

AI Technology for Boosting Efficiency of Logistics and Optimizing Supply Chains

Utilizing Marketing and Demand Forecast Data

The spread of smartphones and social networking services in recent years has had a significant influence on people's purchasing behavior, transforming them as consumers into data-savvy users in the supply chain. Meanwhile, considerable amount of food loss is occurring in the distribution stage of the supply chain, and there is widespread public demand for distribution activities that take into consideration the load on the environment. Hitachi is working on ways to develop decision-making support for optimizing supply chains using artificial intelligence. By using artificial intelligence to accurately capture source data on the needs of individual consumers; then using artificial intelligence again to improve the accuracy of the demand forecasts made based on those consumer data; then, finally, using simulation technology in the planning and execution stages of product supply, it is possible to derive optimum inventory allocations and optimal supply allocations.

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1. Introduction

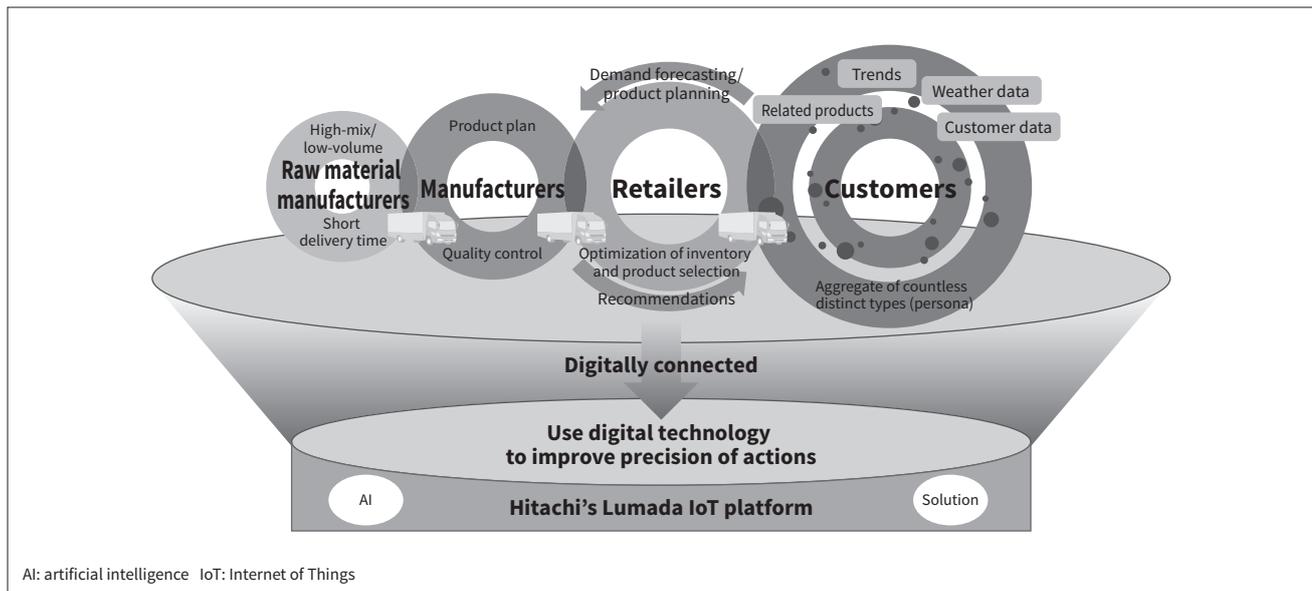
The spread of smartphones and social networking services (SNSs) in recent years has had a significant influence on people's purchasing behavior. The growing diversity of consumer lifestyles and values has led to markets becoming more fine-grained and product lifecycles to become ever shorter. Meanwhile, the desire of people to express themselves and to post the recommendations of friends and acquaintances on SNSs is also transforming people's purchasing behavior, especially in terms of travel and fashion. A change is taking place whereby people are no longer motivated to make purchases by product-focused

promotions based on things like features and price, but are looking for purchasing opportunities that focus on additional value, such as personalized, friendly communications or offers that are tailored to their preferences from trusted brands or companies that understand them. More and more often, people are becoming motivated to buy when they are presented with such opportunities.

