Improving Demand Prediction and Reducing Out-of-Stock – Application of Advanced Data Analytics in Retail Supply Chains

Brandtner Patrick, Darbanian Farzaneh, Falatouri Taha, Udokwu Chibuzor
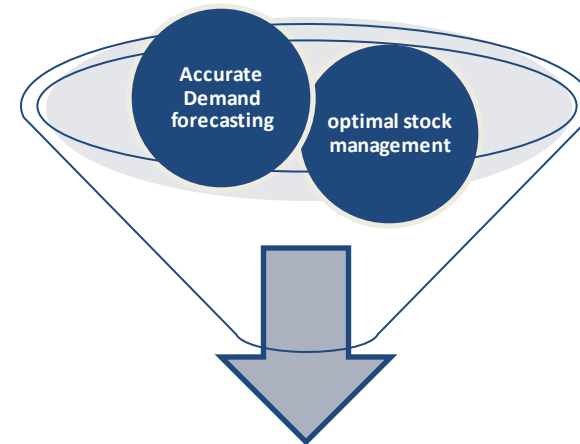
taha.falatouri@fh-steyr.at

Agenda

1. Introduction and Background
2. Research Question and Methodology
3. Results
4. Summary and Conclusion

Introduction and Background – demand prediction in retail sector

- The retail sector is characterized by:

    - High degree of demand uncertainty

    - Volatile customer requirements

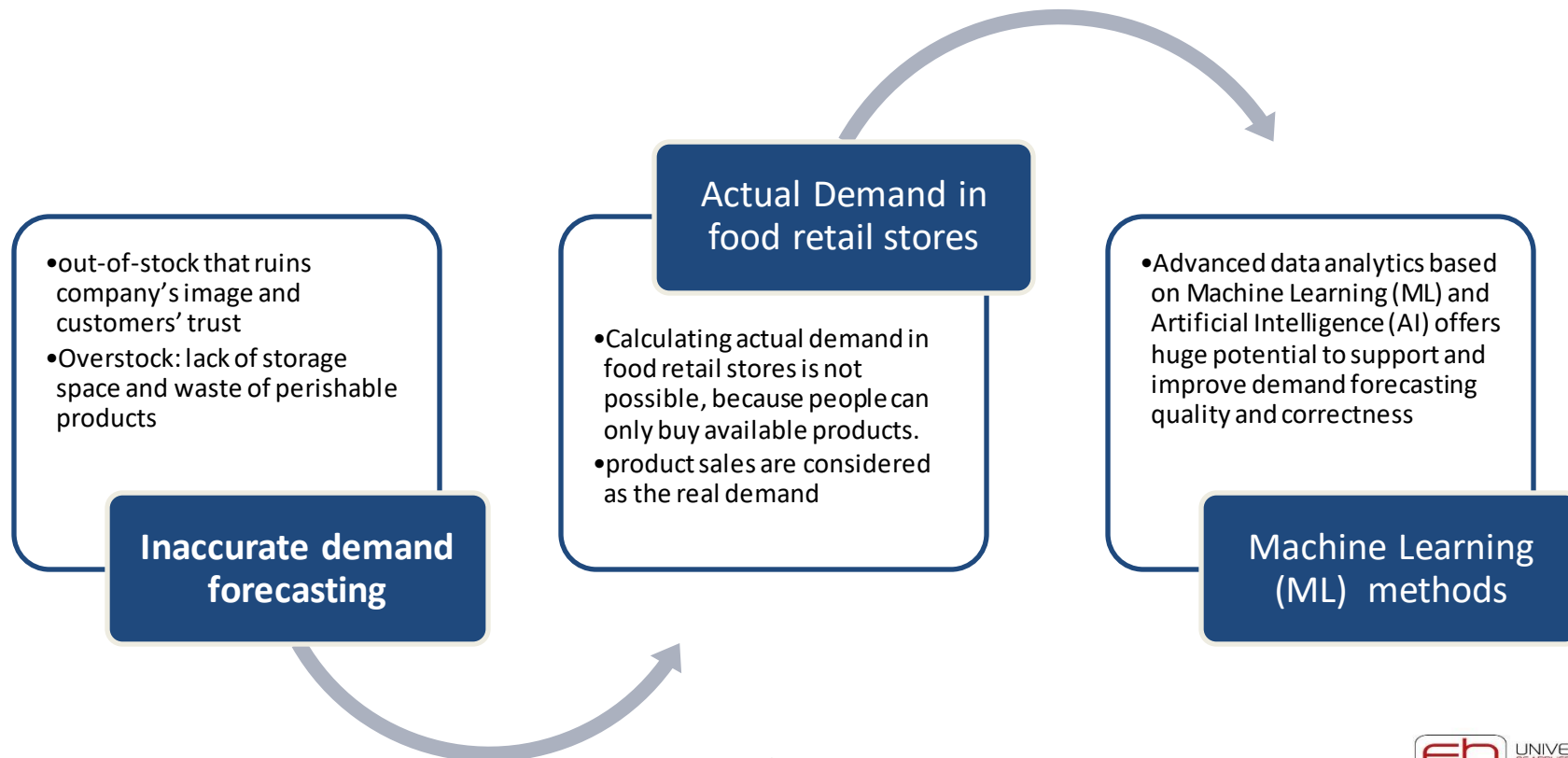   - Fierce competition by online retailers.

