CAPSTONE PROJECT

Problem statement 39:
Predictive Maintenance of Industrial Machinery

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OUTLINE

- Problem Statement
- Proposed System/Solution
- System Development Approach
- Algorithm & Deployment
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- Future Scope
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PROBLEM STATEMENT

Develop a predictive maintenance model for a fleet of industrial machines to anticipate failures before they occur. This project will involve analyzing sensor data from machinery to identify patterns that precede a failure. The goal is to create a classification model that can predict the type of failure (e.g., tool wear, heat dissipation, power failure) based on real-time operational data. This will enable proactive maintenance, reducing downtime and operational costs.

PROPOSED SOLUTION

Develop a predictive maintenance model for a fleet of industrial machines to anticipate failures before they occur. This project will involve analyzing sensor data from machinery to identify patterns that precede a failure. The goal is to create a classification model that can predict the type of failure (e.g., tool wear, heat dissipation, power failure) based on real-time operational data. This will enable proactive maintenance, reducing downtime and operational costs.

The solution will consist of the following components:

- **Data Collection:**
  - Use Kaggle Dataset on Machine Predictive Maintenance Classification.
- **Data Preprocessing:**
  - Clean and preprocess the collected data to handle missing values, outliers, and inconsistencies.
  - Feature engineering to extract relevant features from the data that might impact bike demand.
- **Machine Learning Algorithm:**
  - Implement a machine learning algorithm, such as a classification model like Random Forest Classifier or Decision Tree
- **Evaluation:**
  - Validate the model using Accuracy, precision, recall, f1-score, etc

SYSTEM APPROACH

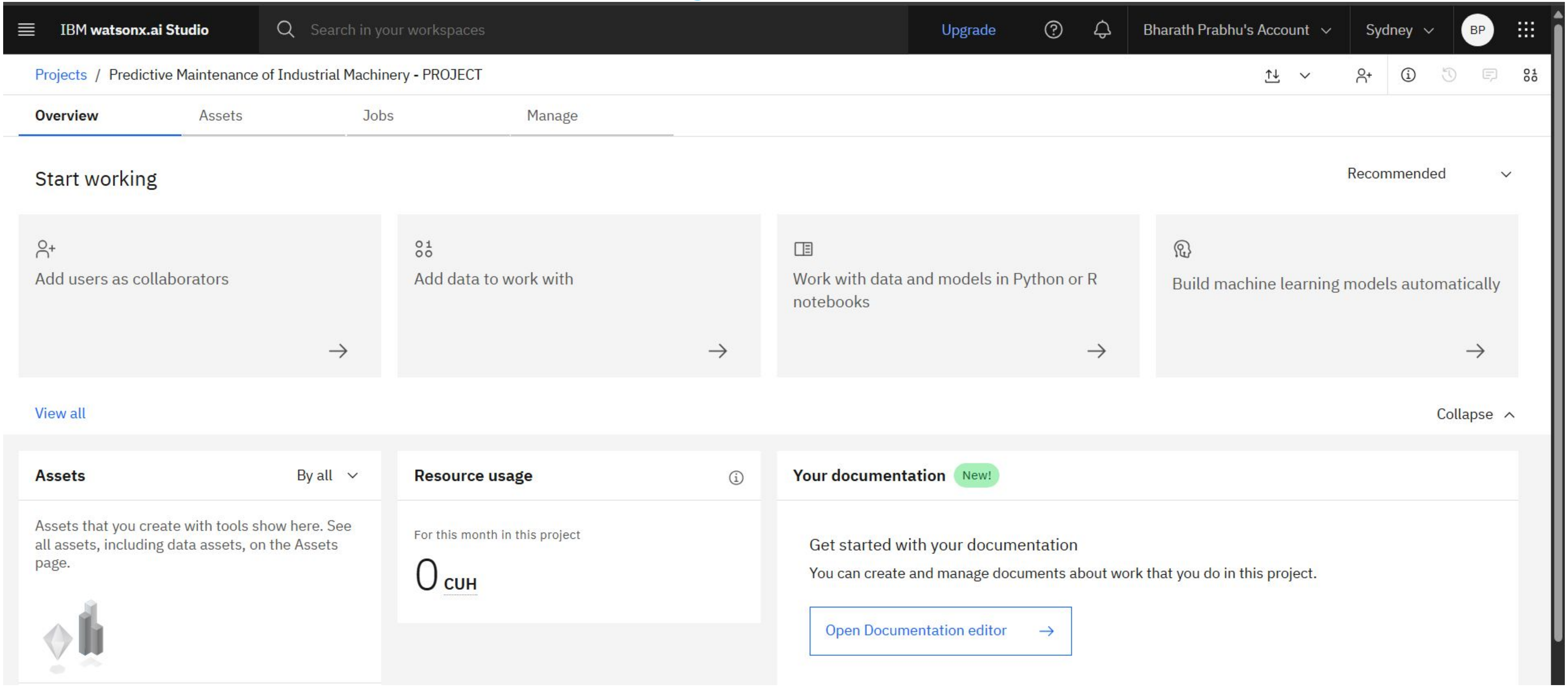
The overall approach for developing and implementing the "Predictive Maintenance of Industrial Machinery" system are:

- System requirements:
  - IBM Cloud
  - IBM Watson Studio
  - IBM Cloud Object Storage for Dataset Handling
- Models Used:
  - Random Forest Classifier and its variations
  - Decision Tree and its variation

ALGORITHM & DEPLOYMENT

- **Algorithm Selection:**
  - Various pipelines with different base algorithm and modifications will be performed and the one with the best accuracy will be chosen.
- **Data Input:**
  - Kaggle dataset “Machine Predictive Maintenance Classification” has the following data columns:
  - Product Type, Air temperature [Kelvin], Process temperature [Kelvin], Rotational speed [rpm], Torque [Nm], Tool wear [min], Target
- **Training Process:**
  - IBM Watson Studio powered - “Automatic Machine Learning Model Build” option.
  - Follows supervised learning using the input data and the label entry “Failure Type”.
- **Prediction Process:**
  - Model deployed on IBM Watson studio with API endpoint for real-time predictions.