This change in purchasing behavior has led retailers and manufacturers to take a growing interest in digital marketing, which has the potential to offer effective measures for enhancing customer loyalty through the digital analysis and understanding of various external data, such as the preferences of consumers and their purchasing behaviors on diverse sales channels.

Figure 1 — How Digital Technologies Connect each Step of the Value Chain

The digital data held by customers provides a basis for activities along each step of the value chain that enhance the precision of the actions taken.



In Japan, meanwhile, there is an estimated 6.21 million tons of edible food that goes to waste (food loss) each year, equivalent to almost double the roughly 3.2 million tons supplied by the United Nations as aid to countries suffering from food shortages⁽¹⁾. It is believed that approximately 55% of these cases of food wastage occur in the distribution stage, with major causes including returns or disposal due to the removal of out-of-date products, expiration of delivery dates, and seasonal re-stocking. The annual value of returned goods is estimated to be approximately 160 billion yen.

An acknowledged factor behind this is that the retailers, wholesalers, manufacturers, and raw material suppliers along the supply chain hold more inventory than they need as a safety margin to ensure that they can fill all the orders that come in without running out of certain items. As a result of this becoming the common practice, it is likely that a considerable amount of food is disposed of as its use-by date comes due.

For companies under extensive pressure from consumers and society to consider the environmental load in their economic activities, this has made it important to optimize inventory by basing their choices of what products to stock on an accurate understanding of fluctuations in demand. If the consumer needs that serve as the basis for all value chains can be accurately understood using digital marketing as described above,

then it will become possible to achieve greater accuracy in product planning and ordering, sales, production planning, and demand forecasting by sharing this data with retailers, wholesalers, manufacturers, raw material suppliers, and others (see **Figure 1**). If logistics data can also be integrated, then it will facilitate the optimization of inventory at production plants and in various sales channels such as distribution centers, which will help reduce the cost and improve the efficiency of logistics, and lead to shorter lead times for delivering products to consumers.

This article describes details of Hitachi's work on decision-making support for optimizing supply chains and the outlook for the future. Targeting the Super Smart Society, in which there is a greater focus on additional value in consumption behavior, this work involves utilizing artificial intelligence (AI) to identify the needs of individual consumers and generate demand, then utilizing simulation technology in cyberspace to derive the optimum inventory allocation in the planning stage and the optimal supply allocation in the execution stage.

2. Utilizing AI for Digital Marketing

If digital marketing is to be adopted with a focus on additional value, it is essential that analyses include

not only the product data, customer data, and point of sale (POS) and other purchase history data used for analysis in the past, but also external data such as the various forms of data obtained through customer touchpoints, such as their level of interest in sales campaigns, weather and event data, and promotional data. As this significantly increases the amount of data that marketing staff need to collect, it means that a lot of time and expense must be put into performing the analyses and then utilizing the results to devise and test hypotheses. This leaves less time for formulating the promotions themselves or investigating new products or services, which is making it difficult for companies to differentiate themselves from competitors. Another recognized challenge is that expertise in conducting analysis tends to be concentrated in certain experienced marketing staff, such that the interpretation of analysis results depends on experience and intuition.

In response to this challenge of having adequate data, but not being able to utilize it, Hitachi has developed a service that utilizes proven analysis techniques and Hitachi AI Technology/H (AT/H) to support the analysis of huge amount of data and the acquisition of the analysis expertise required for digital marketing. This frees up marketing staff, enabling them to focus on creating new products and services or marketing initiatives. To put this service into actual use, Hitachi has engaged in collaborative creation with leading companies to launch a demonstration project that uses AT/H to support the plan, do, check, act (PDCA) process in digital marketing.

A major feature of this service is that it automatically assigns “product DNA” tags to each product that express features, such as high-quality, value-focused, or health-conscious. These DNA tags are used as hints when collecting and analyzing the product purchase history data of individual customers to make in-depth assessments of preferences and lifestyles, such as identifying other high-value customers who are women in their thirties with a preference for high-quality goods that they trust or for whom cost-performance is an important consideration when shopping, for example. Furthermore, it is also possible through ongoing analyses to rapidly identify when a customer’s preferences have changed.