key success: efficient and cost optimized operational processes

- Advanced data analytics based on Machine Learning (ML) and Artificial Intelligence (AI) offers huge potential to support and improve demand forecasting quality and correctness.

Accurate Demand forecasting

optimal stock management

Efficient retail operations, Product availability and Customer Satisfaction

Introduction and Background – demand prediction in retail sector

Actual Demand in food retail stores

- out-of-stock that ruins company's image and customers' trust
- Overstock: lack of storage space and waste of perishable products

Inaccurate demand forecasting

- Calculating actual demand in food retail stores is not possible, because people can only buy available products.
- product sales are considered as the real demand

- Advanced data analytics based on Machine Learning (ML) and Artificial Intelligence (AI) offers huge potential to support and improve demand forecasting quality and correctness
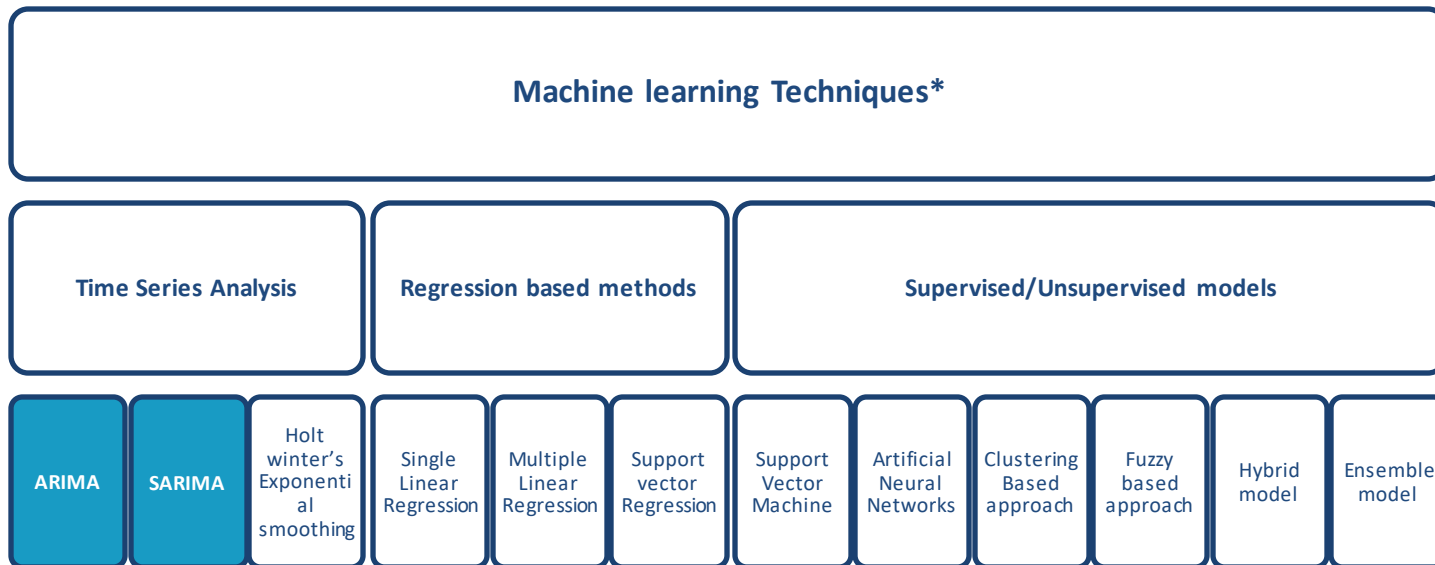
**Machine Learning (ML) methods**

