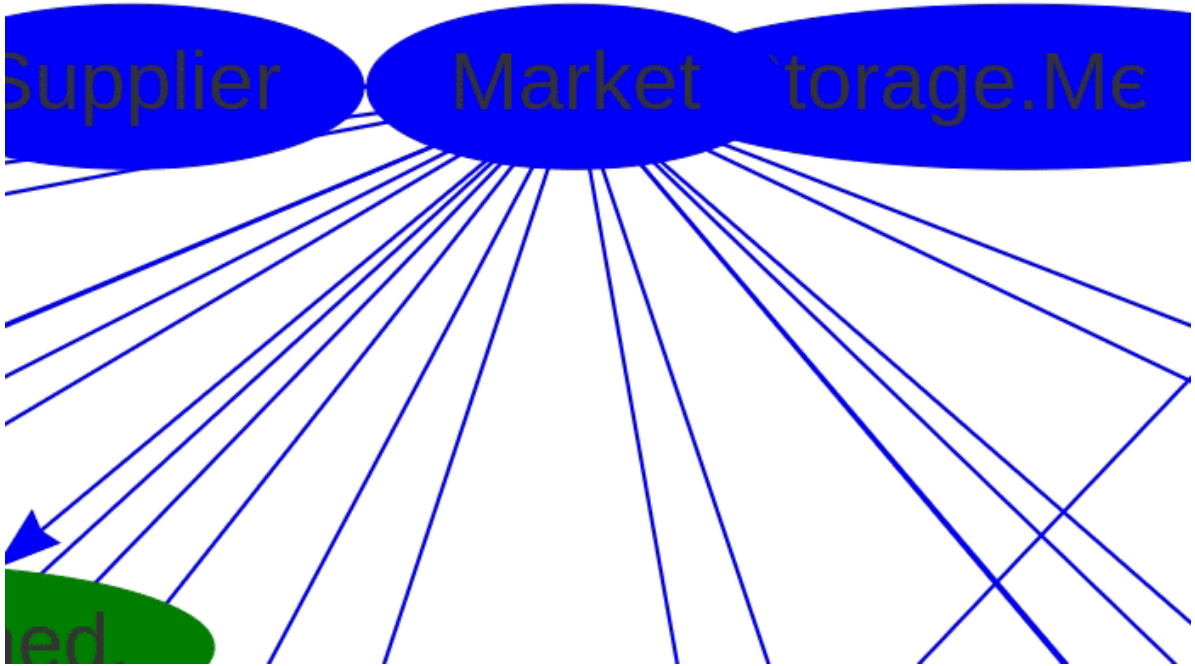

- Conditional Probability Functions encode causal links
- Market directly influences:
  - Transit,
  - Post-transit and
  - Fruit defects
- Different fruit defects linked to different stages of the cool chain

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Predicting Fruit Quality

Can we predict Offshore fruit quality assessment using cool chain properties?

- Feature selection
  - Remove highly correlated parameters
- Fix Class-imbalance
  - Resample minority classes with SMOTE
- Incorporate Temperature histories
  - Autoencoder
- Train ML models to predict fruit defects
  - Different bands of fruit defects
- Discover important variables
  - Perform feature permutation analysis