RESULT - New Project Creation



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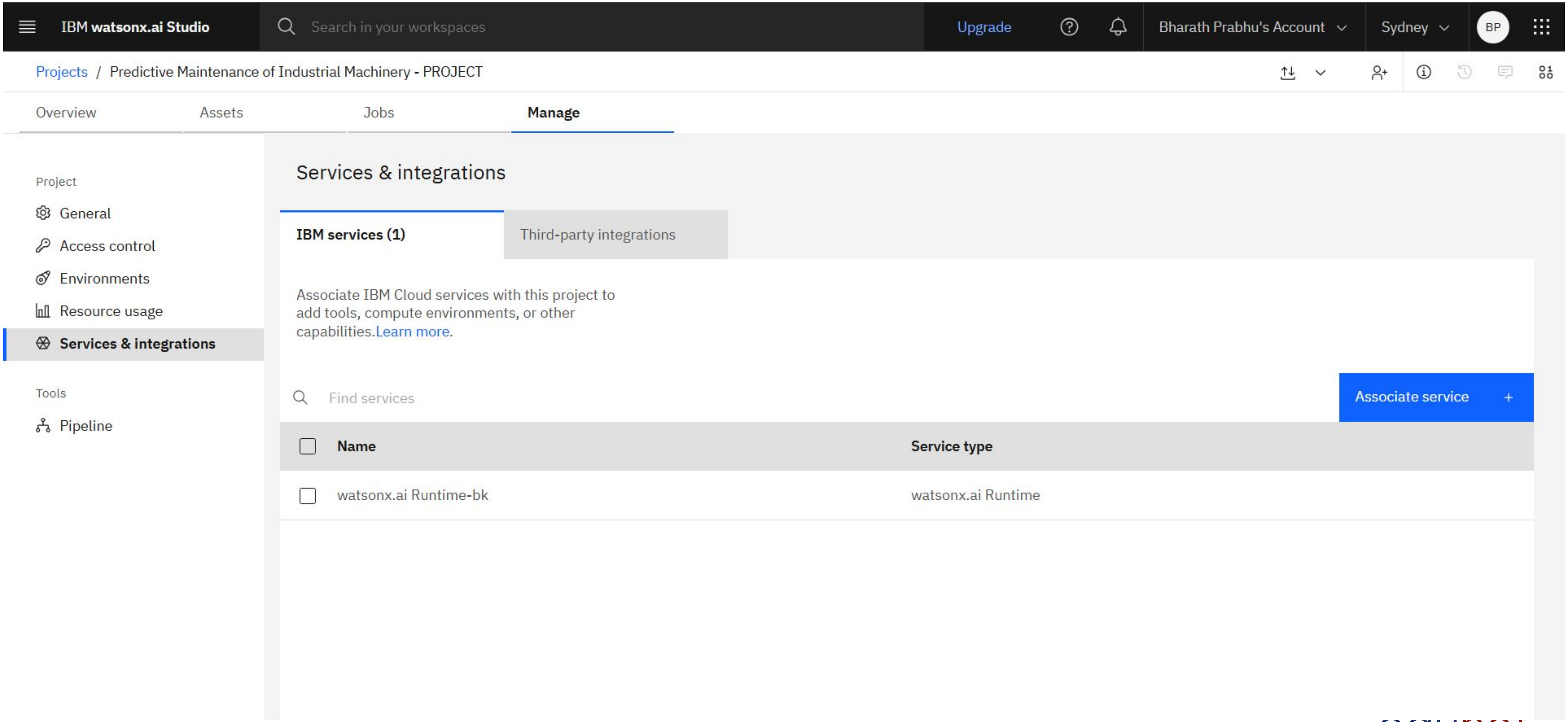
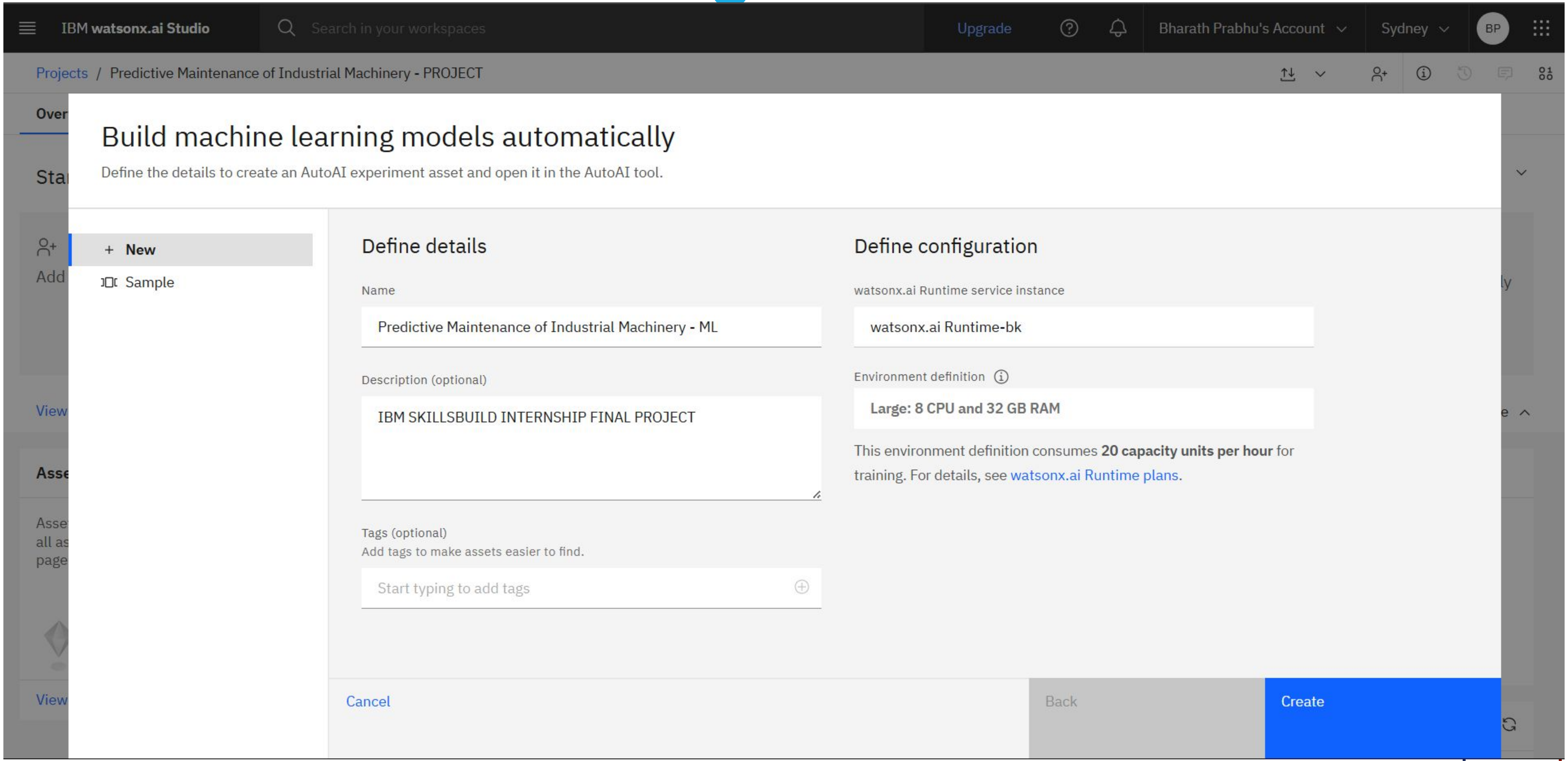
RESULT - Runtime Added



