

CLAIMS

WHAT IS CLAIMED IS:

1. A system comprising ~~one or more computers and one or more storage devices storing instructions that are operable, when executed by the one or more computers, to cause the one or more computers to perform operations comprising:~~
a memory; and
one or more processors communicatively coupled to the memory, the one or more processors configured to:
receiving an inventory dataset comprising a plurality of inventory variables that indicate at least historical (i) inventory levels, (ii) inventory holding costs, (iii) supplier orders, or (iv) lead times over time, wherein the plurality of inventory variables are characterized by having one or more future uncertainty levels;
processing the inventory dataset using ~~process an inventory dataset using~~ a trained machine learning model ~~to generate a prediction of the~~ to predict statistical distributions of a plurality inventory variables ~~that are characterized by having one or more future uncertainty levels,~~ wherein the plurality of inventory variables comprise at least historical (i) inventory levels, (ii) inventory holding costs, (iii) supplier orders, or (iv) lead times over time, and wherein the trained machine learning model ~~has been is~~ trained on with ~~historical inventory datasets~~ values of the plurality of inventory variables;
and
providing the processed inventory dataset to apply ~~an optimization algorithm~~ to at least the predicted statistical distributions of the plurality of inventory variables to produce an optimized inventory dataset comprising one or more predicted inventory management parameters that achieve a target service level while satisfying ~~wherein the optimization algorithm is one or more constraint conditions; and~~ used to predict one or more inventory management parameters that result in a particular probability of achieving a target service level, while minimizing a cost, and wherein the optimization algorithm comprises one or more constraint conditions
generate an inventory management recommendation configured to modify inventory levels based on the predicted one or more inventory management parameters.

2. The system of claim 1, wherein the one or more processors are configured to apply the operations further comprise optimization algorithm to :
—— ~~providing~~ a current inventory level and a quantity of current supplier orders to predict the one or more inventory management parameters to the optimization algorithm; and
—— ~~using the optimization algorithm to enable achieving the target service level based at least on the current inventory level and the quantity of current supplier orders and in the presence of different sources of uncertainty.~~
3. The system of claim 2, wherein the ~~operations further comprise~~ inventory dataset corresponds to a node in a multi-echelon supply network:
—— ~~generating an inventory management recommendation based on the prediction of underlying uncertainties with the aim of achieving the target service level while minimizing operational costs.~~
4. The system of claim 3, wherein the inventory management recommendation comprises a recommendation to reduce the current inventory level.
5. The system of claim 3, wherein the inventory management recommendation comprises a recommendation to increase the current inventory level.
6. The system of claim ~~3~~1, wherein the one or more processors are configured to generate the inventory management recommendation comprises determining a difference between the predicted one or more inventory management parameters and a reference inventory dataset wherein the inventory management recommendation is generated in real time, substantially real time, or just in-time.
7. The system of claim 1, wherein the one or more constraint conditions ~~require~~ comprise a requirement for the target service level to satisfy a present, incoming, or expected demand requirement, and wherein the ~~operations further comprise~~ one or more processors are configured to:
computing compute the present, incoming or expected demand requirement using forecasted demand for finished products and a bill of materials (BOM) for the finished products.

8. The system of claim 7, wherein the BOM comprises a dynamic hierarchical graph.
9. The system of claim 1, wherein the one or more processors are configured to determine a difference between the predicted one or more inventory management parameters and a reference inventory dataset, and wherein the inventory management recommendation is generated at least in part on the difference between the predicted one or more inventory management parameters and the reference inventory dataset~~the inventory dataset comprises internal data and external data.~~
10. The system of claim 1, wherein the inventory dataset is received from a plurality of disparate sources selected from the group consisting of smart devices, sensors, enterprise systems, extraprise, and Internet sources.
11. The system of claim 1, wherein the plurality of inventory variables further comprises one or more inventory movements selected from the group consisting of arrival movements, consumption movements, blocked movements, and inter-factory movements.
12. The system of claim 1, wherein the plurality of inventory variables further comprises one or more of a demand forecast, material consumption, transit time, and shipping cost.
13. The system of claim 1, wherein the trained machine learning model is selected from the group consisting of a support vector machine (SVM), a naïve Bayes classifier, a linear regression model, a quantile regression model, a logistic regression model, a random forest model, a neural network, a Gaussian process, and a Dirichlet processes.
14. The system of claim 1, wherein the prediction of the plurality of inventory variables comprises a statistical distribution of the plurality of inventory variables.
15. The system of claim ~~14~~1, wherein the optimization algorithm is configured to minimize a cost function representing an inventory holding~~statistical distribution comprises one or more statistical parameters.~~

16. The system of claim 15, wherein the one or more statistical parameters are selected from the group consisting of a median, a mean, a mode, a variance, a standard deviation, a quantile, a measure of central tendency, a measure of variance, a range, a minimum, a maximum, an interquartile range, and a percentile.

17. The system of claim 14, wherein the predicted statistical distributions comprise-is:
a parametric distribution comprising one or more statistical parameters selected from the group consisting of a median, a mean, a mode, a variance, a standard deviation, a quantile, a measure of central tendency, a measure of variance, a range, a minimum, a maximum, an interquartile range, and a percentile, or
a parametric distribution selected from the group consisting of a Gaussian distribution, a Gamma distribution, and a Poisson distribution~~a parametric or a non-parametric distribution selected from the group consisting of a Gaussian distribution, a Gamma distribution, and a Poisson distribution.~~

18. The system of claim 1, wherein the optimization algorithm is configured to search for parameters of interest concerning a supply chain network using Bayesian optimization~~minimizes a cost function.~~

19. The system of claim 1, wherein the ~~optimization algorithm further comprises a~~one or more constraint conditions are selected from the group consisting of an inventory constraint, a service level constraint, an arrival window constraint, an order size constraint, and an ordering window constraint.

