Hands-on tutorials

Prepare Training Data for Machine Learning with Minimal Code

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Prepare Training Data for Machine Learning with Minimal Code: Hands-on tutorials

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Prepare Training Data for Machine Learning with Minimal Code

AWS experience	Beginner
Time to complete	30 minutes
Cost to complete	See Amazon SageMaker AI pricing to estimate cost for this tutorial.
Services used	Amazon SageMaker AI Data Wrangler
Last updated	March 7, 2023

Overview

In this tutorial, you will learn how to prepare data for machine learning (ML) using Amazon SageMaker AI Data Wrangler.

Amazon SageMaker AI Data Wrangler reduces the time it takes to aggregate and prepare data for ML from weeks to minutes. Using SageMaker AI Data Wrangler, you can simplify the process of data preparation and feature engineering and complete each step of the data preparation workflow, including data selection, cleansing, exploration, and visualization from a single visual interface.

In this tutorial, you will use Amazon SageMaker AI Data Wrangler to prepare data to train a rental prediction model. You will use a version of the Brazil house rental dataset found in the Kaggle Data Repository. The data consists of thousands of records, each containing thirteen different features including area, rooms, parking, and other attributes. In addition, each record includes the target feature called rent amount. You will upload the data into Amazon Simple Storage Service (Amazon S3), create a new SageMaker AI Data Wrangler flow, transform the data, check the data for bias, and lastly save the output to Amazon S3 to be used later for ML training.

What you will accomplish

In this guide, you will:

- Visualize and analyze data to understand key relationships
- Apply transformations to clean up the data and generate new features
- Automatically generate notebooks for repeatable data preparation workflows

Prerequisites

Before starting this tutorial, you will need:

- An AWS account: If you don't already have an account, follow the Setting Up Your AWS Environment getting started guide for a quick overview.

Implementation

Step 1: Set up your Amazon SageMaker AI Studio domain

With Amazon SageMaker AI, you can deploy a model visually using the console or programmatically using either SageMaker AI Studio or SageMaker AI notebooks. In this tutorial, you deploy the model programmatically using a SageMaker AI Studio notebook, which requires a SageMaker AI Studio domain.

An AWS account can have only one SageMaker AI Studio domain per Region. If you already have a SageMaker AI Studio domain in the US East (N. Virginia) Region, follow the SageMaker AI Studio setup guide to attach the required AWS IAM policies to your SageMaker AI Studio account, then skip Step 1, and proceed directly to Step 2.

If you don't have an existing SageMaker AI Studio domain, continue with Step 1 to run an AWS CloudFormation template that creates a SageMaker AI Studio domain and adds the permissions required for the rest of this tutorial.

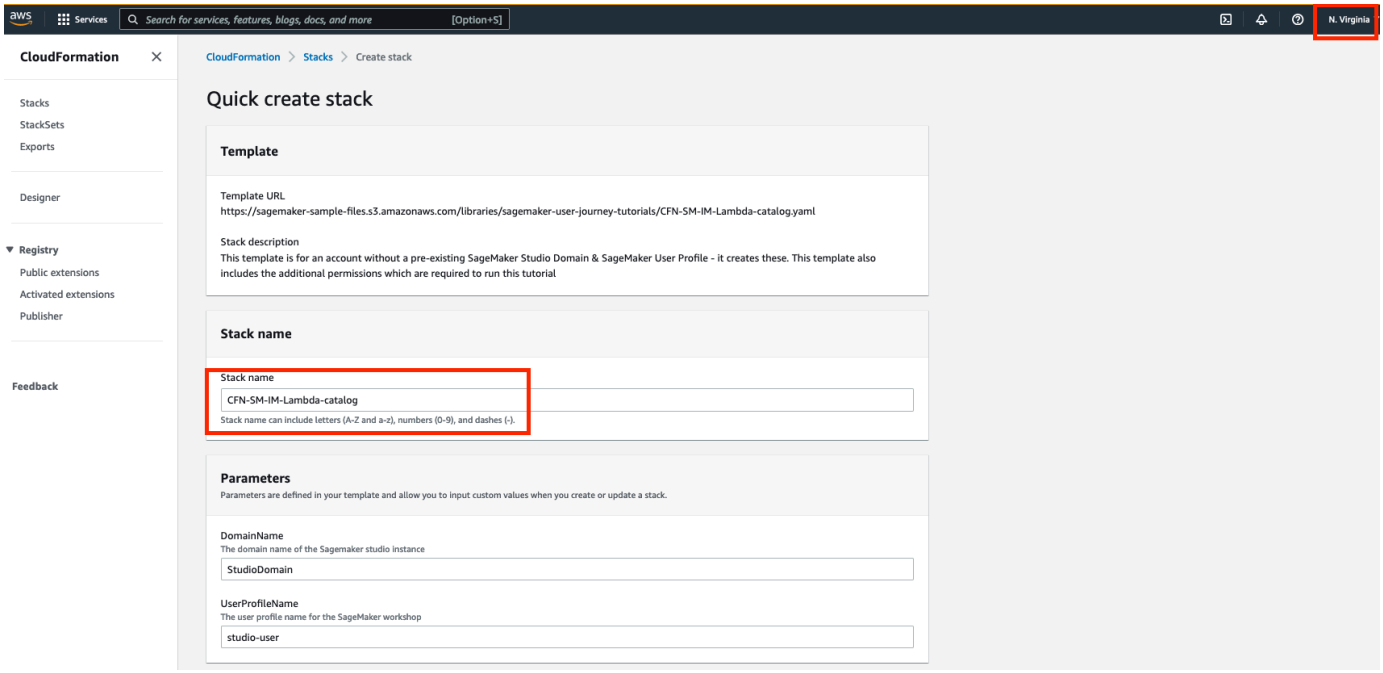
Choose the AWS CloudFormation stack link. This link opens the AWS CloudFormation console and creates your SageMaker AI Studio domain and a user named **studio-user**. It also adds the required permissions to your SageMaker AI Studio account. In the CloudFormation console, confirm that **US East (N. Virginia)** is the **Region** displayed in the upper right corner. **Stack name** should be **CFN-SM-IM-Lambda-catalog**, and should not be changed. This stack takes about 10 minutes to create all the resources.

This stack assumes that you already have a public VPC set up in your account. If you do not have a public VPC, see VPC with a single public subnet to learn how to create a public VPC.

1. Create the stack

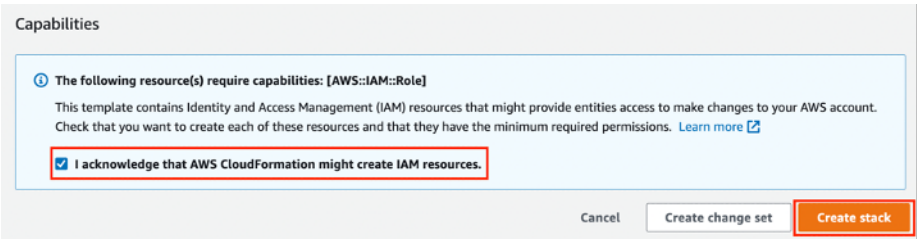
   Choose the AWS CloudFormation stack link. This link opens the AWS CloudFormation console and creates your SageMaker AI Studio domain and a user named **studio-user**. It also adds the required permissions to your SageMaker AI Studio account. In the CloudFormation console, confirm that **US East (N. Virginia)** is the **Region** displayed in the upper right corner. **Stack name** should be **CFN-SM-IM-Lambda-catalog**, and should not be changed. This stack takes about 10 minutes to create all the resources.

   This stack assumes that you already have a public VPC set up in your account. If you do not have a public VPC, see VPC with a single public subnet to learn how to create a public VPC.



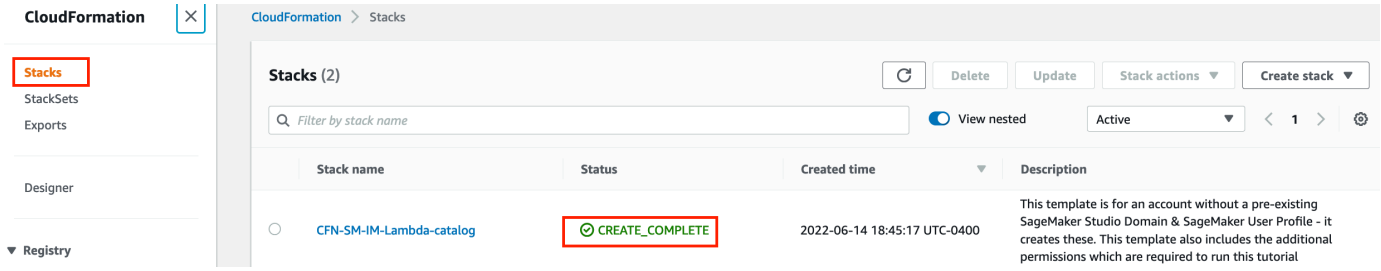
2. Acknowledge IAM resource creation

   Select **I acknowledge that AWS CloudFormation might create IAM resources**, and then choose **Create stack**.