Research Question and Methodology (1)

How can advanced analytics and Machine Learning-based approaches be applied in retail supply chains to improve demand forecasting and out-of-stock detection?

Machine learning Techniques*		
Time Series Analysis	**Regression based methods**	**Supervised/Unsupervised models**

ARIMA	SARIMA	Holt winter's Exponential smoothing	Single Linear Regression	Multiple Linear Regression	Support vector Regression	Support Vector Machine	Artificial Neural Networks	Clustering Based approach	Fuzzy based approach	Hybrid model	Ensemble model

* Ref: Ga, Sumaiya Farzana, and N. Prakashb. "Machine Learning in Demand Forecasting-A Review."

Research Question and Methodology (2)

- **data collection**:
  - The data is related to cashier data of three perishable food items from the category of fruits and vegetables: cucumber, salad and avocado for more than 90 stores in Austria from January 2017 to December 2019.
  - Sample data for this study consists of aggregated daily sales data of stores that were consistently open within this time period.
- **data preparation**:
  - To fill missing data elements, we used alternative data from operational Supply Chain process (shipping data from distribution center to store) if available. Otherwise, they are filled using Simple Arithmetic Average (SAA Simple arithmetic average) method.
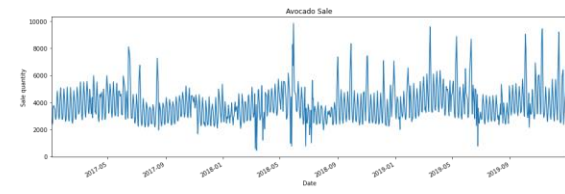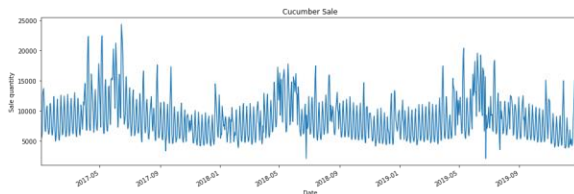
Results – ARIMA and SARIMA comparison

	AVOCADO ARIMA	AVOCADO SARIMA	CUCUMBER ARIMA	CUCUMBER SARIMA	SALAD ARIMA	SALAD SARIMA
p,d,q	p=0,d=0,q=7	p=3,d=0,q=3	p=0,d=0,q=7	p=0,d=0,q=4	p=0,d=0,q=10	p=0,d=0,q=2
P,D,Q		P=1,D=1,Q=1		P=1,D=1,Q=1		P=1,D=1,Q=1
RMSE	1,023.306	909	2,506.811	2,094.040	1,102.381	953
RMSPE	50	48	34	24	32	27
MAE	730	544	1,865.378	1,346.918	807	608
MAPE	23	17	23	16	20	15
MAXAE	5,451.908	5,363.323	15,856.889	16,736.227	5,416.038	5,520.990
MAXAPE	678	762	443	241	427	372
AIC	13,009.143	12,704.178	14,688.995	14,258.716	13,148.781	12,790.952
BIC	13,043.049	12,733.202	14,718.058	14,282.902	13,182.688	12,810.302