RESULT - Building the ML Model



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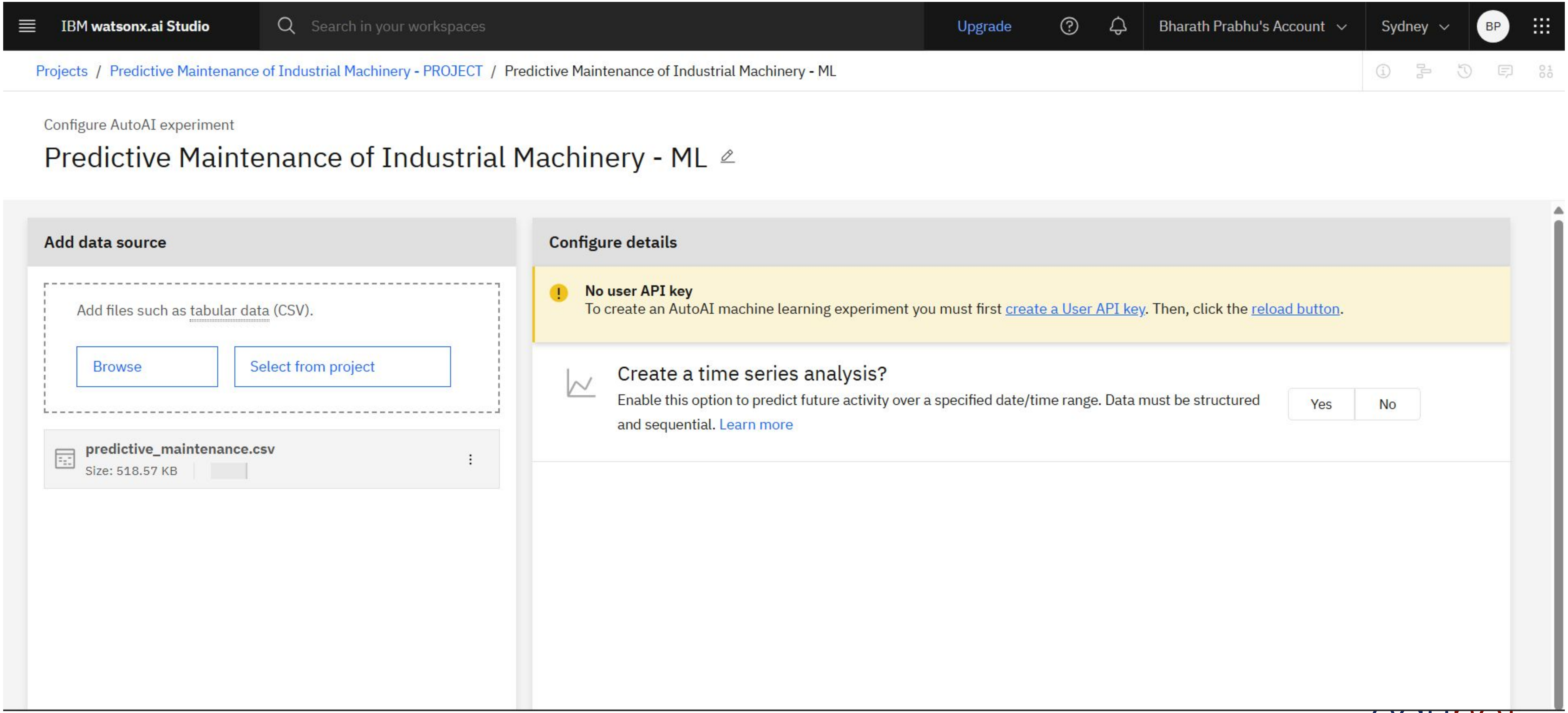
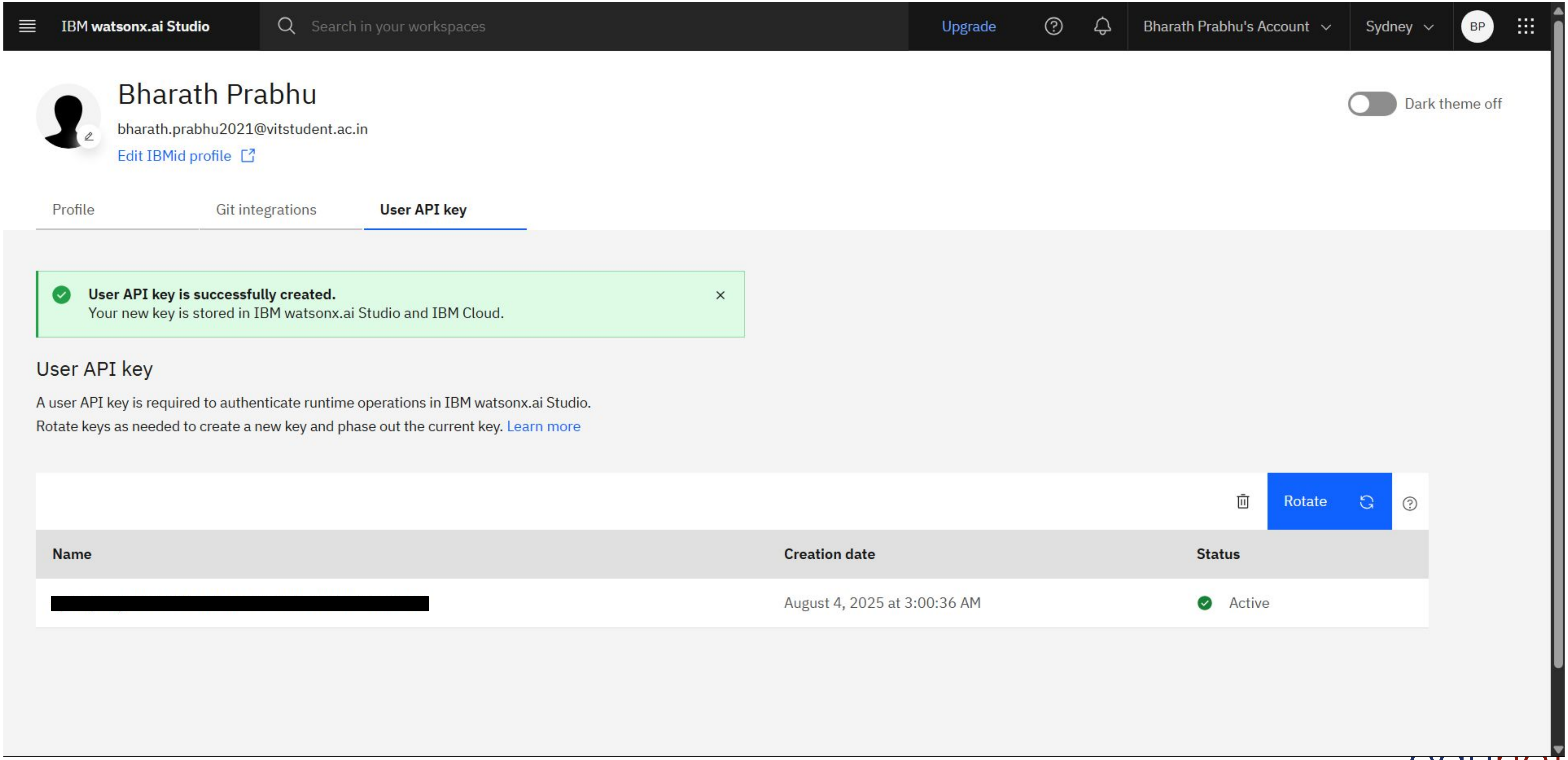
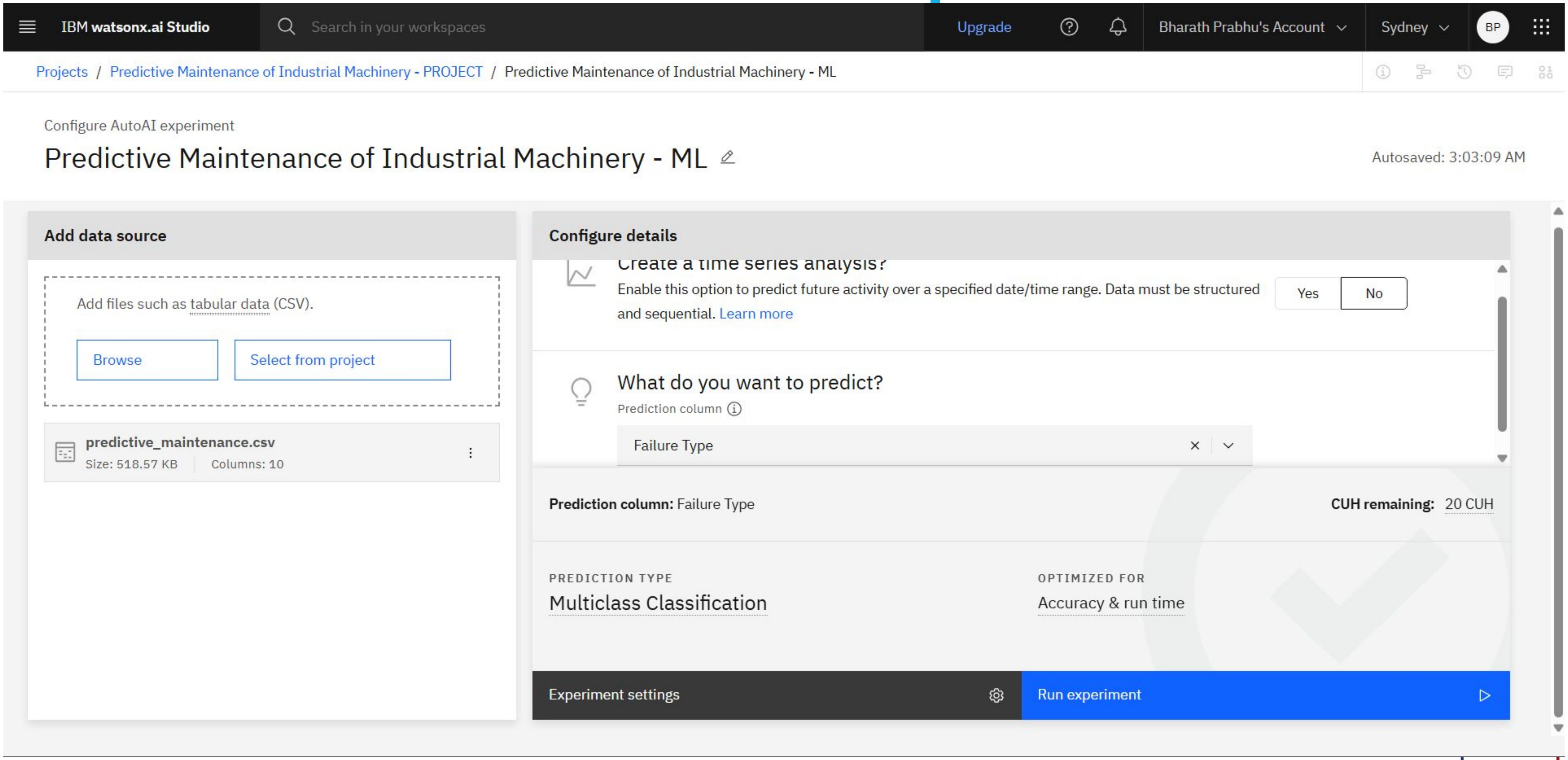
RESULT - Upload the dataset