3. Monitor stack creation progess

On the **CloudFormation** pane, choose **Stacks**. It takes about 10 minutes for the stack to be created. When the stack is created, the status of the stack changes from **CREATE_IN_PROGRESS** to **CREATE_COMPLETE**.

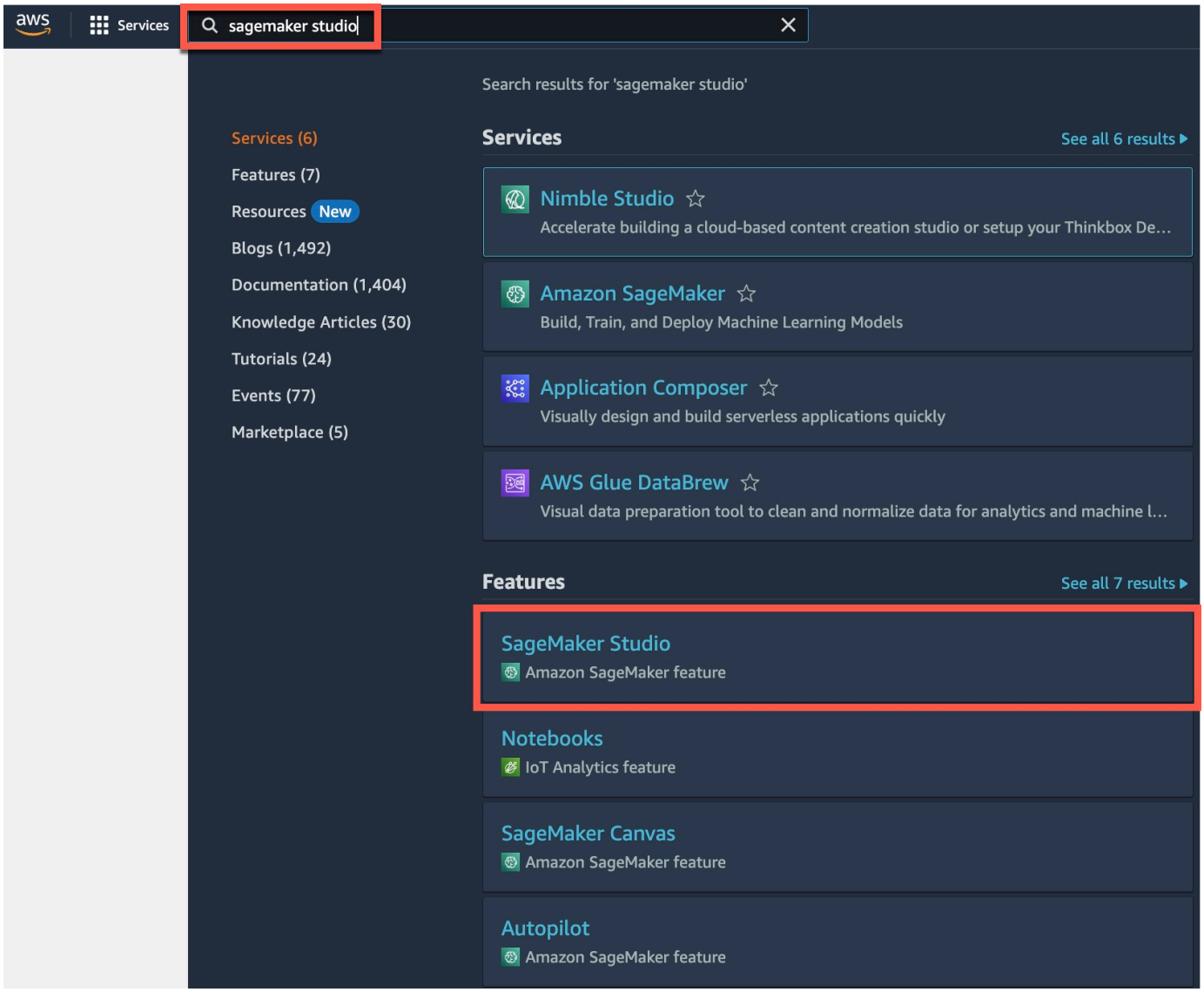


Step 2: Create a new SageMaker AI Data Wrangler flow

SageMaker AI accepts data from a wide variety of sources, including Amazon S3, Amazon Athena, Amazon Redshift, Snowflake, Databricks, and SaaS data sources. In this step, you will create a new SageMaker AI Data Wrangler flow using the Kaggle Brazil house rental dataset stored in Amazon S3. This dataset contains demographic and financial information about homes along with a target column indicating the rental amount of the property.

1. Open SageMaker AI Studio

   Enter **SageMaker AI Studio** into the console search bar, and then choose **SageMaker AI Studio**.

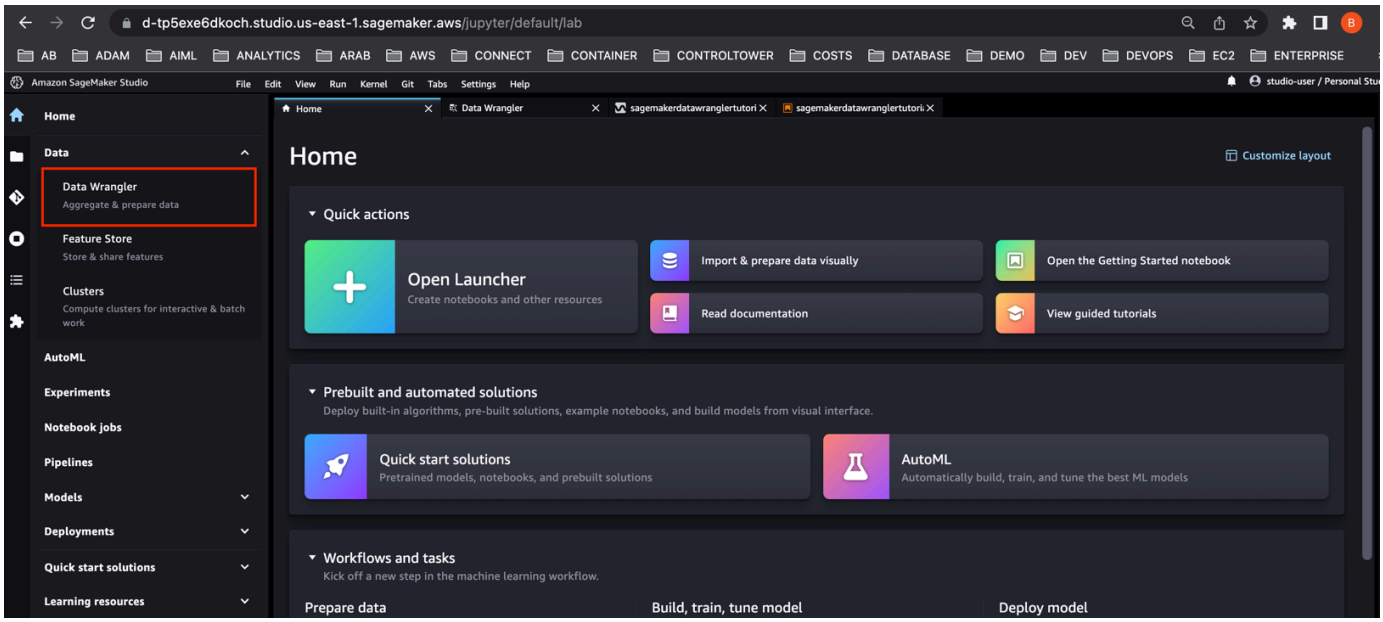


2. Open Studio

   Choose **US East (N. Virginia)** from the Region dropdown list on the upper right corner of the SageMaker AI console. Browse to the **Getting Started** section in the left-hand navigation and then choose **Studio**. Then select the studio-user profile and then choose the **Open Studio** button.