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Predicting Fruit Quality

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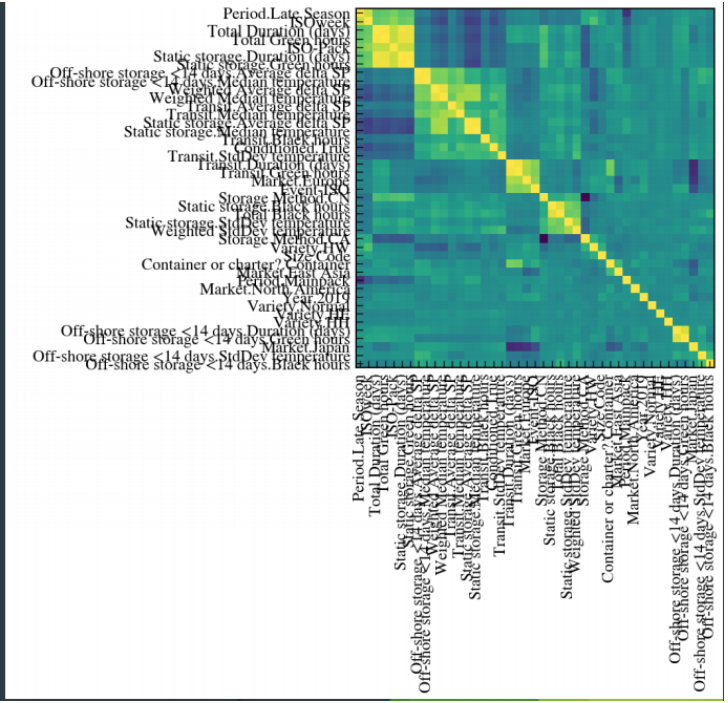
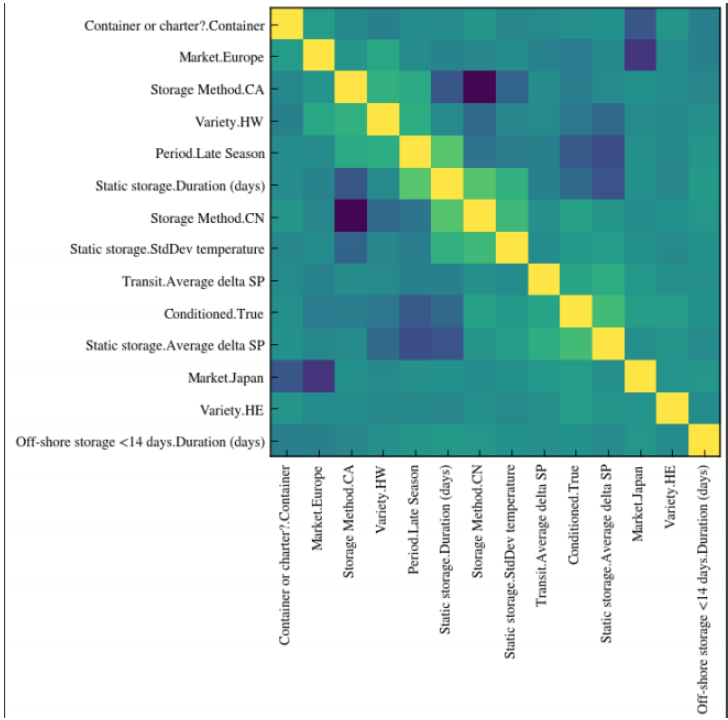
Feature selection





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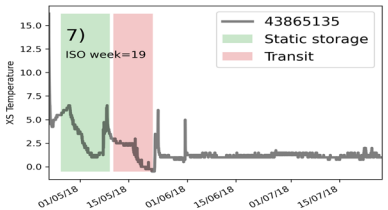
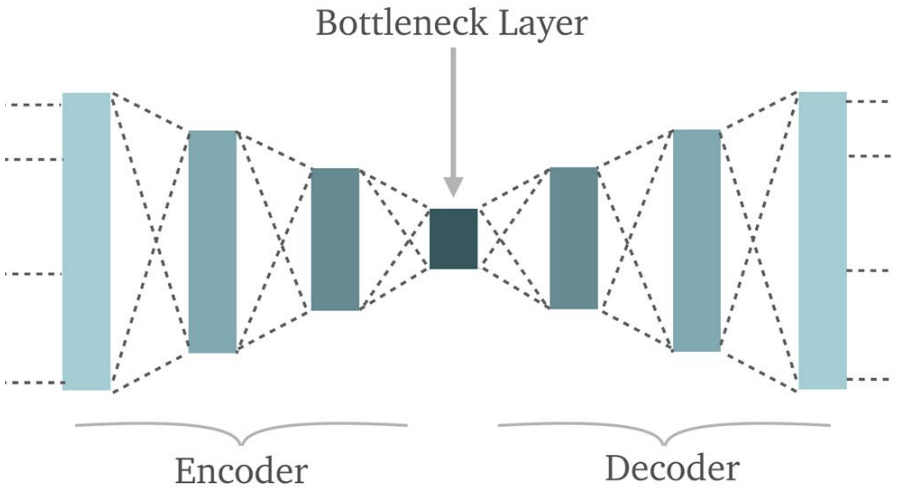
Temperature histories and model predictions: *Autoencoders*