Within the service, this categorization of individual customers is called a preference segment. The service produces a guess and classification of individual personas (customer profiles), such as whether they are discerning consumers with a preference for luxury, health-conscious, or value-focused, etc. Using these personas, it is possible to visualize which products should be pitched to which customers to increase sales. It also becomes possible to steadily improve the accuracy of analysis knowledge by having AT/H provide quantitative assessments of the effectiveness of initiatives, such as promotions based on purchase histories, and thereby to learn the merits and demerits of the analysis knowledge held by AT/H itself and update these accordingly.

Using data analysis and formulating initiatives in the PDCA process for corporate marketing activities, the service can help increase the proportion of high-value customers by applying its ability to analyze data and perform learning to analysis knowledge in quantities that no human could handle (see **Figure 2**).

3. Demand Forecasting and Ordering Utilizing AI

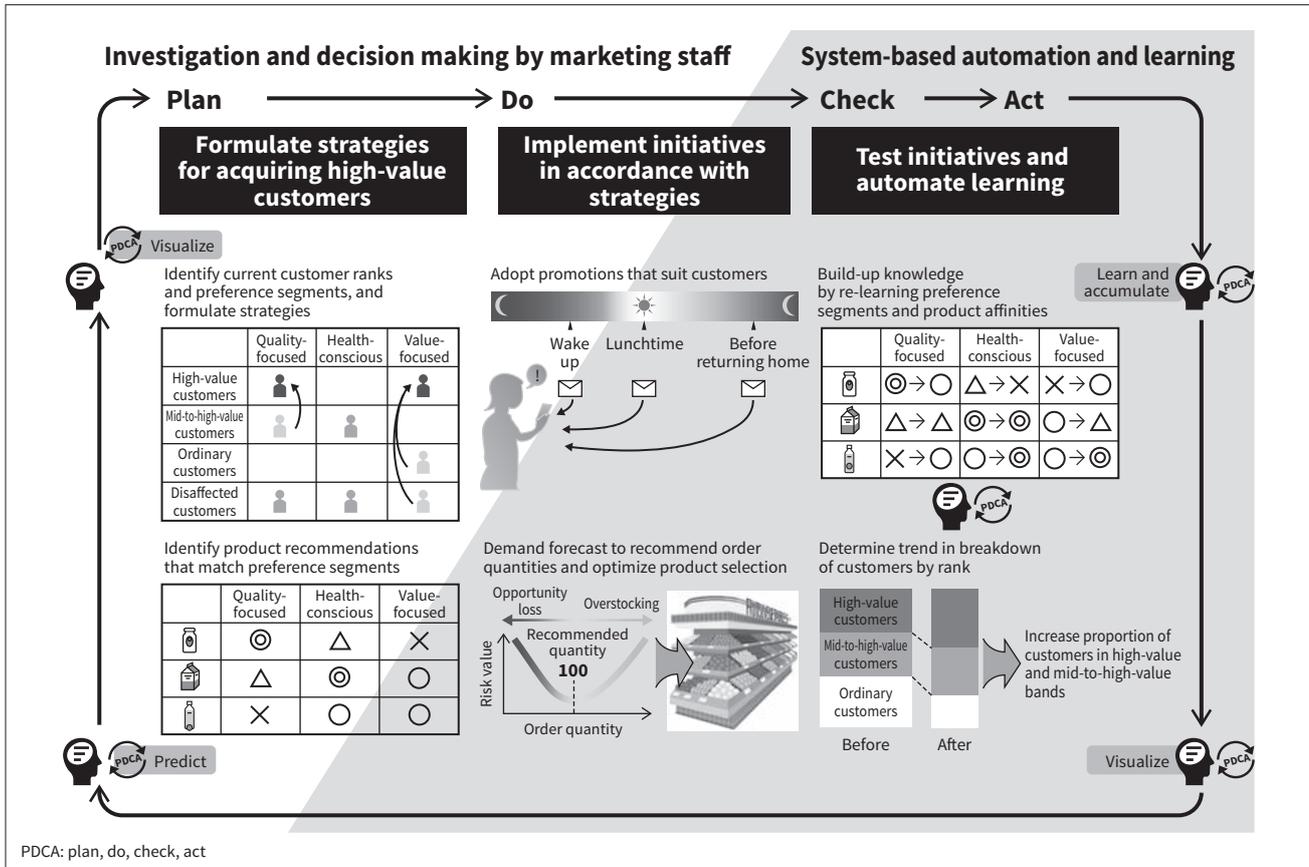
In the past, companies strove to acquire products based on an accurate understanding of fluctuations in demand (demand forecasting), with their planning and development departments conducting various forms of marketing and using these to run promotions, while the departments that supply products had responsibility for setting appropriate inventory levels and minimizing losses in the distribution process.