20. The system of claim 1~~5~~, wherein the optimization algorithm ~~is~~comprises a stochastic constrained optimization algorithm with one or more constraint conditions.

21. The system of claim 20, wherein the stochastic constrained optimization algorithm is a mixed integer linear programming (MILP) problem.

22. The system of claim 1, wherein the optimization algorithm comprises a technique selected from the group consisting of a grid search, a random search, and a Bayesian optimization search.

23. The system of claim 1, wherein the ~~inventory dataset comprises a~~ plurality of inventory variables ~~for~~ are associated with a single-echelon inventory, and wherein the single-echelon inventory corresponds to a single node or facility.

24. The system of claim 1, wherein the optimization algorithm is configured to perform multi-echelon inventory optimization (MEIO), wherein the inventory dataset comprises a plurality of inventory variables for a multi-echelon inventory, and wherein the multi-echelon inventory corresponds to a supply chain network comprising a plurality of nodes or facilities.

25. The system of claim 24, wherein the optimization algorithm is configured to model the plurality of inventory variables using a probabilistic graphical model of the supply chain network.

26. The system of claim 24, wherein the optimization algorithm is configured to search for parameters of interest concerning the supply chain network using Bayesian optimization.

27. The system of claim 1, wherein the optimization algorithm maximizes a product output.

28. The system of claim 1, wherein the optimization algorithm maximizes a profit.

29. The system of claim 1, further comprising providing simulation and predictive tools for predicting future supply and demand behavior and a future service level from the inventory data set to enable better management practices.

30. A method comprising:

~~receiving an inventory dataset comprising a plurality of inventory variables that indicate at least historical (i) inventory levels, (ii) inventory holding costs, (iii) supplier orders, or (iv) lead times over time, wherein the plurality of inventory variables are characterized by having one or more future uncertainty levels;~~

processing ~~the inventory dataset using an inventory dataset using~~ a trained machine learning model to predict statistical distributions of a ~~generate a prediction of the~~ plurality inventory variables ~~that are characterized by~~ having one or more future uncertainty levels, wherein the

plurality of inventory variables comprise at least historical (i) inventory levels, (ii) inventory holding costs, (iii) supplier orders, or (iv) lead times over time, and wherein the trained-machine learning model has been trained with ~~on~~ historical values of the plurality of inventory variablesinventory datasets; and

~~providing the processed inventory dataset to applying~~ an optimization algorithm ~~to at least the predicted statistical distributions of the plurality of inventory variables to produce an optimized inventory dataset comprising one or more predicted inventory management parameters that achieve a target service level while satisfying one or more constraint conditions; and, wherein the optimization algorithm is used to predict one or more inventory management parameters that result in a particular probability of achieving a target service level, while minimizing a cost, and wherein the optimization algorithm comprises one or more constraint~~

~~generating an inventory management recommendation configured to modify inventory levels based on the predicted one or more inventory management parameters.~~

31. The method of claim 30, further comprising applying the optimization algorithm to:
~~providing a current inventory level and a quantity of current supplier orders to predict the one or more inventory management parametersto the optimization algorithm; and~~
~~using the optimization algorithm to enable achieving the target service level based at least on the current inventory level and the quantity of current supplier orders and in the presence of different sources of uncertainty.~~

32. One or more non-transitory computer storage media storing instructions that are operable, when executed by one or more computers, to cause the one or more computers to perform operations comprising:

~~receiving an inventory dataset comprising a plurality of inventory variables that indicate at least historical (i) inventory levels, (ii) inventory holding costs, (iii) supplier orders, or (iv) lead times over time, wherein the plurality of inventory variables are characterized by having one or more future uncertainty levels;~~

~~processing the inventory dataset using applying~~ a trained machine learning model to an inventory dataset to produce a prediction dataset comprising statistical distributions of a generate-a prediction of the plurality inventory variables ~~that are characterized by~~ having one or more future uncertainty levels, wherein the plurality of inventory variables comprise at least historical (i)

inventory levels, (ii) inventory holding costs, (iii) supplier orders, or (iv) lead times over time, and wherein the ~~trained~~-machine learning model has been trained using inventory variable levels extracted from ~~on~~-historical inventory datasets; and

~~providing the processed inventory dataset to applying~~ an optimization algorithm to at least the predicted statistical distributions of the plurality of inventory variables to produce an optimized inventory dataset comprising one or more predicted inventory management parameters that achieve a target service level while satisfying one or more constraint conditions; and, wherein the optimization algorithm is used to predict one or more inventory management parameters that result in a particular probability of achieving a target service level, while minimizing a cost, and wherein the optimization algorithm comprises one or more constraint conditions

~~generating an inventory management recommendation configured to modify inventory levels based on the predicted one or more inventory management parameters.~~

33. The one or more non-transitory computer storage media of claim 32, wherein the operations ~~further~~ comprise:

—— ~~providing~~ applying the optimization algorithm to a current inventory level and a quantity of current supplier orders to predict the one or more inventory management parameters~~the optimization algorithm;~~ and

—— ~~using the optimization algorithm to enable achieving the target service level based at least on the current inventory level and the quantity of current supplier orders and in the presence of different sources of uncertainty.~~