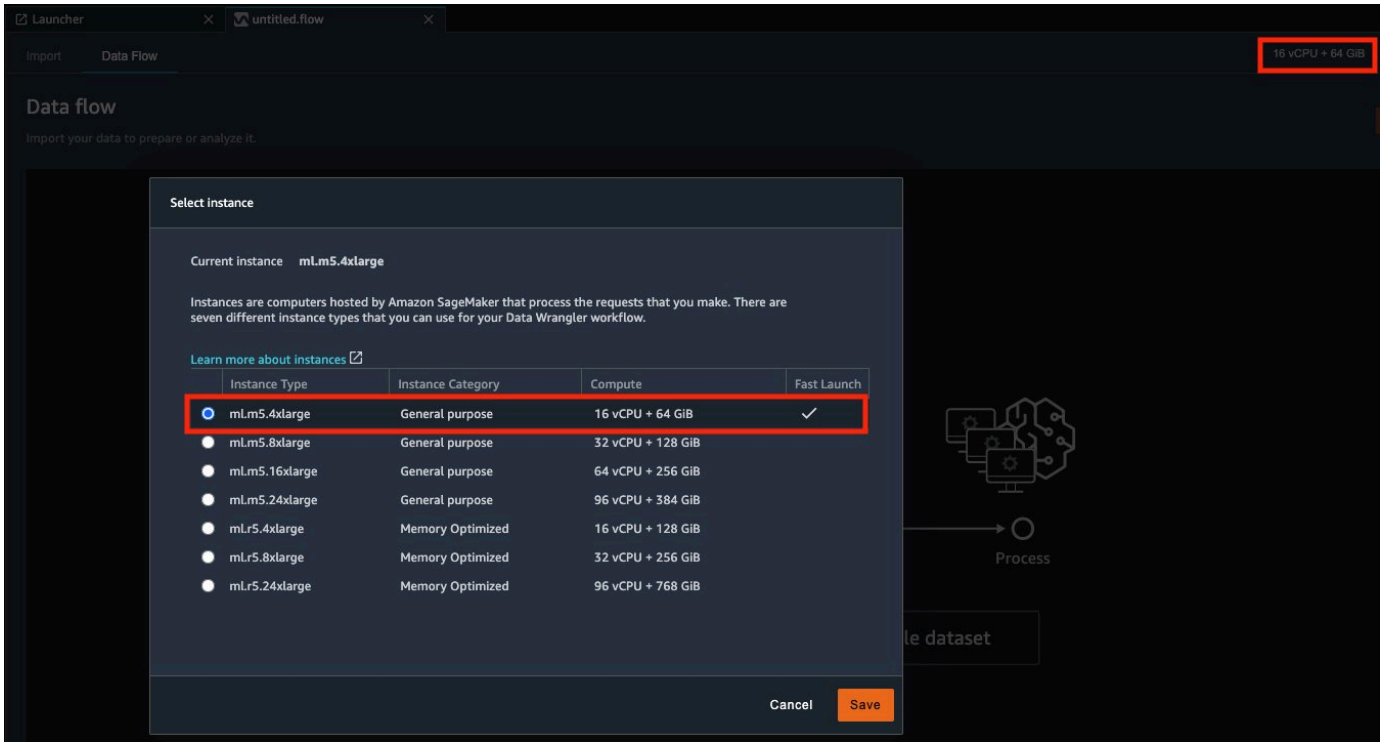
3. Start Data Wrangler

   Open the **SageMaker AI Studio** interface. On the navigation bar, choose **Data Wrangler** on the left-hand side, and then choose the **Import Data** button.



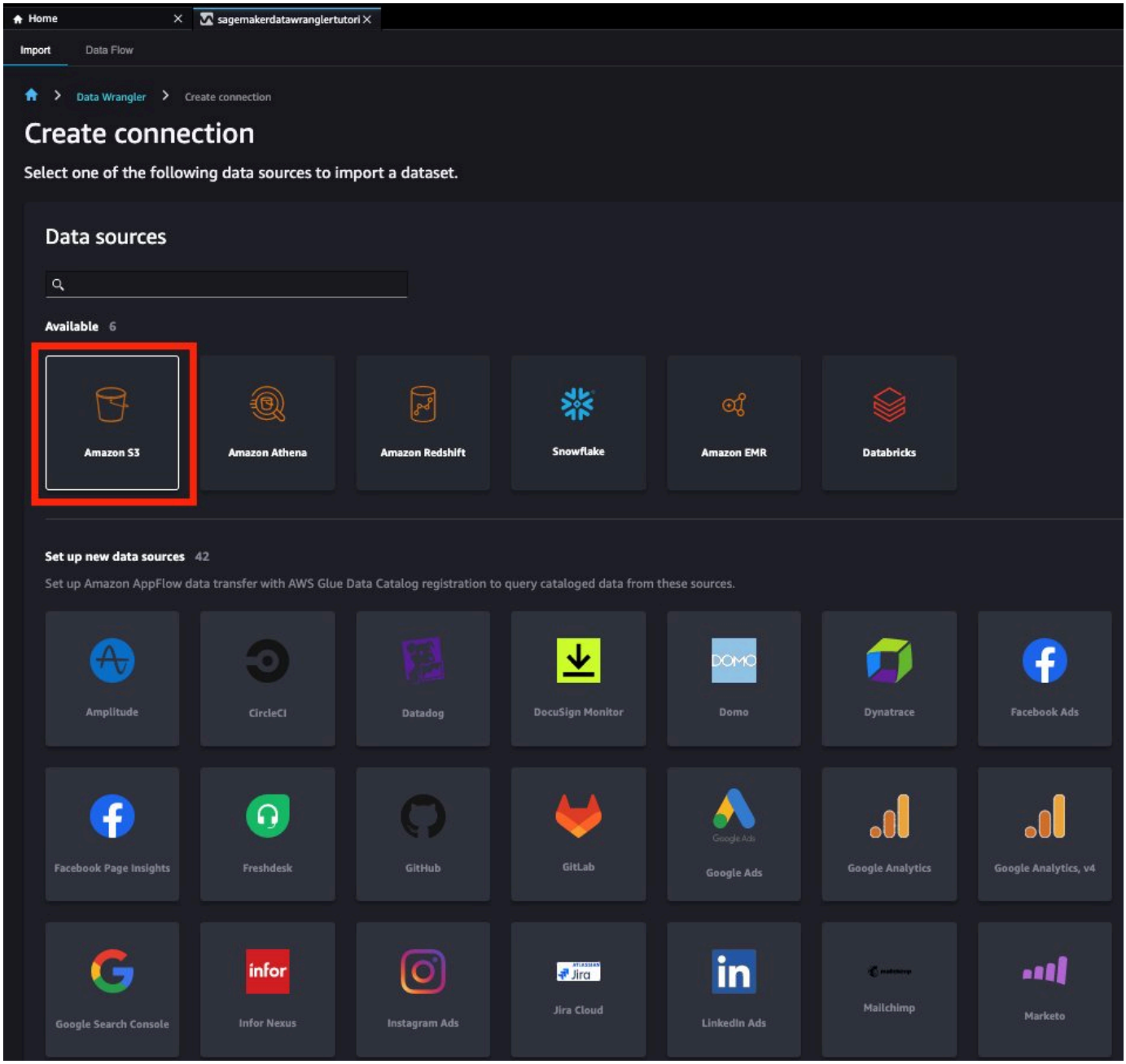
4. Choose instance type

   Note that you can change the Flow's compute instance type using the upper right button showing the current Compute instance. You may decide to change the compute instance type based on your scenario's dataset size and can scale it up or down when your requirements change. For the purposes of this tutorial, you can use the default **ml.m5.4xlarge**.



5. Import data from S3

   In the **Data Import** tab, under I**mport data**, choose **Amazon S3**.

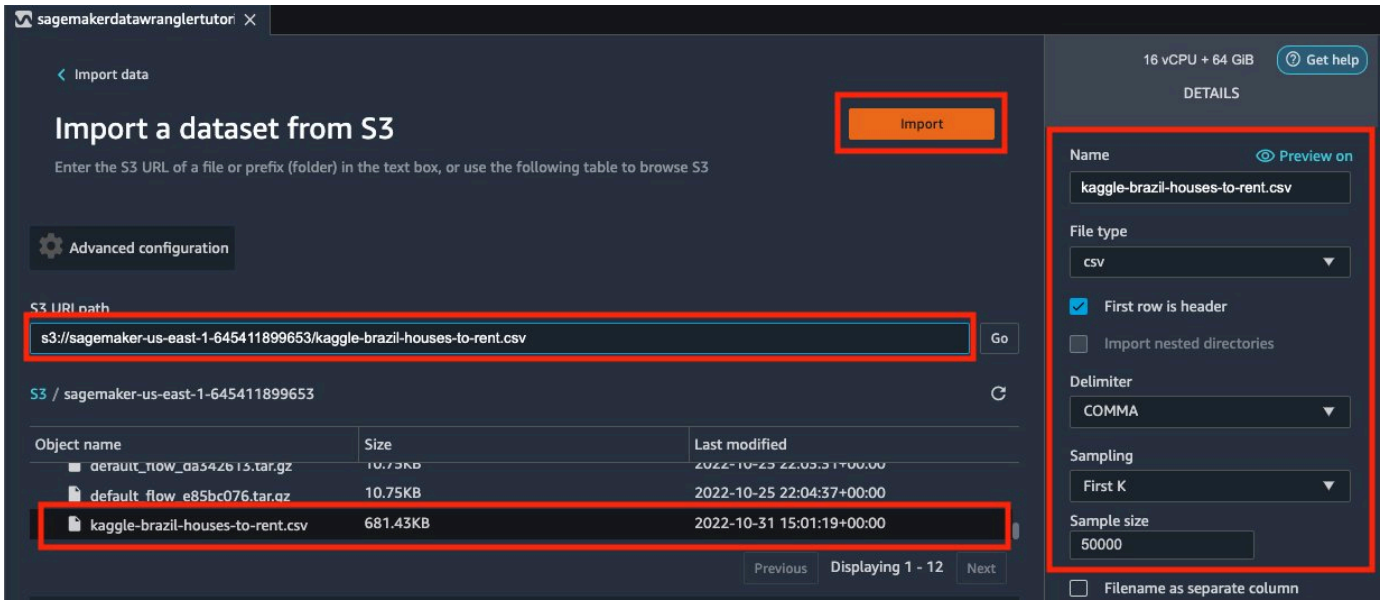


6. Specify S3 location

   In the S3 URI Path field, enter **s3://sagemaker-sample-files/datasets/tabular/brazil_houses/kaggle_brazil_houses_rental_data.csv**, and then choose **Go**. Under **Object name**, select **kaggle_brazil_houses_rental_data.csv**.