However, there is a limit to how far accuracy can be improved when using conventional rule-based demand forecasting logic that works by accumulating data on product sales. Accordingly, there is a need to collect data in greater varieties and quantities, going beyond the usual product sales data to include data on consumer purchases as well as shop-floor data on things like sales promotions, shelf space allocations, and cannibalization. Hitachi seeks to use AI for analyzing these huge amounts of data and to build up its analysis expertise.

When calculating sales forecast figures, for example, a task that in the past was done manually on a

Figure 2 — Digital Marketing Using AI

AI can itself grow through the analysis of huge amount of data and by ongoing learning of analysis knowledge, supporting investigation and decision making by marketing staff, and achieving more advanced system-based automation.



rule-of-thumb basis using sample data to test hypotheses, Hitachi tried formulating sales forecast models from AI analyses of detailed sales data. By doing so, it succeeded in building a model based on factors that were not embodied by existing concepts from big data that could not be handled manually.

The following describes an example of an approach for calculating the optimal order quantities for each store in a retail chain. This approach optimizes product inventory by formulating a sales forecast model to generate detailed sales projections for each product, using detailed store order data and past records of sales of similar products as inputs, and providing predictions and recommendations on when and how much of each product to order.

This involves first calculating sales projections by identifying multiple product groups that are similar to a new product and initializing the model for predicting sales after the launch of the new product based on the sales figures for the similar product groups. Once the product goes on sale, the actual sales results are

incorporated and, from then on, the model is updated and adjustments to predicted sales figures are made on a daily basis. In addition to calculating optimal order quantities from the predicted sales numbers and inventory data, daily order quantities are provided with an index that puts a value on the risk of opportunity loss or overstocking.

The sales forecast model is progressively upgraded by using an AI to perform learning on the difference between predicted and actual sales to prevent a fall in prediction accuracy due to the model losing applicability over time. Prediction accuracy is also enhanced by having the AI perform quantitative assessments to determine which of the sales forecast models is best suited to each product. Moreover, faster decision making, such as adjusting order quantities or discounting products so that they sell out, is achieved by providing prompt notification to the person in charge of ordering of any deviation from the sales forecasts calculated by the AI. This helps to keep inventory and in-store quantities at appropriate levels.

The use of more accurate demand forecast data in warehouse operations improves the accuracy of quantity predictions, and this in turn improves the prediction accuracy for the required staffing levels, something that in the past has tended to rely on the intuition and experience of administrators. It is anticipated that this will help rationalize operations and labor costs by getting staffing levels right.

4. Supply Chain Simulation

Hitachi is conducting research into simulation tools to allow the design of supply chains based on demand data and control of how inventory is held on an on-demand basis, and has begun deploying them in-house and as part of its collaborative creation work with customers.

One of these is a multi-site/multi-level parts allocation technique that was developed both to minimize the build-up of inventory through the appropriate management of international parts procurement and to improve the ability to keep up with fluctuations in demand. The technique supports two different stages of operations by setting appropriate safety stock levels in the planning stage to cope with fluctuations in demand, and making optimal supply allocation adjustments in the execution stage when demand fluctuates.

Firstly, in the planning stage, this involves a simulation that incorporates a technique using predicted values for demand increases and decreases in each market to assess the placement of inventory, and determines the optimal allocation of inventory between suppliers, warehouses, and factories using order fill rates and inventory levels as judgment criteria (see Figure 3). Similarly, in the execution stage, it uses a technique for working out optimal supply allocations that compensate for differences between the predictions and the actual demand fluctuations to determine the optimum supply allocation plan considering the trade-offs between order fill rates and transportation costs. This can suggest ways to change the means of transportation and the destination, such as diverting goods intended for shipment by sea to Japan, where demand has fallen, and air-freighting them to Europe, where demand is rising.