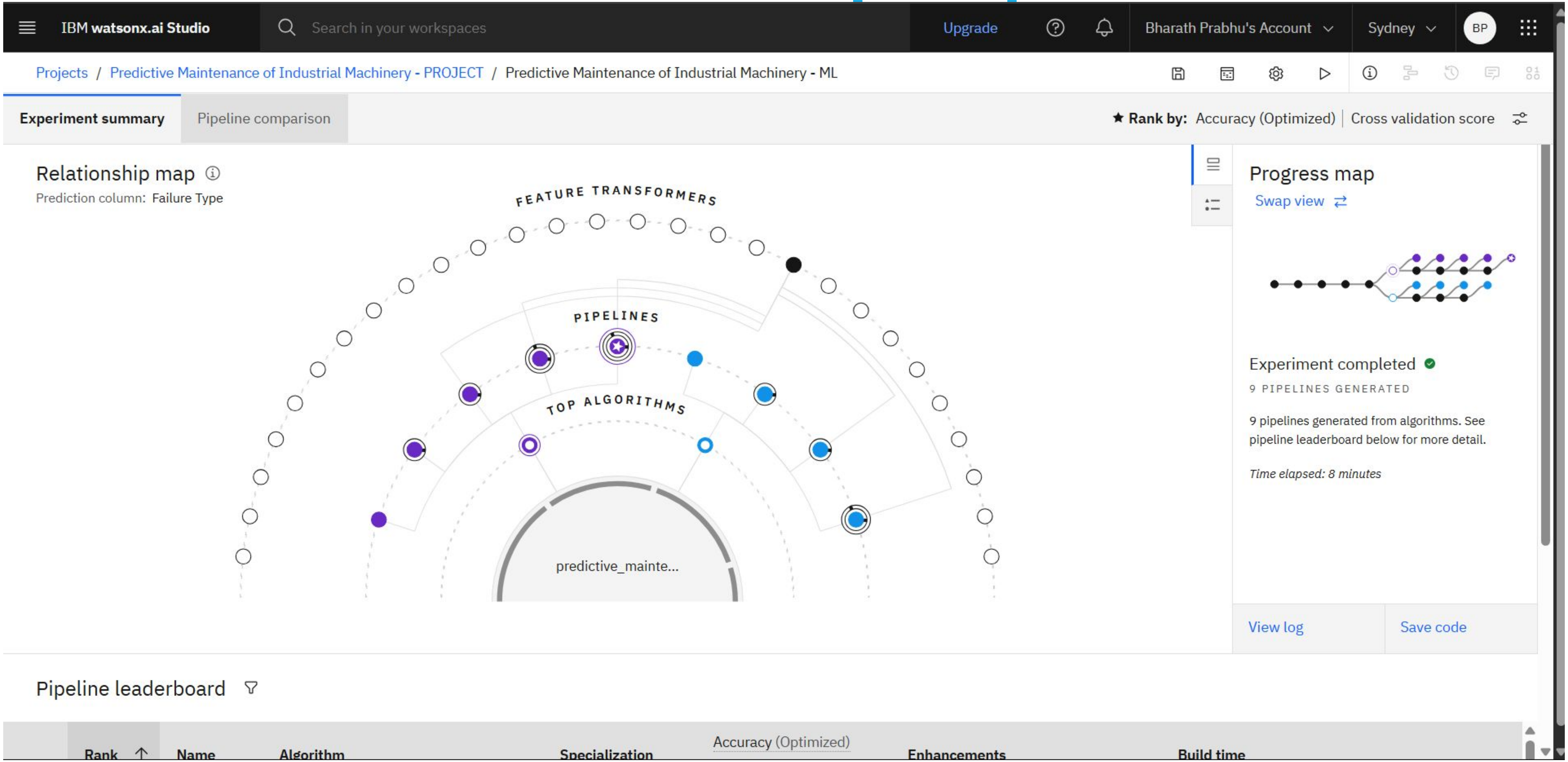
RESULT - API KEY CREATED



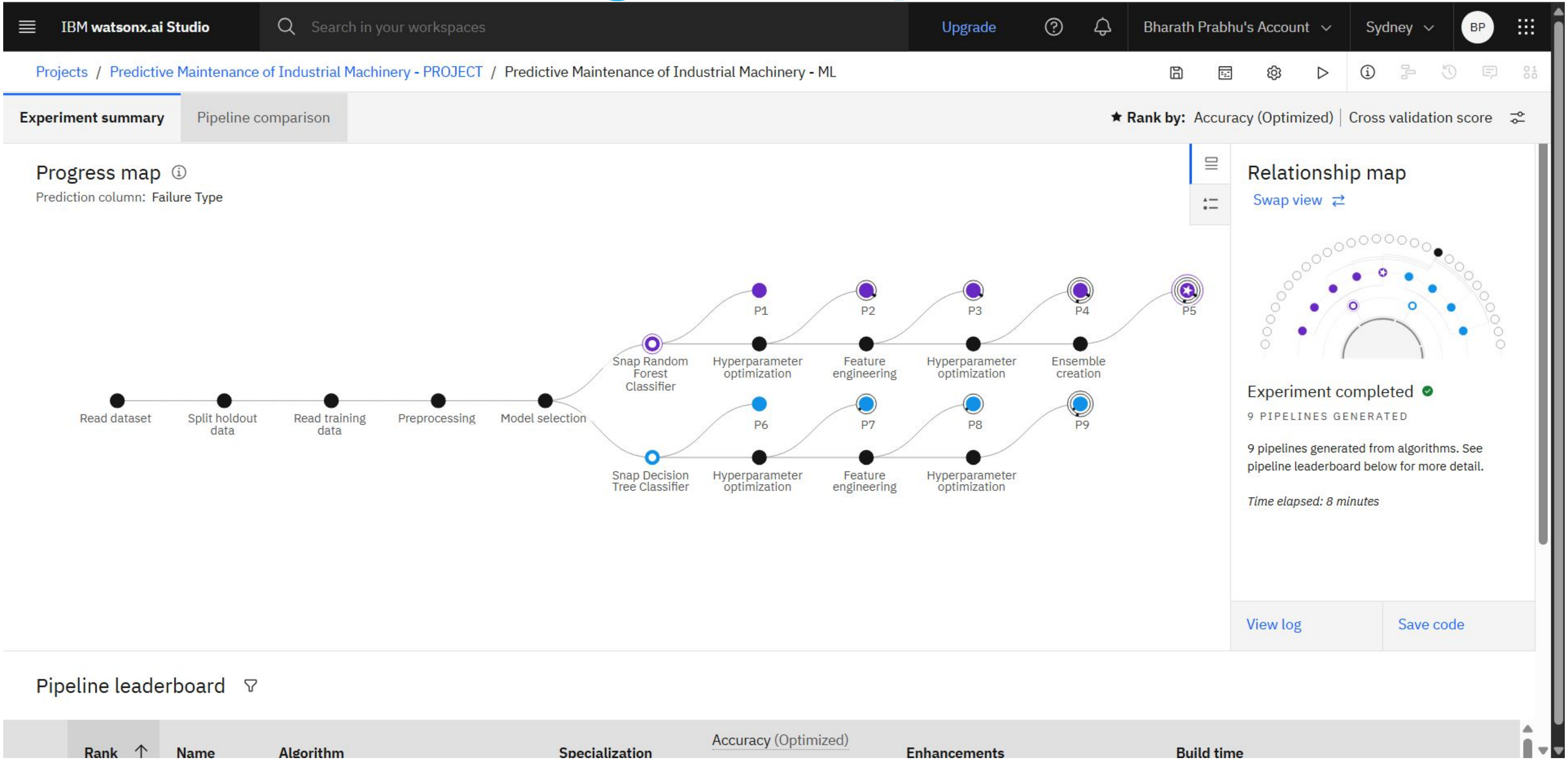
RESULT - Select Label to predict



RESULT - Relationship Map



RESULT - Progress Map



RESULT - Pipeline Performance Leaderboard

Pipeline leaderboard

	Rank	Name	Algorithm	Specialization	Accuracy (Optimized) Cross Validation	Enhancements	Build time
★	1	Pipeline 5	Batched Tree Ensemble Classifier (Snap Random Forest Classifier)	INCR	0.995	HPO-1 FE HPO-2 BATCH	00:01:35
	2	Pipeline 4	Snap Random Forest Classifier		0.995	HPO-1 FE HPO-2	00:01:32
	3	Pipeline 3	Snap Random Forest Classifier		0.995	HPO-1 FE	00:00:33
	4	Pipeline 9	Snap Decision Tree Classifier		0.994	HPO-1 FE HPO-2	00:00:03
	5	Pipeline 2	Snap Random Forest Classifier		0.994	HPO-1	00:00:09
	6	Pipeline 1	Snap Random Forest Classifier		0.994	*None*	00:00:02
	7	Pipeline 8	Snap Decision Tree Classifier		0.993	HPO-1 FE	00:02:50
	8	Pipeline 7	Snap Decision Tree Classifier		0.991	HPO-1	00:02:29
	9	Pipeline 6	Snap Decision Tree Classifier		0.988	*None*	00:01:36