100's of timestamps



5 numbers



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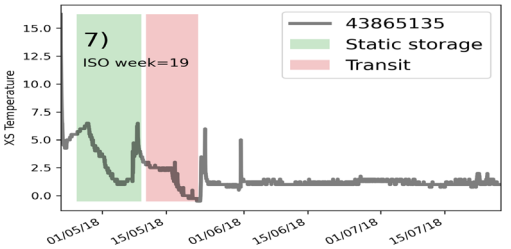
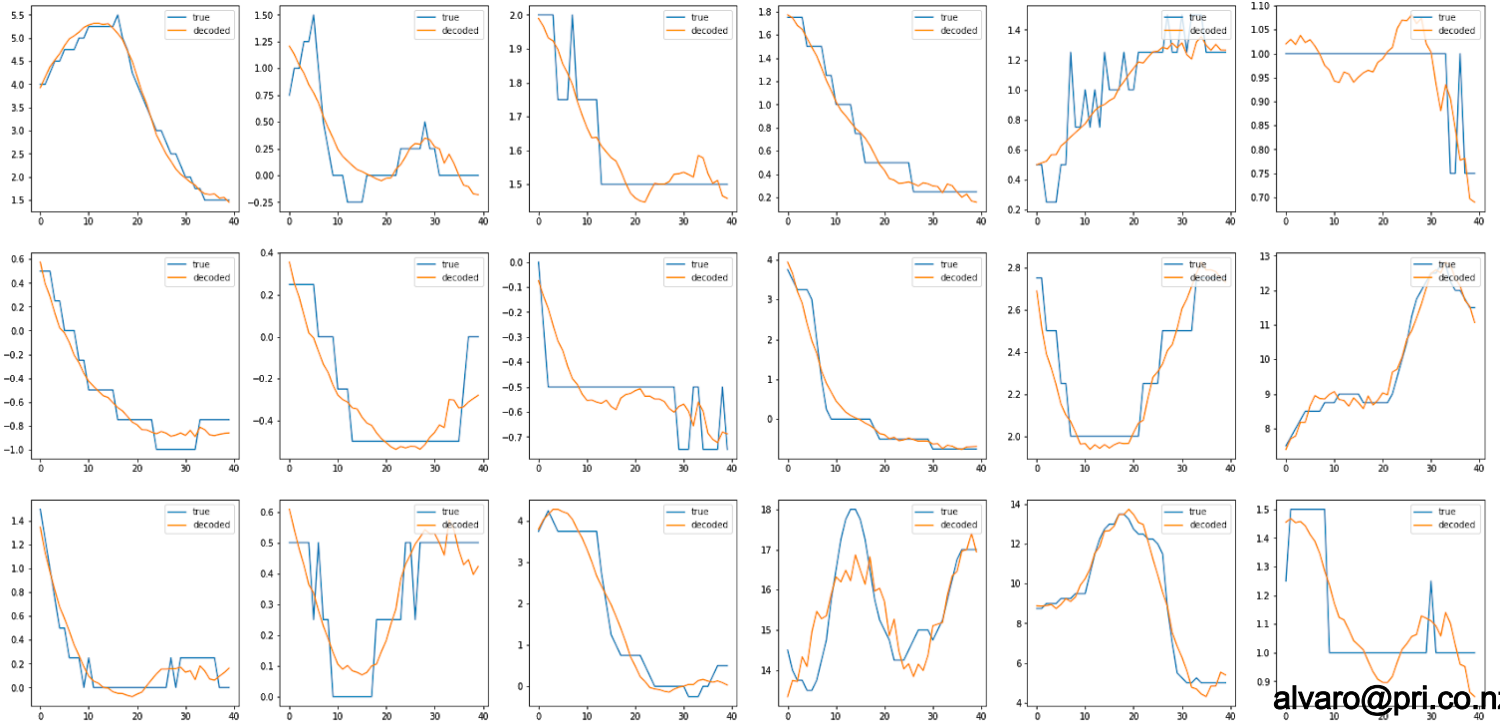