Interpretation of the MAPE

	MAPE	Interpretation
	<10	Highly accurate forecasting
SARIMA	10-20	Good forecasting
	20-50	Reasonable forecasting
	>50	Inaccurate forecasting

Results – out of stock estimation

External factors
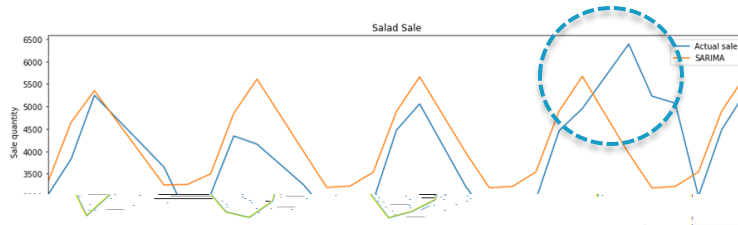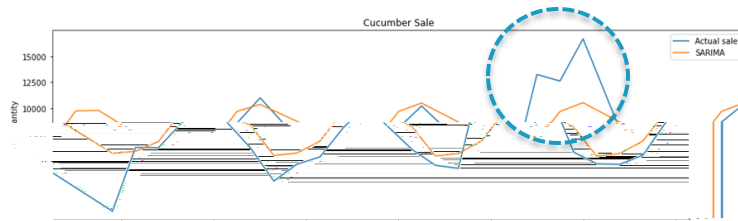
substitute products

Product	December 2019	January 2020
Avocado sub1	20051	32569
Avocado sub2	42082	46250
Avocado - target	103349	96141
Total	165482	174960

Results – out of stock estimation

Traditional methods for detecting out of stock situations are based on sale gaps in the last hours of a day.
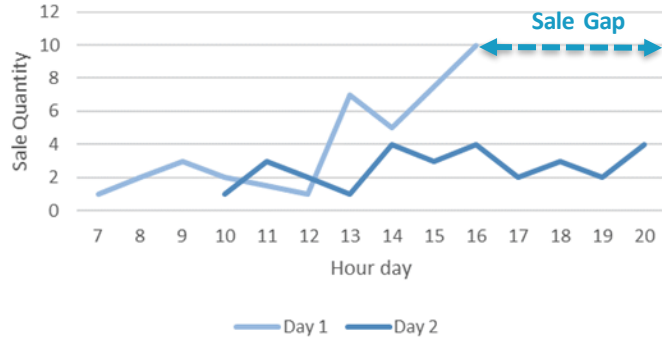
No detection of operational out-of-stock at the store level during the day.
Does not allow for estimating how many product sales were potentially missed.

Advanced analytics approach identified out of stock situations as well as their amount. → The differences between expected sales and real sales

Product	Out-Of-Stock situations Traditional method	Out-Of-Stock situations Forecasting method	Missed sale	Ave daily sale
Cucumber	1	2	221	157
Salad	1	9	168	79
Avocado	1	5	104	45

Summary and Conclusion

- **Main goal** is improving demand forecasting and out-of-stock detection based on Machine Learning approaches. Applicability of time series forecasting with ARIMA and SARIMA in order to better predict the sales of the single stores on daily levels of an actual practice use case from the Austrian retail sector .

- **benefits** of applying advanced analytics in retail demand forecasting:
  - providing the basis for establishing a more efficient demand planning across the network
  - Reduce out-of-stock situations, food wastage and unfulfilled customer demands
  - Plan transportation and warehouse infrastructure closer to real demand at an early stage
  - better utilization of resources and the avoidance of express orders and shipping

- The **results** provide:
  - forecasted daily sales of stores with good forecasting quality
  - In contrast of traditional methods, the improved out-of-stock detection approach is not limited to overall sold quantity and the sales gaps and identify higher amount of critical out-of-stock situations

- Possible **limitation** is focusing on one specific retail case in Austria and having missed data in some cases

- **Future research** would be adding and analyzing the effect of external data such as substitute products and promotions on prediction approaches.

THANK YOU FOR YOUR ATTENTION!

taha.falatouri@fh-steyr.at

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