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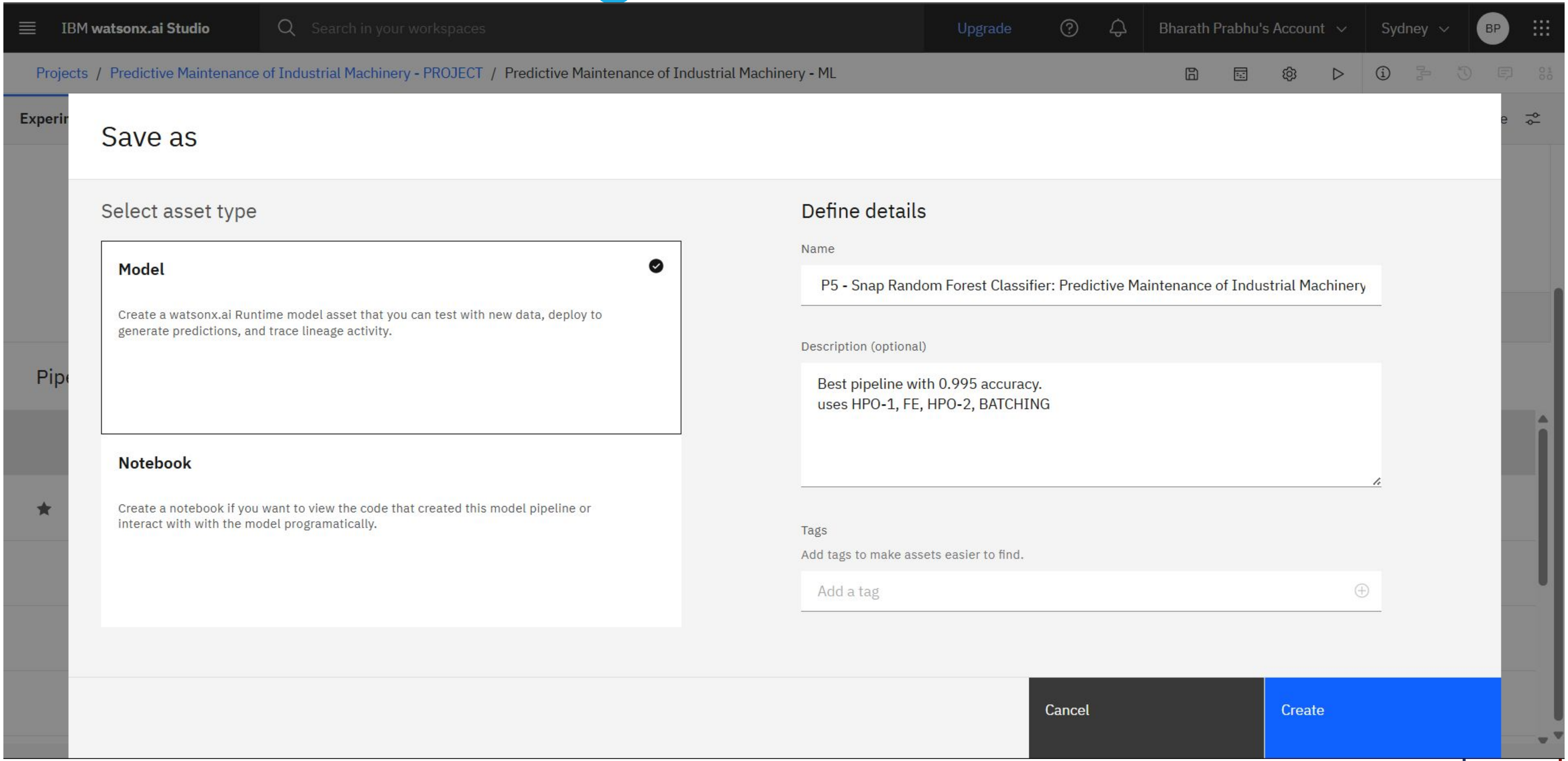
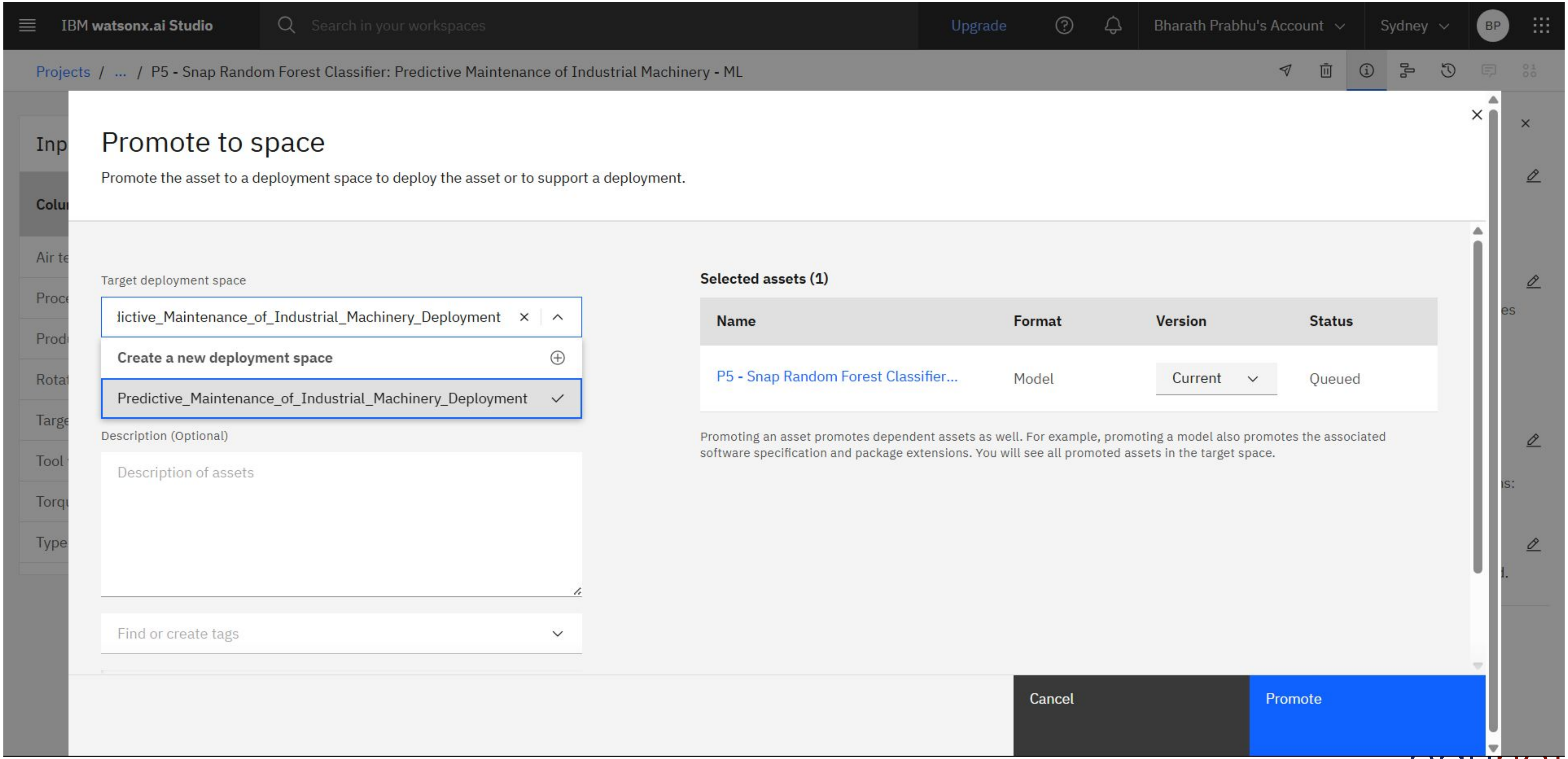
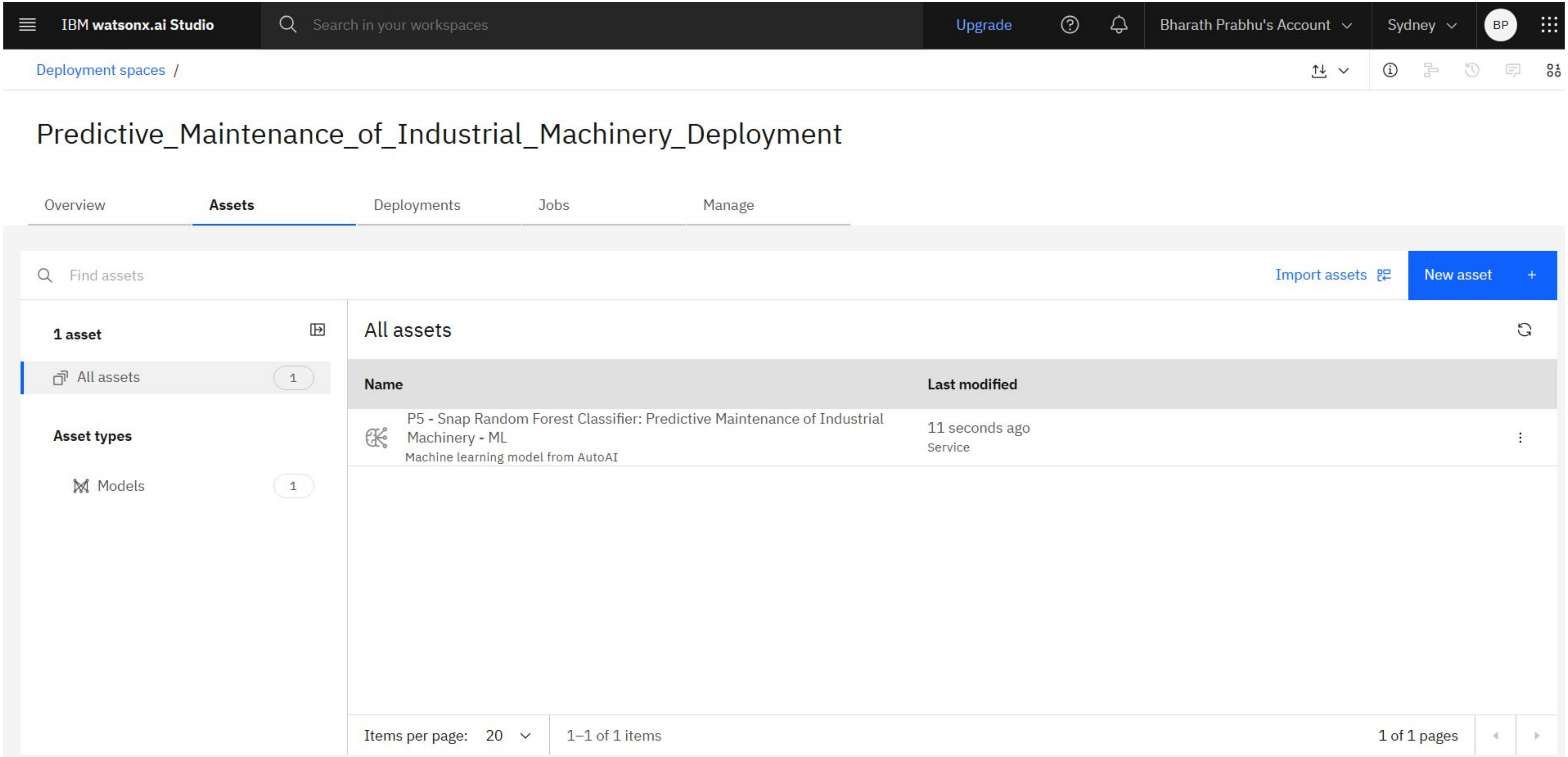
RESULT - Saving the best model