Temperature histories and model predictions: *Autoencoders*



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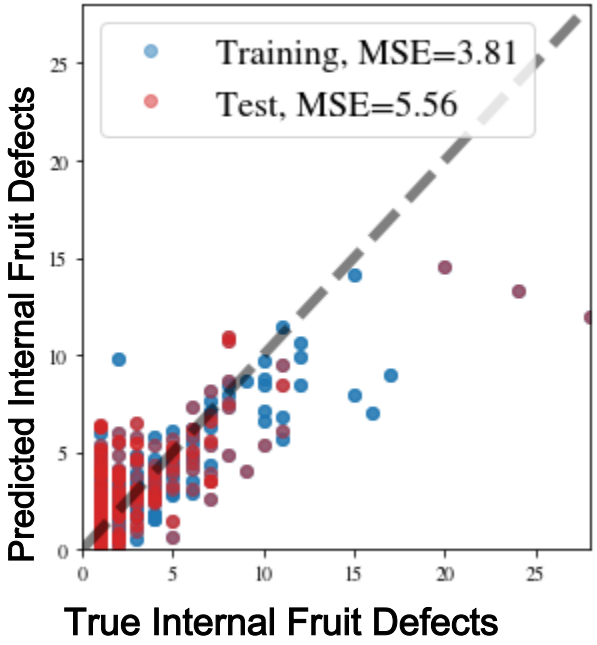
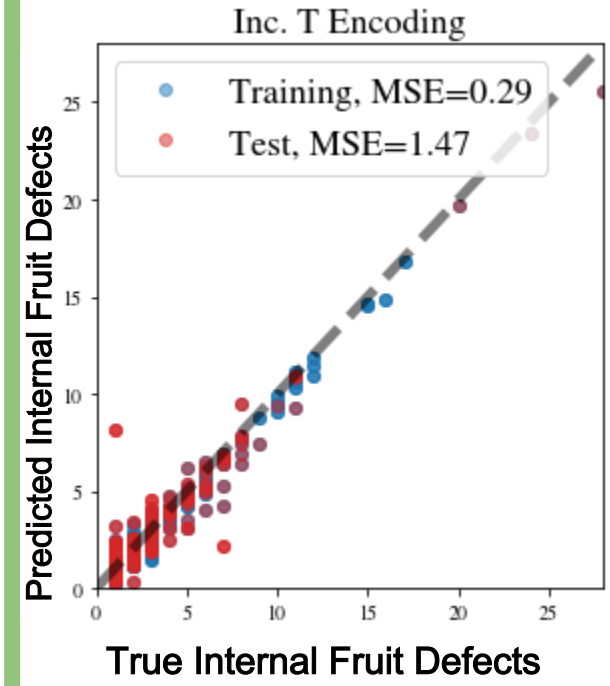
Temperature histories and model predictions: *Impact on model performance*