7. Import the dataset

   In the S3 import details panel, note that you can change the default delimiter and the sampling method when necessary. For the purposes of this tutorial, you can use the default **comma delimiter** and **First K sampling method**. Then choose **Import**.

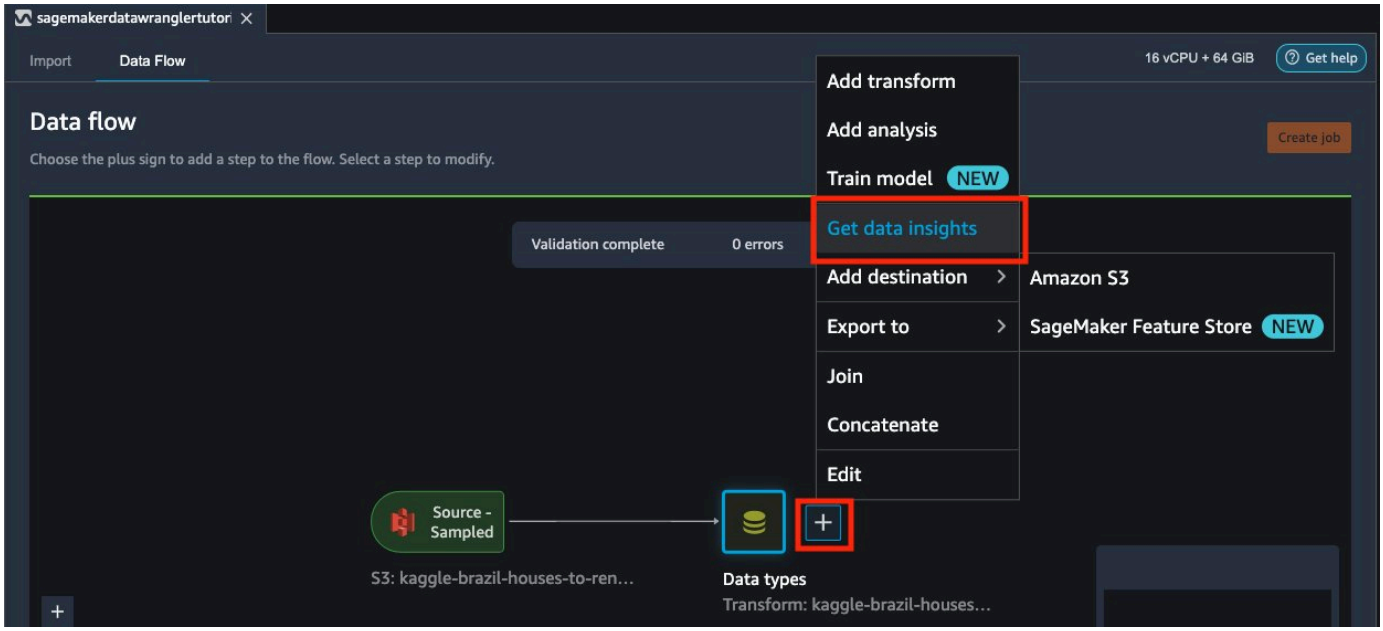


Step 3: Explore the data

In this step, you use SageMaker AI Data Wrangler to assess and explore the quality of the training dataset for building machine learning models. Use the Data Quality and Insights report feature to understand your dataset quality, and then use the Quick Model feature to estimate the expected prediction quality and the predictive power of the features in your dataset.

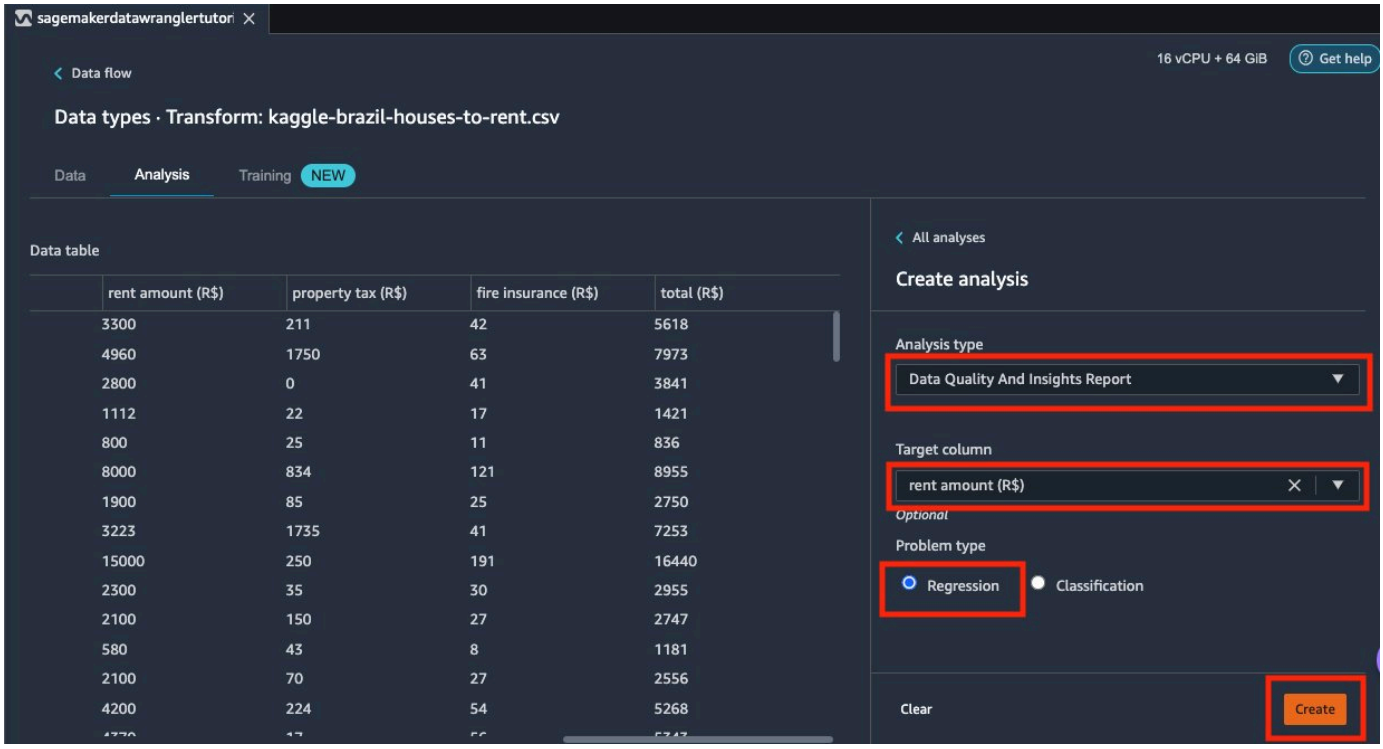
1. Generate data insights

   When exploring your dataset, begin by using the Data Quality and Insights report to help you quickly understand your dataset, identify possible issues, and focus your attention on the most important areas to improve the data. On the **Data flow** tab, in the data flow diagram, choose the **+ icon**, then choose **Add analysis**. Then choose **Get data insights**.