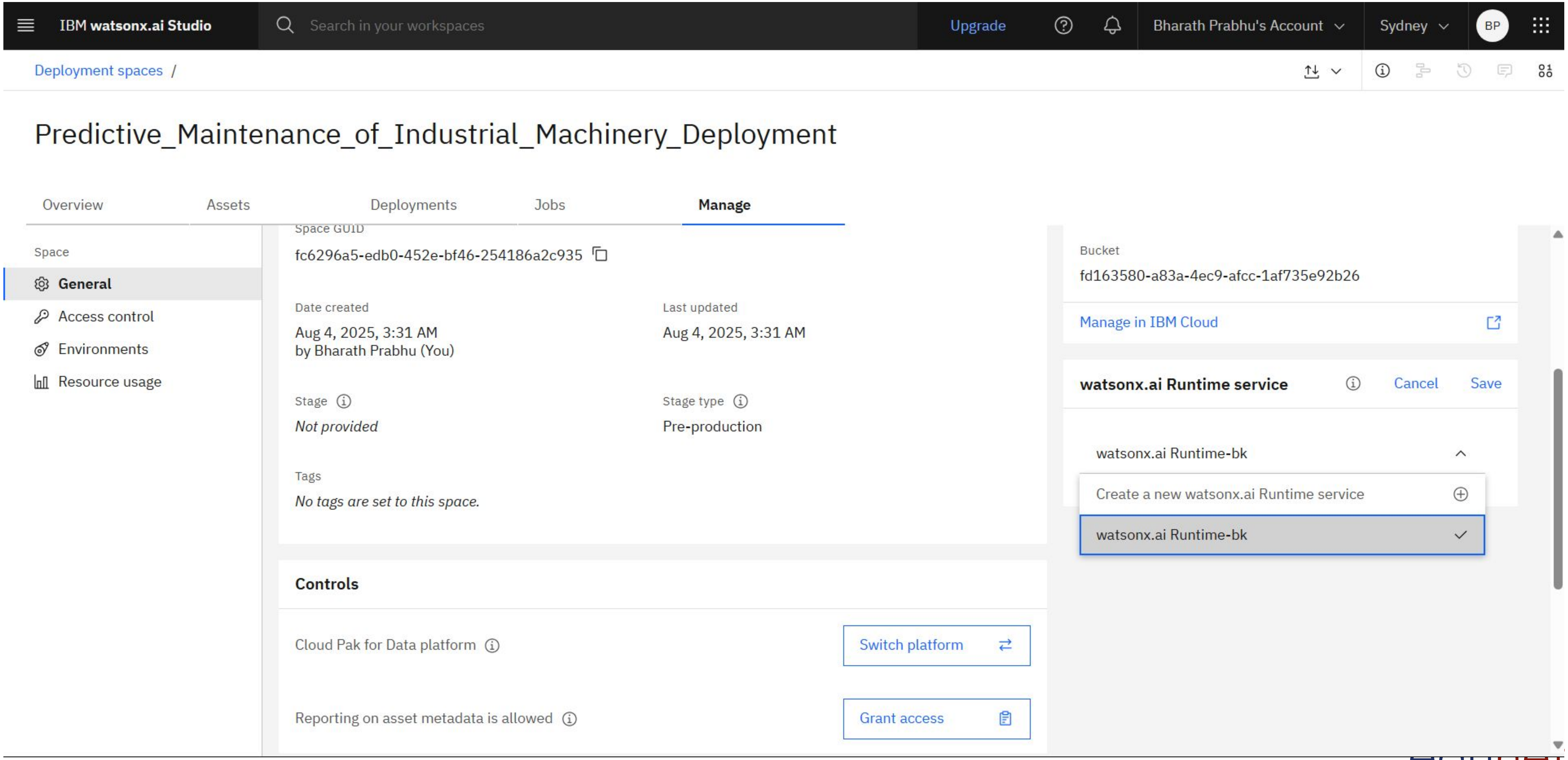
RESULT - Deployment and Promoting to Space