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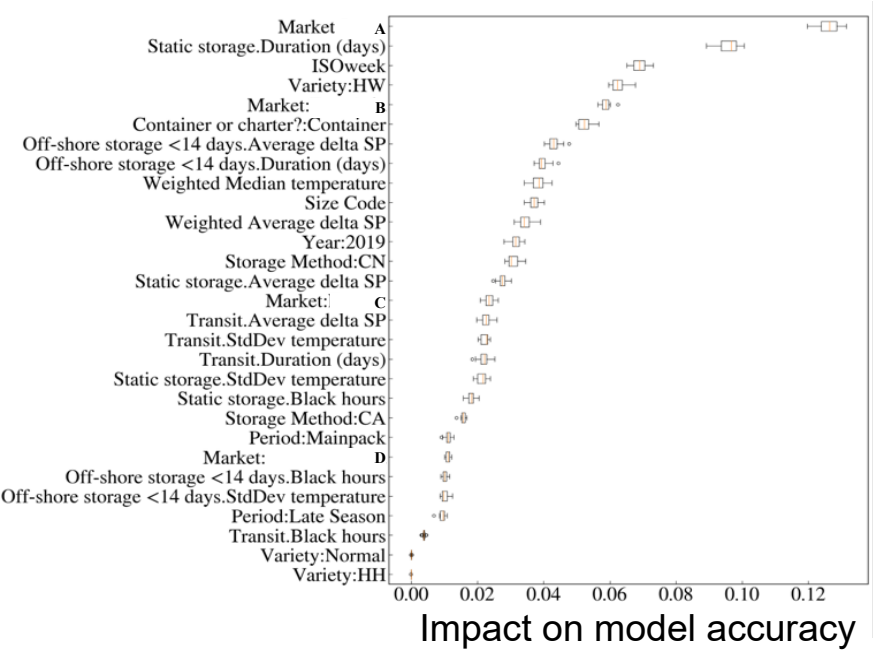
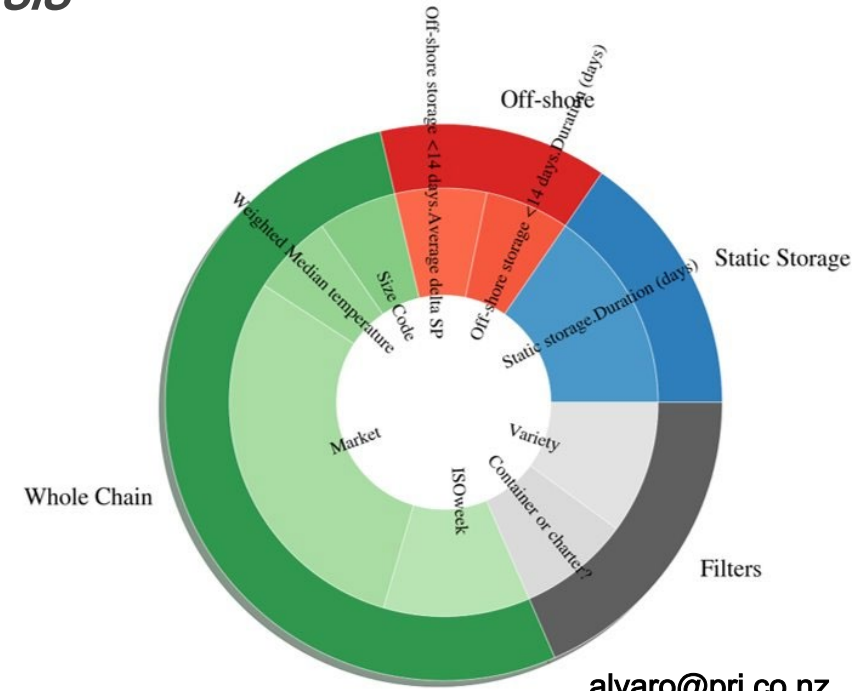
Discover important variables that impact model performance

Feature permutation analysis





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Conclusions

- Kiwifruit coolchain is a complex process
  - High dimensional parameter space
  - Variable dependencies intertwined with each other
- Dimensionality reduction and Bayesian Networks reveal structure and links in the coolchain
  - Period within the season defines pallet properties
  - Market influences transit and post-transit
    - ISOWeek
    - Growing method
    - Conditioning
- Encoding Temperature histories can boost model predictions significantly
- Feature importance analysis also reveals the role of different stages in coolchain
  - Temperature control
  - Duration of different stages
  - Period, fruit variety, conditioning
- This approach informs Zespri of particular aspects of the coolchain that affect fruit quality, so further improvements can be made based on a data-driven quantitative foundation

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