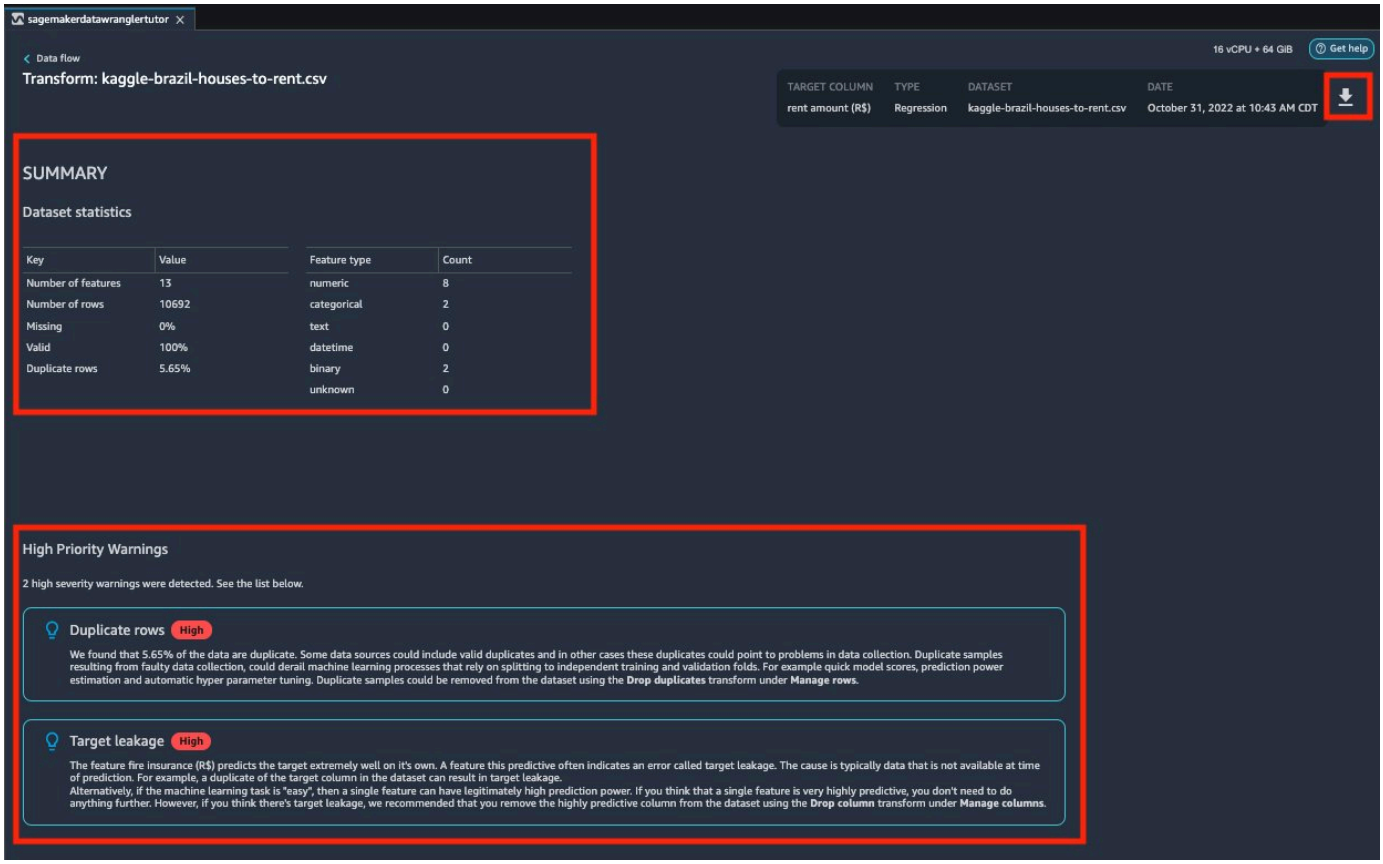
2. Set analysis parameters

   From the **Data Insights** pane, choose **rent amount** as the Target column. Then choose **Regression** as the **Problem type**. Then choose **Create**.



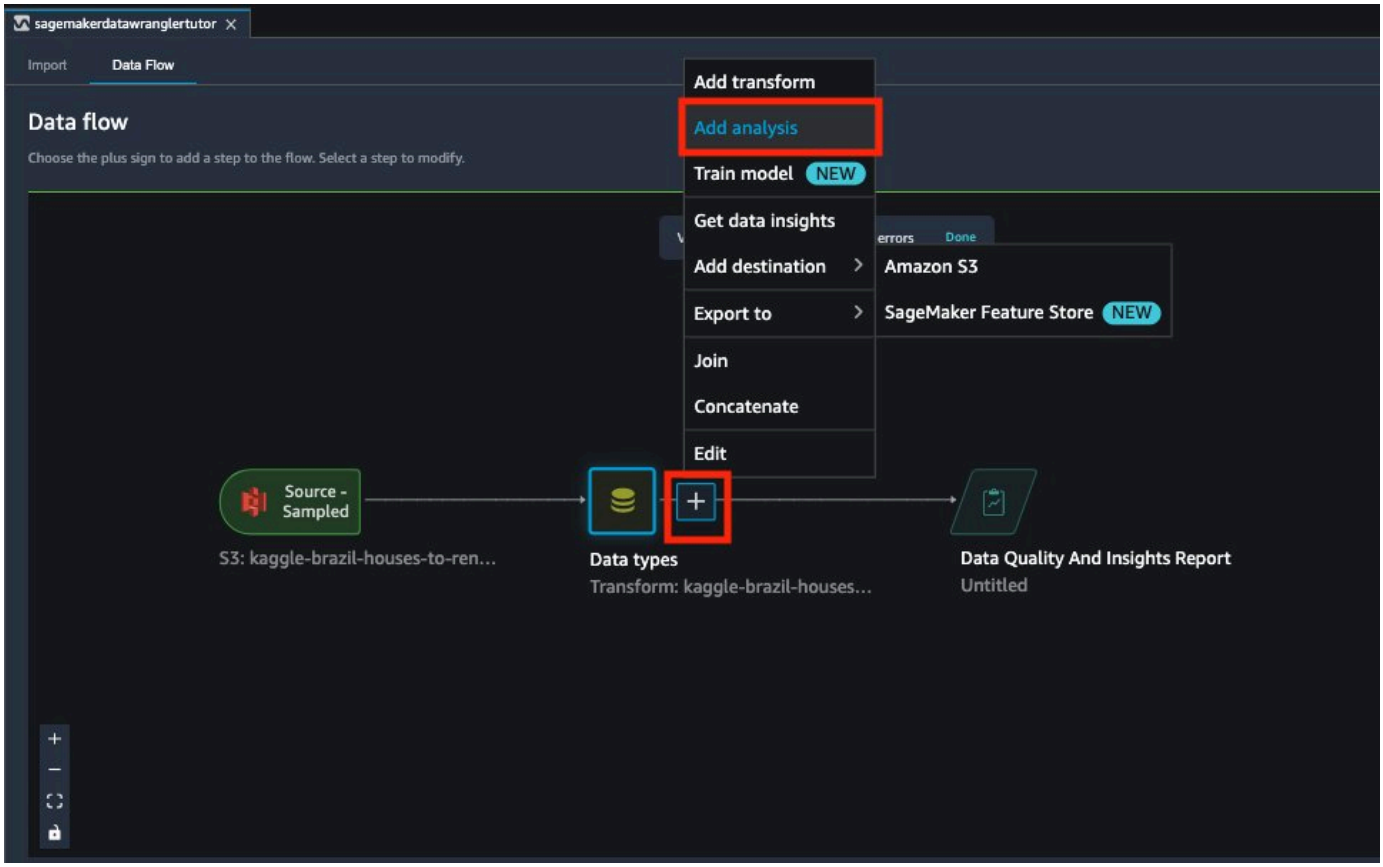
3. View insights report

   You may need to wait a minute while the report is generated. Once completed, review the Data Quality and Insights report sections to improve the dataset further before building the ML model. For this specific dataset, the Data Insights report has highlighted two possible issues: the first is related to **duplicate rows** in the dataset and the second is related to possible **target leakage** such that one feature is highly correlated with the output and may indicate a duplicate of the target **rent** column. The report can also be downloaded to a PDF file and shared with colleagues on your team.



4. Create an analysis

   For further data analysis and exploration, you can create additional analytical artifacts including correlation matrices, histograms, scatter plots, and summary statistics as well as custom visualizations. For example, choose the **+ icon**, then choose **Add analysis**.