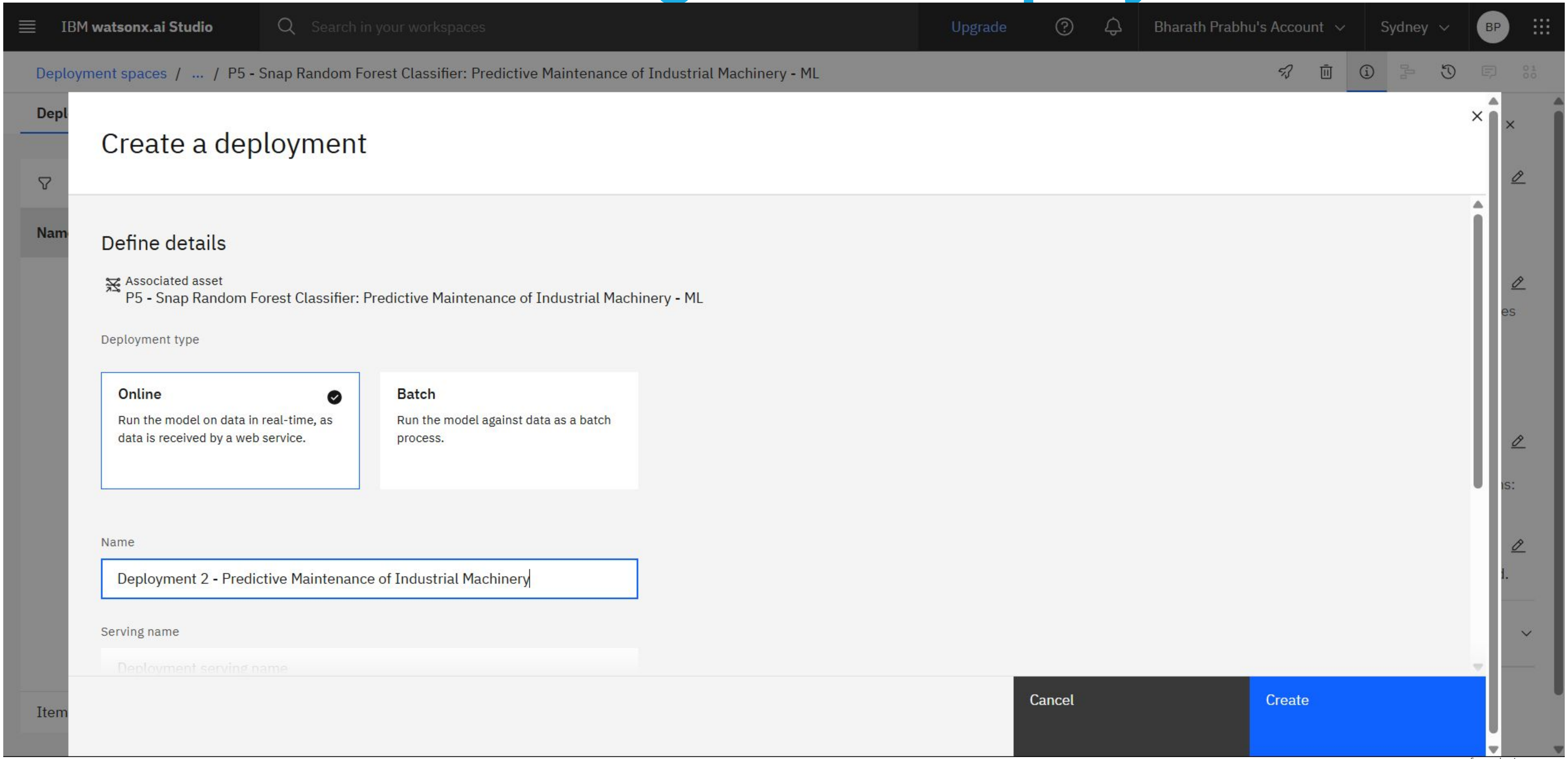
RESULT - Model Successfully Deployed



RESULT - Associating Runtime to our Model



RESULT - Creating a New Deployment



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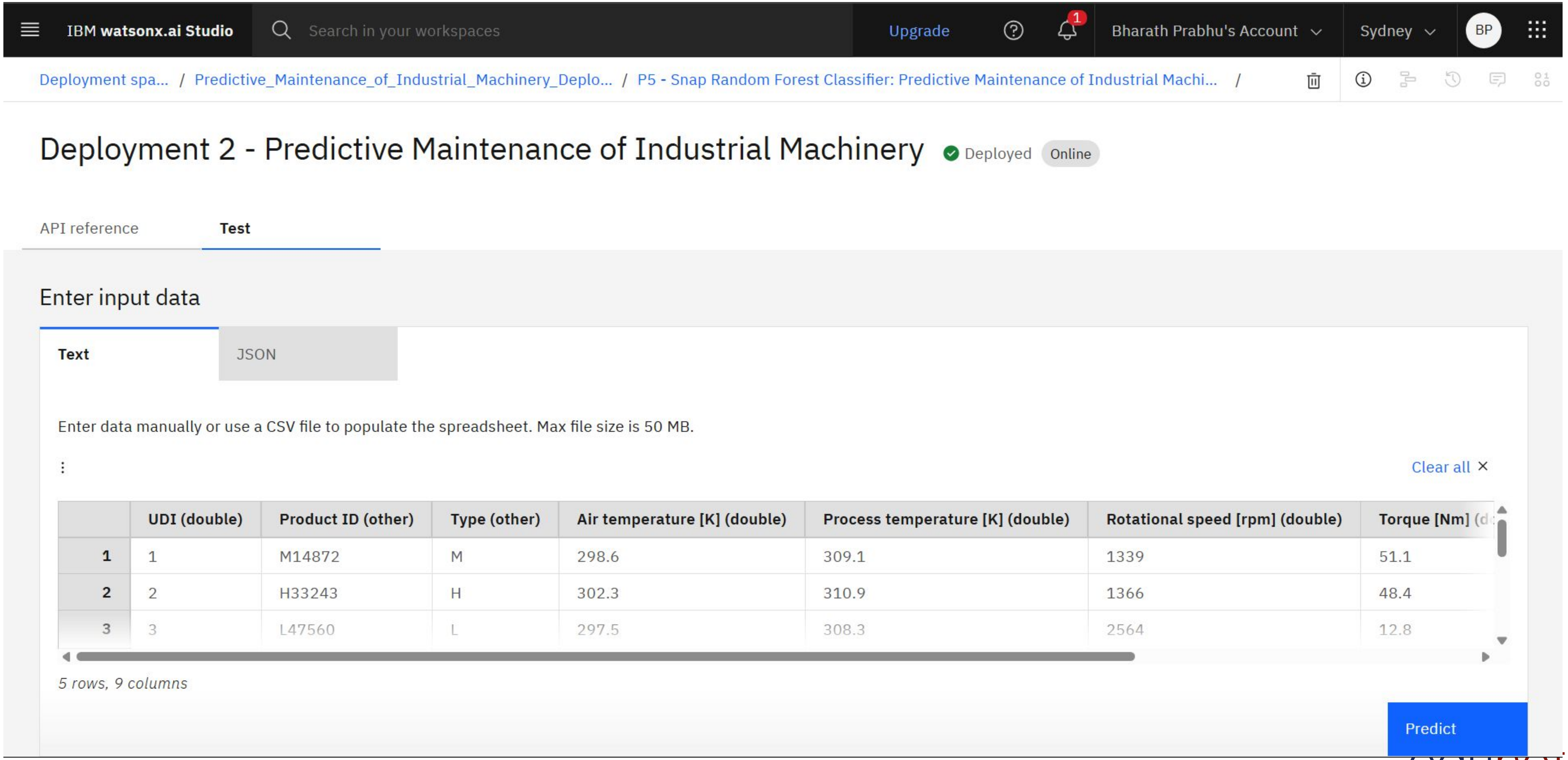
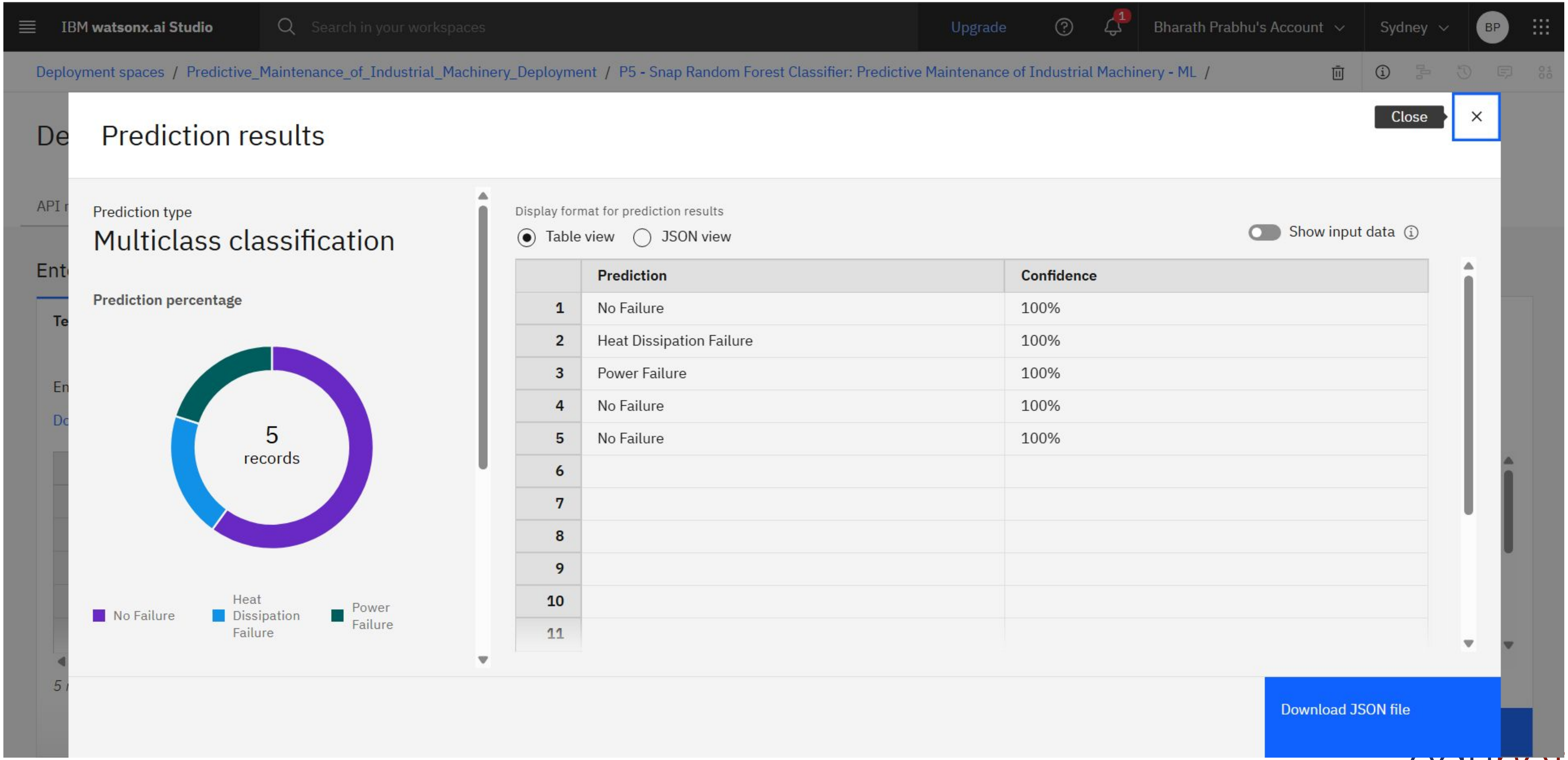
RESULT - TESTING WITH USER INPUTS