In this way, better and faster decision making can be achieved by running simulations beforehand and then incorporating the results into real-world execution plans.

5. Outlook for the Future

Initiatives aimed at minimizing waste by improving the efficiency of supply chains, beginning with

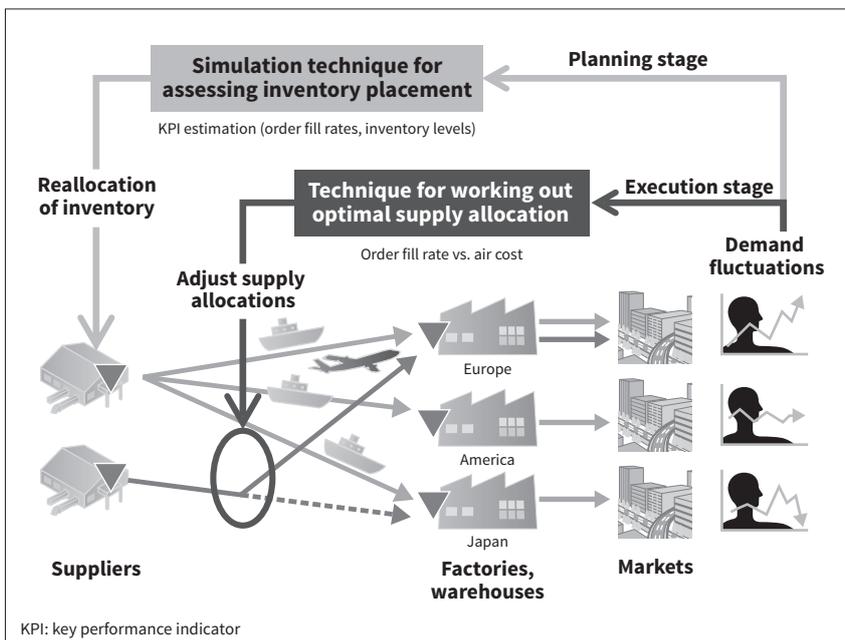


Figure 3 — Overview of Multi-site/Multi-level Parts Allocation Technique

The technique supports two different stages of operations by setting appropriate safety stock levels in the planning stage to cope with fluctuations in demand, and by making optimal supply allocation adjustments when demand fluctuates in the execution stage.

consumers, are achieved through collaboration, with the mutual trust and sharing of data between the companies and organizations that make up the supply chain. This is not something that can be achieved overnight, so it is important to work through a repeated process of trial and error to determine what constitute the best methods and approaches. However, Hitachi believes that one effective measure for boosting efficiency throughout the supply chain is to leave the people involved free to focus on decision making. This can be accomplished by delegating to AI the task of analyzing the huge amount of data involved in marketing, demand forecasting, and quantity prediction, which require the analysis of the past and the prediction of the future.

While utilizing Lumada, Hitachi's open platform for the Internet of Things (IoT), to connect all the digital data representing the diverse activities that make up a real-world supply chain, Hitachi intends in the future to work toward implementing processes that can rapidly plan and re-plan by replicating the real world in cyberspace and using this to understand various situations and make predictions in place of the real world.

6. Conclusions

Measures for using data to coordinate supply chains are now reaching the stage of practical application, with AIs being used to forecast demand and the data being utilized in making supply more efficient. Moreover, by having AIs use these forecasts to predict the quantity and timing of work, Hitachi also intends to contribute to people — as people rather than as consumers — such as by formulating shift plans that can cope with more diverse working styles.

References

- 1) Ministry of Economy, Trade and Industry, "6.42 Million Tons per Year! – Food Loss and Waste in Japan," <http://www.meti.go.jp/english/mobile/2015/20151021001.html>
- 2) A. Tsujibe et al., "Study of Multi-Echelon Parts Allocation Technology in Global Supply Chain Management," Transactions of Manufacturing Systems Division Conference, The Japan Society of Mechanical Engineers (Mar. 2014) in Japanese.

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