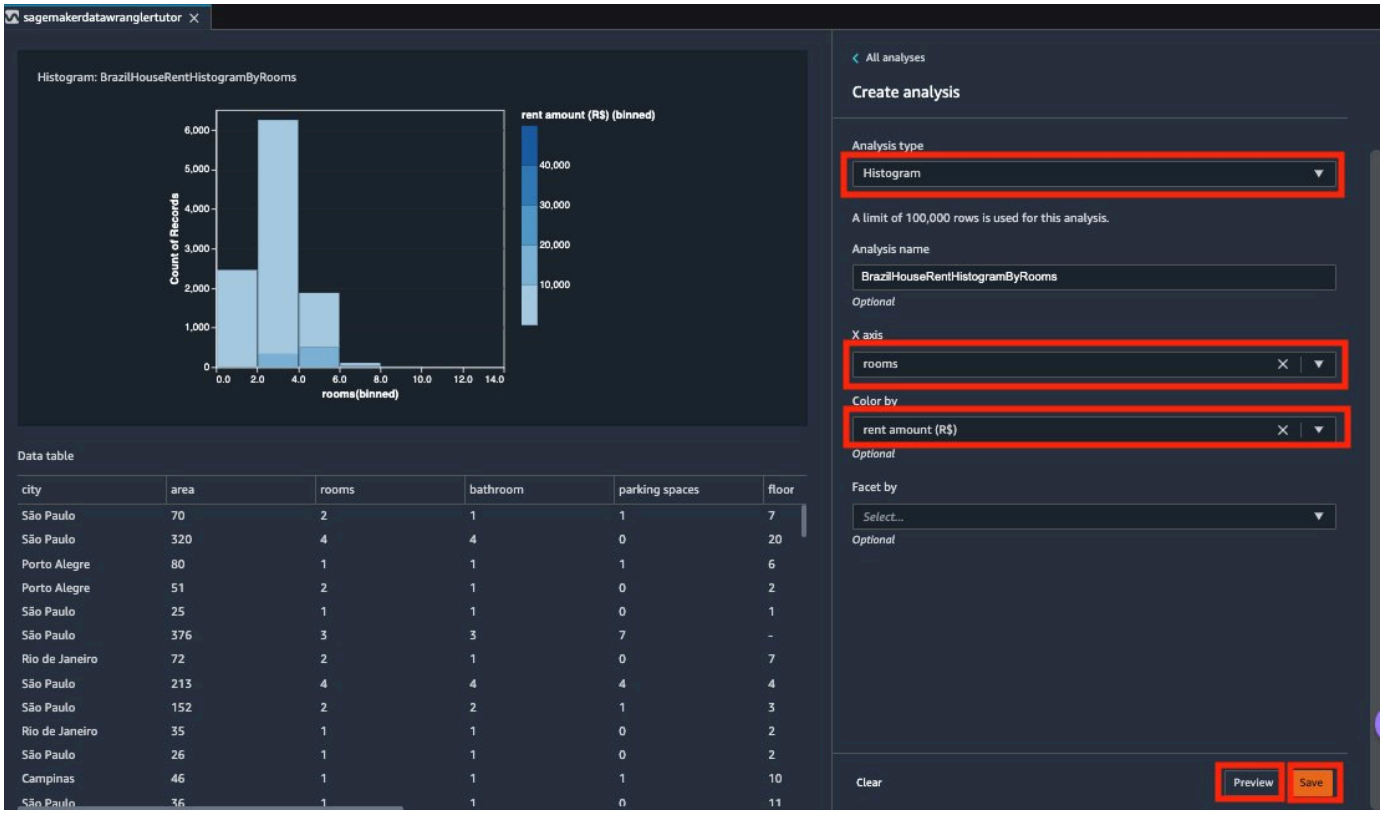
5. Create a histogram

   Under the **Create analysis** panel, for **Analysis type**, select **Histogram** and name it **RentHistogramByRooms**. For **X axis**, select **rooms**.

   For **Color by**, select **Rent amount**.

   Choose **Preview** to generate a **histogram** of the **rent amount** field, color-coded by the **rooms** variable.

   Choose **Save** to save this analysis to the data flow.

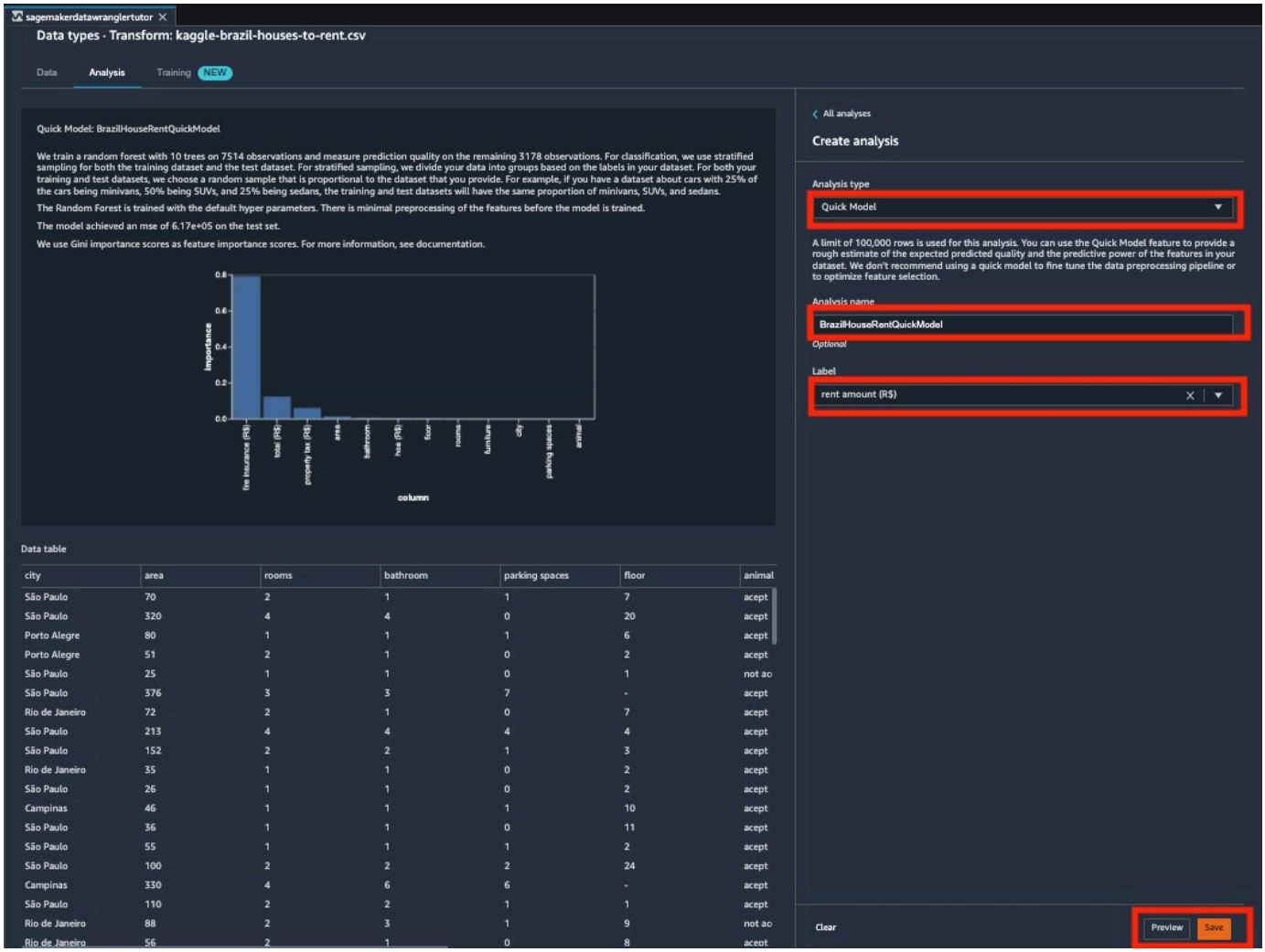


6. Create a Quick Model

   Next, to gain higher confidence that the underlying data has some predictive power, we are going to create a Quick Model. Under the **Create analysis** pane, for **Analysis** type, choose **Quick Model** and name it **RentQuickModel**.

   Then for **Label**, select **rental amount** and then choose **Preview**.

   The **Quick Model** may take several minutes to complete, then the pane shows a brief overview of the Random Cut Forest model built and trained with default hyperparameters. The model generated also displays some statistics, including the Mean Square Error (MSE) score and feature importance to help you evaluate the quality of the dataset. Choose **Save**.