RESULT - Test Results/Predictions



CONCLUSION

The predictive maintenance model for industrial machinery successfully leverages real-time sensor data to anticipate potential equipment failures. By using IBM Watson Studio's AutoAI functionality, we explored multiple algorithmic pipelines and selected the one with the best accuracy for classifying failure types such as tool wear, heat dissipation issues, and power failures. The model enables timely and proactive maintenance by identifying early warning signs from features like air temperature, torque, and tool wear. The deployment through an API endpoint allows seamless integration into industrial monitoring systems, significantly reducing unexpected downtime and enhancing overall operational efficiency.

FUTURE SCOPE

- **Incorporation of Time-Series Data:**
  - Future iterations can include time-series analysis to detect gradual trends and degradation patterns over extended operational periods.
- **Multi-Sensor Integration:**
  - Expanding the dataset to include additional sensor types such as vibration, acoustic signals, or infrared imaging could improve the robustness and accuracy of the model.
- **Automated Maintenance Trigger System:**
  - Integrate the prediction outputs with an automated workflow that schedules maintenance or sends alerts to technicians in real-time.
- **Self-Learning Feedback Loop:**
  - Implement a feedback system where the model updates itself based on new failure events, continuously improving its accuracy over time with minimal human intervention.
- **Cross-Factory Generalization:**
  - Train and test the model on datasets from different types of machines and manufacturing environments to ensure scalability and generalization.

REFERENCES

- Dataset: https://www.kaggle.com/datasets/shivamb/machine-predictive-maintenance-classification?resource=download

- Tools: https://cloud.ibm.com/

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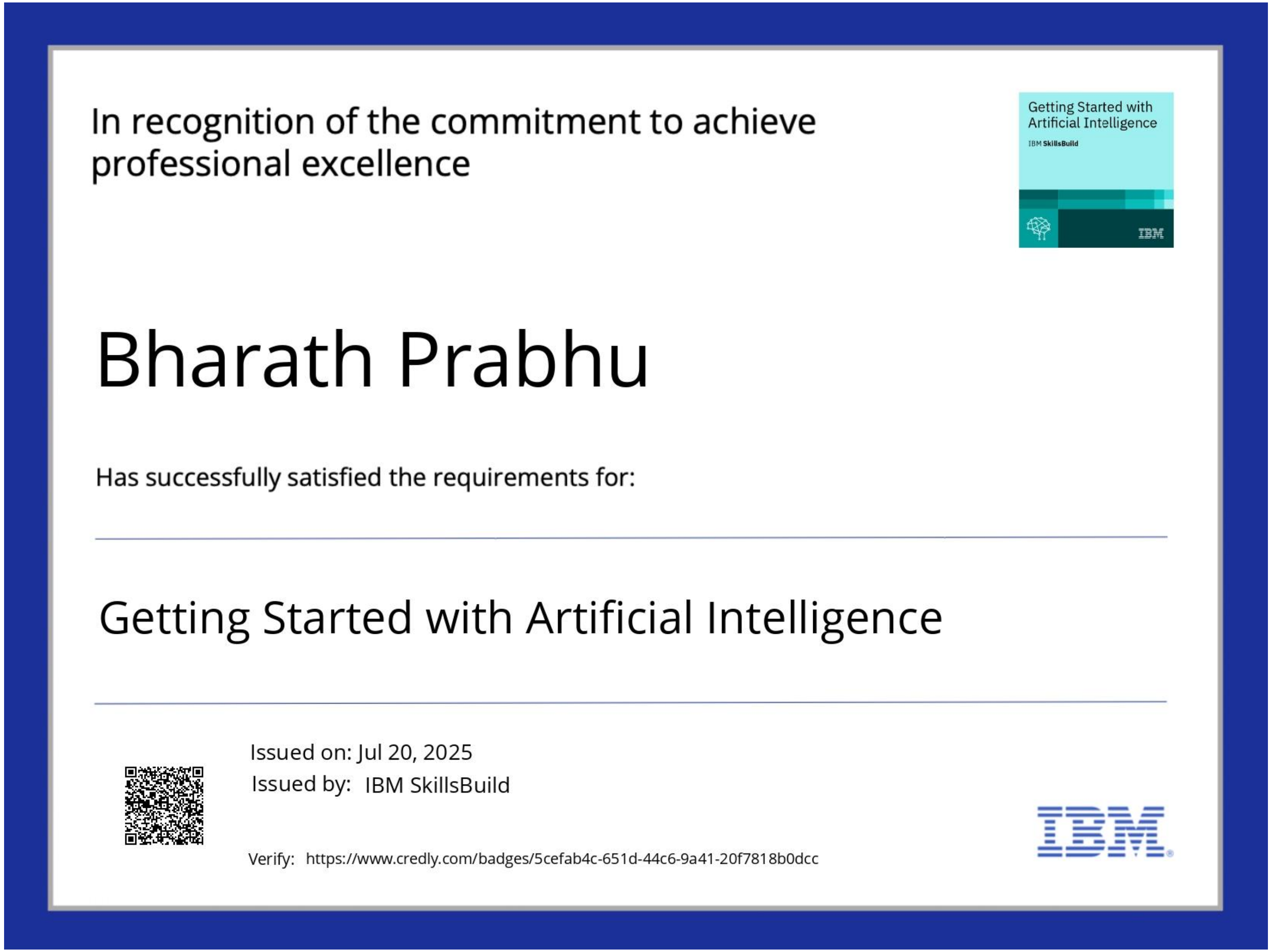
IBM CERTIFICATIONS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