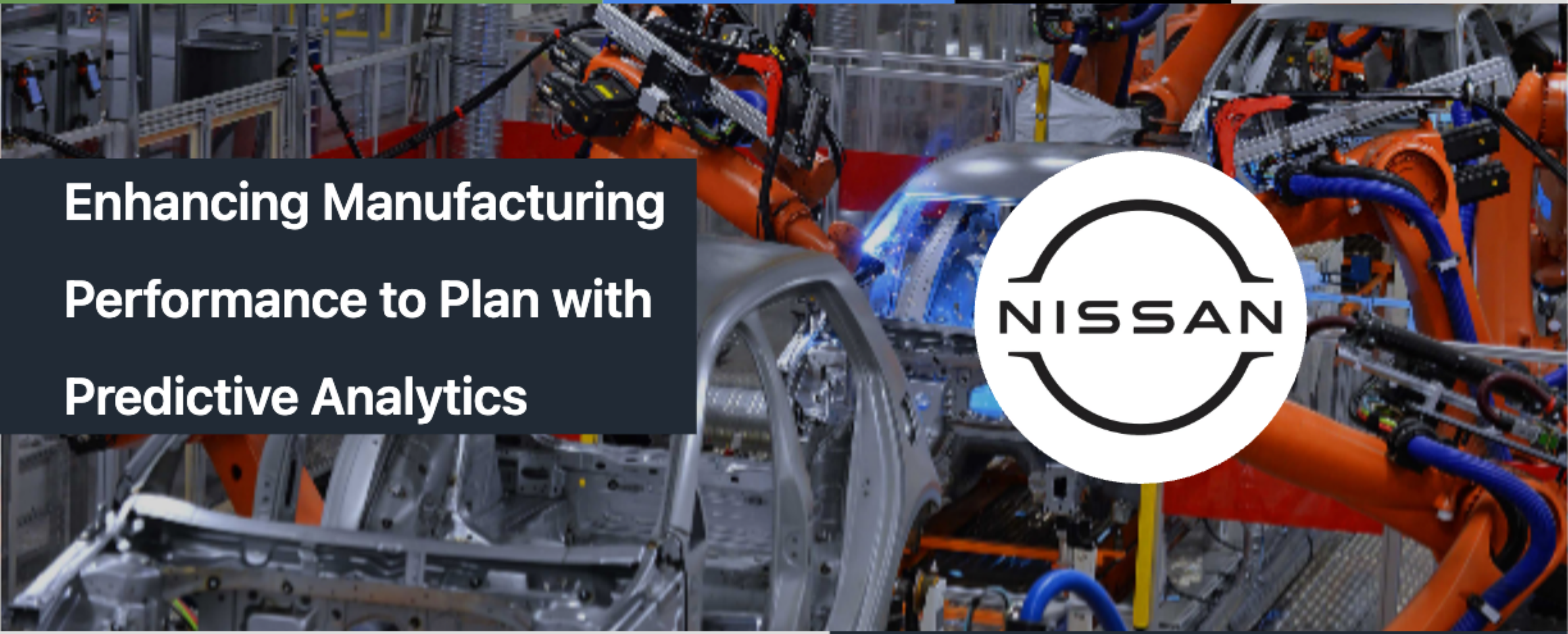


Enhancing Manufacturing Performance to Plan with Predictive Analytics

BUSINESS PROBLEM

Variances between actual production and original or revised manufacturing plans occur for several reasons. Sales may change their order, or disruption can force plans for later time periods to increase volume and catch-up. Further, capacity constraints can be inaccurate, unknown, or realized too late due to the complexity of process & product mix. Inaccuracy in manufacturing planning can lead to incorrect headcount, costly unscheduled overtime, and inaccurate purchasing from suppliers, which leads to excessive & obsolescent inventory, the bullwhip effect, and expedited orders.

APPROACH

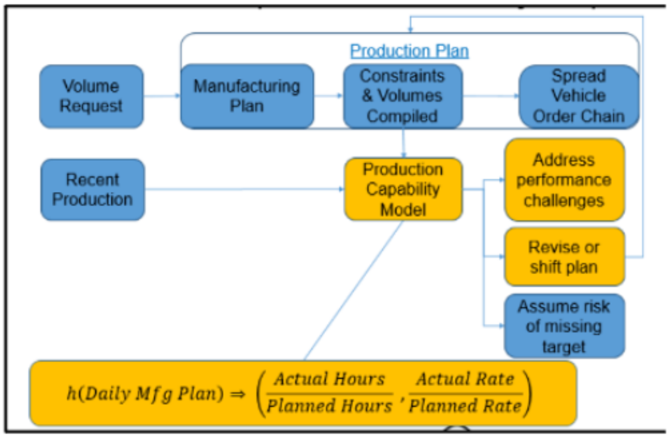
Monthly plans over time are compared to actual daily production. Empirical capacities are established based on best recent performance. Characteristics of the plan, such as model & trim mix, rate fluctuation, etc. are used to predict the actual daily vehicle output of each production line. An interpretable model predicts the output of future plans to correct or enable aggressiveness.