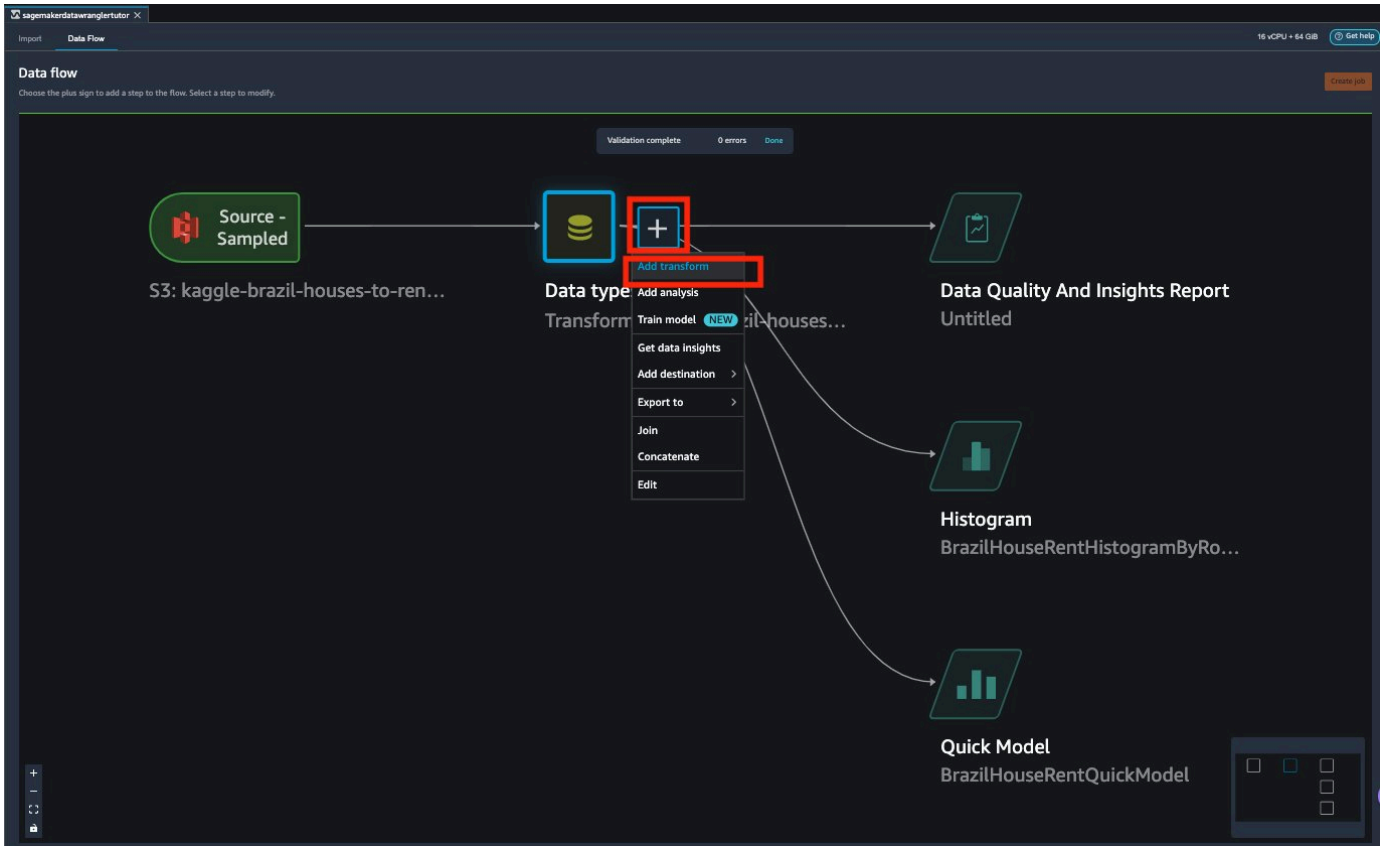


Step 4: Add transformations to the data flow

SageMaker AI Data Wrangler simplifies data processing by providing a visual interface with which you can add a wide variety of pre-built transformations. You can also write your custom transformations when necessary using SageMaker AI Data Wrangler. In this step, you change the type of a string column, rename columns, and drop unnecessary columns using the visual editor.

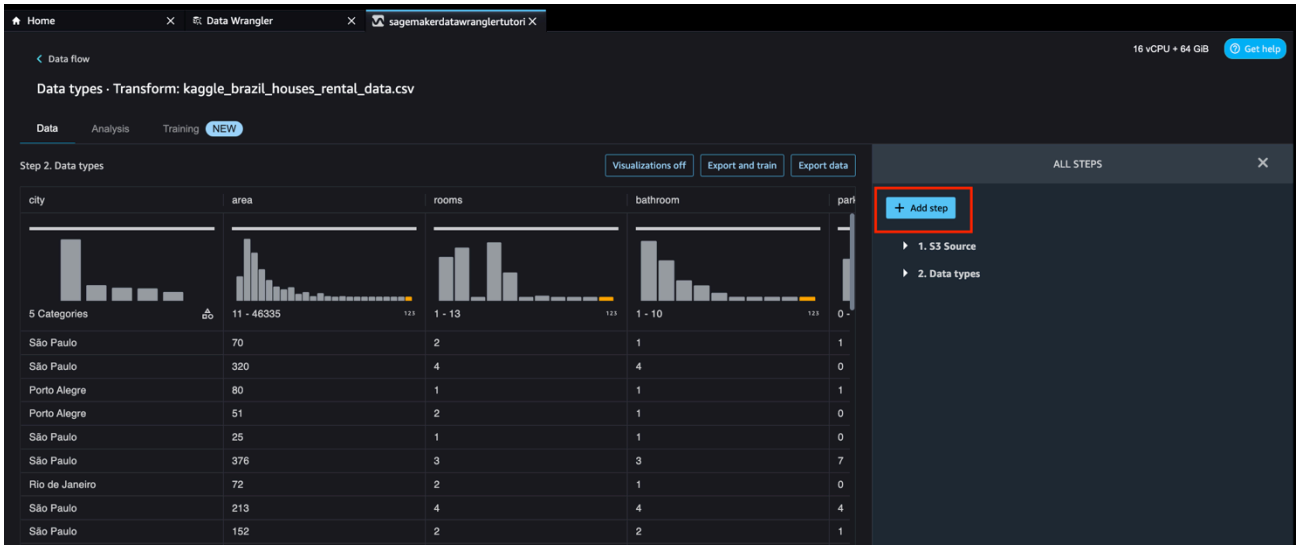
1. Open Data Wrangler flow

   To navigate to the data flow diagram, choose **Data flow**. On the data flow diagram, choose the **+ icon**, then **Add transform**.



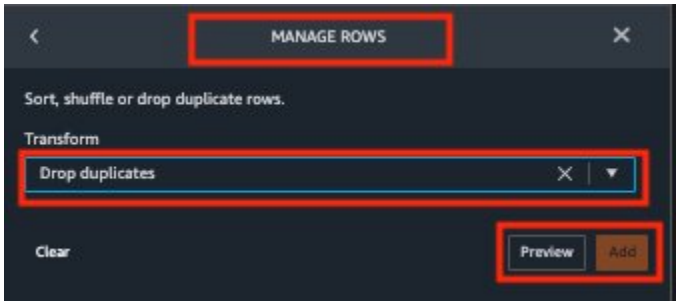
2. Add a transformation

   Under the **ALL STEPS** pane, choose **Add step**.



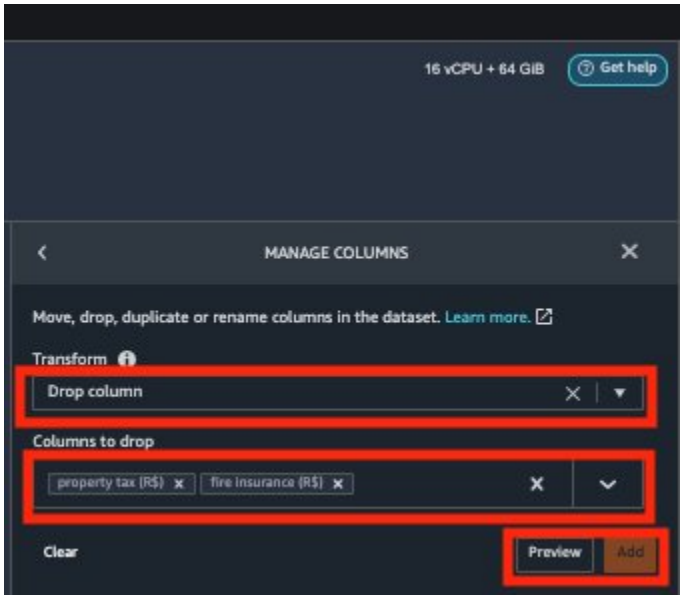
3. Remove duplicates

The first step is following the Data Insights Report recommendations regarding high risk items and removing the duplicate rows. So as the first transform step, choose **Manage Rows**, and then select the **Drop duplicates** operation. Then choose **Preview** and **Save**.



