# Reinforcement Learning for Inventory Optimization Using the DataCo Dataset

**Muhammad Zaka Shaheryar - 500648718**

**Overview:**

Inventory control has been a prominent subject of study in management science for over a century [1]. Effective inventory management plays a crucial role in ensuring smooth supply chain operations and customer satisfaction, particularly in the face of increasing globalization. Traditional models like Economic Order Quantity (EOQ) do not dynamically adapt to fluctuating demand and supply conditions. Reinforcement Learning (RL) offers a promising solution by enabling adaptive, real-time decision-making through continuous learning from the environment. RL refers to agent-based machine learning methods that aims to learn the dynamics of an environment by interacting with it [2]. This project uses the deep learning-based sales forecasting as input to RL-based inventory optimization. Specifically, the focus will be on optimizing inventory policies to maximize delivery reliability (on-time delivery rate) and minimize lead times (order-to-delivery durations), addressing key operational challenges in real-world supply chains.

**Objective:**

The aim of the project is to accomplish the following objectives:

- Integrate sales forecasts as input features in the RL framework.
- Develop and train various RL models such as SARSA, DQN, DPG, Reinforce, and PPO to dynamically optimize order fulfillment policies.
- Design reward functions emphasizing delivery reliability improvement and lead time minimization, penalizing delayed deliveries and unfulfilled orders
- Evaluate and compare the performance of the developed model against naïve and traditional inventory management models like the EOQ and Newsvendor models.
- Develop the model to incorporate feedback from real-time data changes and learn optimal policies for inventory management.
- **Performance Metrics:** On-Time Delivery Rate (%), Lead Time Variance, Cumulative Reward Stability and computational efficiency of the model.

**Dataset:** The DataCo Supply Chain dataset, obtained from Kaggle [3], consists of 51 columns and 180,520 rows. It covers around three years of data (2015-2017). Some important attributes for RL include Days for shipment (real), Days for shipment (scheduled), Benefit per order, Sales per customer, Delivery Status, Late_delivery_risk, Category Name, Customer Fname, Latitude, Longitude, Customer Country, Department Name, order date (DateOrders), Order Item Total, Order Item Profit Ratio, Sales, and Product Name, among others.

**References:**

[1] D. P. Neghab et al., "Machine Learning-Based Control of Dual-Sourcing Inventory Systems," *IEEE*. URL: https://ieeexplore-ieee-org.ezproxy.lib.torontomu.ca/document

[2] N. Mohamadi et al., “An application of deep reinforcement learning and vendor-managed inventory in perishable supply chain management,” *Engineering Applications of Artificial Intelligence*. URL: https://www-sciencedirect-com.ezproxy.lib.torontomu.ca

[3] Kaggle. DataCo Dataset. URL: https://www.kaggle.com/datasets/shashwatwork/dataco-smart-supply-chain-for-big-data-analysis