DATA SOURCES

Roughly 5 years of previous plans over multiple planning stages, and actual production, have been collected by processing & compiling saved data in excel/csv files, emails, and Nissan's data lake. Planning data has been cleaned to correct for inconsistency in human processes, and then supplemented with annual capacity estimates to calculate historical utilization levels.

Data Types and Format

Compiled data has been processed in a Jupyter Notebook and stored in csvs and pickled (pkl) data tables.



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IMPACT

Manufacturing requires meticulous planning to coordinate tightly wound supply chain activities in the face of disruption. This is especially true for automotive OEMs, which produce complex products at high rates. These uncertainties lead to high error in plans, propagating changes to suppliers, other areas of the business, and future periods. Changes harm stability, efficiency, and thus profitability for all stakeholders. This study shows how predictive analytics can help. Results showed predictions provided Median Absolute Error (MdAE) improvements of 40%-60% over a 3 month lead time and 10%-40% over a 1 month lead time. Using these predictions to reduce error can improve stability such that better decisions can be made. Interpretation of the model can improve the factory's ability to meet demand. Benefactors include customers looking to purchase and receive their desired products, employees needing more consistency, and suppliers aiming to maintain a healthy business. The Covid-19 pandemic wreaked havoc on supply chains, and brought unprecedented strains on supplier relationships. Improving planning accuracy can increase robustness of operations for future major disruptions. While no plan would have foreseen the consequences of the pandemic, improved planning methods which better incorporate the capabilities of the plant can ensure that volatility is caused only by external factors, while machine learning models properly capture the impacts of controllable factors.

DRIVERS

The urgency of this project is driven by the volatility due to the pandemic. With an increase in supply disruptions, notably semi-conductor chips, the production plan accuracy has been lower, and more biased. This has led to deteriorating supplier relationships, and a need for more stability. Although the machine learning will not predict the supply shocks, it can help Nissan manage the controllable factors of planning, to increase robustness.

BARRIERS

The largest barrier is data access, as before 2020 data was kept in excel spreadsheets, emails, and csv files. Several months were spent finding, cleaning, and compiling data for model training. In addition, the incentives of the manufacturing planning process make it challenging to decrease volume. This means that the model should be interpretable, and provide guidance to improving performance, rather than only decreasing planned volume.

ENABLERS

Nissan Information Systems infrastructure made python and R tools readily available, as well as a snowflake data system, though it did not contain data from before 2020. In addition, the Supply Chain analytics team was a critical source of feedback and ideas. Finally, domain knowledge from the Nissan Supply Chain & Operations colleagues was crucial to ensuring the model would train on key metrics of the production system.

ACTIONS

An application which provides an interface to the machine learning model was provided. The application takes a manufacturing plan as input, and returns calculated fields, and a predicted performance to plan for each day as output. It also displays several visualizations to aid in interpretation of the model. With this predicted performance to plan, the manufacturing plan can be adjusted to increase probability of success.

INNOVATION

Previous work has reduced instability in automotive manufacturing. Improvements have been made to forecasting, postponement of variety, inventory held at the OEM, and to the variety of products made. This project innovates by augmenting the information available to the process with a prediction of performance, such that the capability of the current system is better understood. Previously, only binary capacity rules were applied to planning.

IMPROVEMENT

The resulting improvement is a 40-60% reduction in Median Absolute Error (MdAE) from the 3-month-out planning process and a 10-40% reduction in MdAE from the plan submitted the month prior to production, based on a test set of unseen data. This reduction in error leads to a more accurate and stable production process, if the predictions of performance are adopted into the plan.

BEST PRACTICES

480+ features were developed to characterize the manufacturing plan and recent performance, including empirical capacity estimates. To select features, a categorical selection process was used in parallel with hyperparameter tuning. K-means was used for anomaly detection to remove Covid-19 supply shocks, which are likely to confuse the models of other projects as well. Finally, R-shiny was used to deploy python-built models for a quick MVP.

OTHER APPLICATIONS

The methods used in this work can be applied to the production of other products. Each process should be uniquely trained, but the concept of using machine learning to predict performance to plan, in order to either adjust plan or improve performance, can be applicable elsewhere.