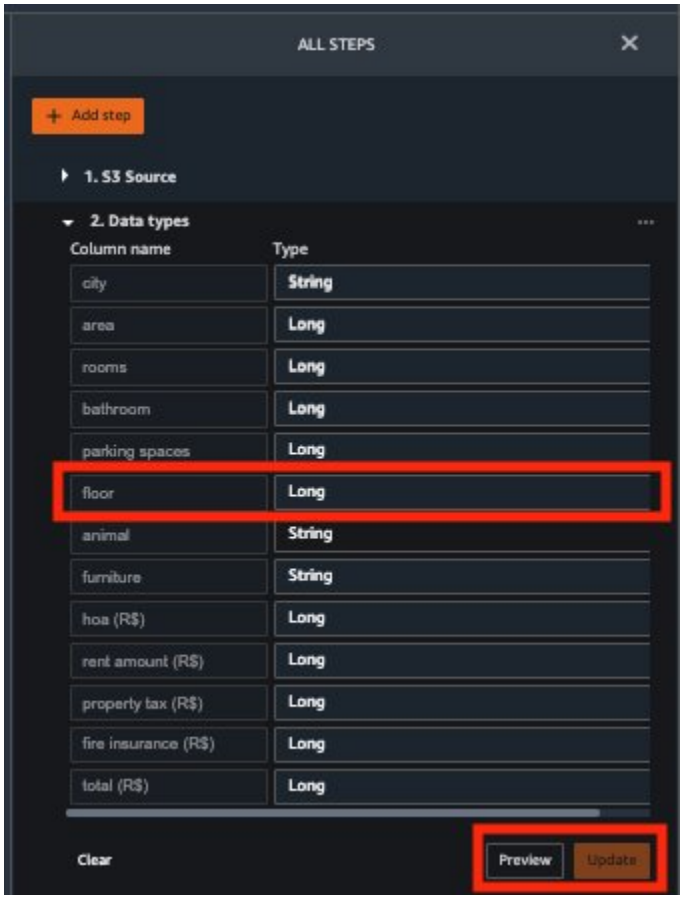
4. Select columns to drop

   Second, we are going to remove the dataset features highlighted as possible sources of target leakage and not appropriate for a machine learning model predicting the rental amount. From the **ADD TRANSFORM** list, choose **Manage columns**. Then choose **Drop column** and choose **property tax** and **fire insurance**. Choose **Preview** then **Save**.



5. Change column type

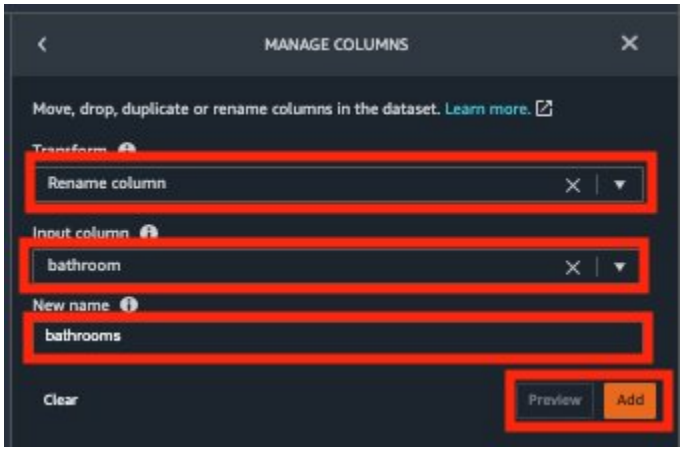
   Next, change the data type of the **floor** column from **string** to **long**. Machine learning models can benefit from using numerically typed columns and this step will allow us to perform further processing later on.



6. Update column names

   Then rename several columns to improve the readability of the input data set and later analysis.

   From the **ADD TRANSFORM** list, choose **Manage columns**. Then choose **Rename column**. Then choose **bathroom** as the input column and **bathrooms** as the output column. Choose **Preview** then **Save**. Repeat this renaming column process for **hoa** [originally from **hoa (R$)**], **rent** [originally from **rent amount (R$)**], and **total** [originally from **total (R$)**].



Step 5: Add categorical encoding and numeric scaling transformations to data flow

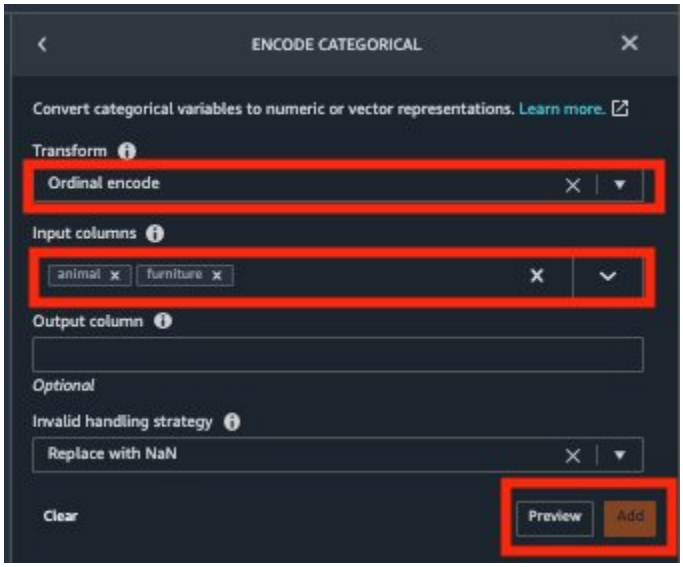
In this step, you encode categorical variables and scale numerical variables. Categorical encoding transforms string data type categories into numerical features. It's a common preprocessing task because the numerical features can be used in a wide variety of machine learning model types.

1. Configure encoding

   In the dataset, the rental property's **animal** and **furniture** classification is represented by various strings. In this step, you convert these string values to a binary representation, 0 or 1.

   Under the **ALL STEPS** pane, choose **+ Add step**. From the **ADD TRANSFORM** list, choose **Encode categorical**. SageMaker AI Data Wrangler provides three transformation types: Ordinal encode, One hot encode, and Similarity encode.

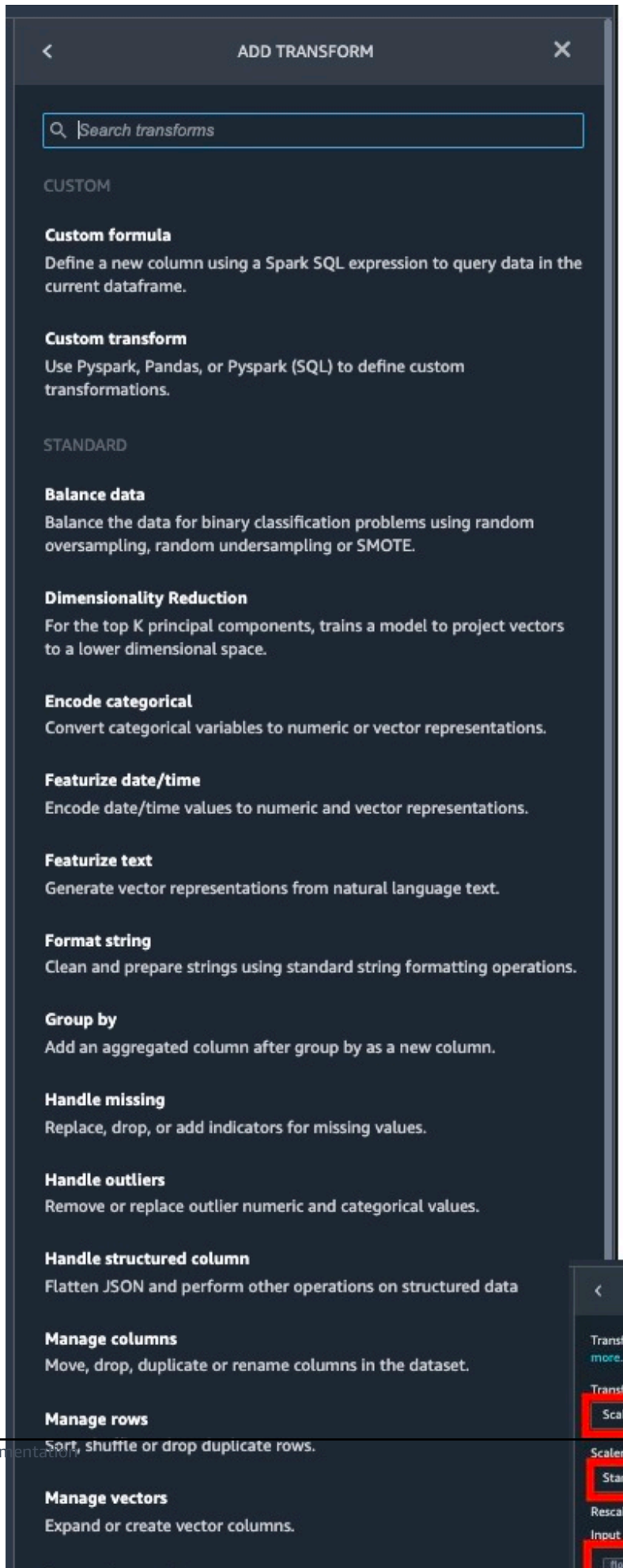
   Under the **ENCODE CATEGORICAL** pane, for **Transform**, use the default **Ordinal encode**. For **Input** columns, select **animal** and **furniture**. Ignore the **Invalid handling strategy** box for this tutorial. Choose **Preview**, then **Add**.

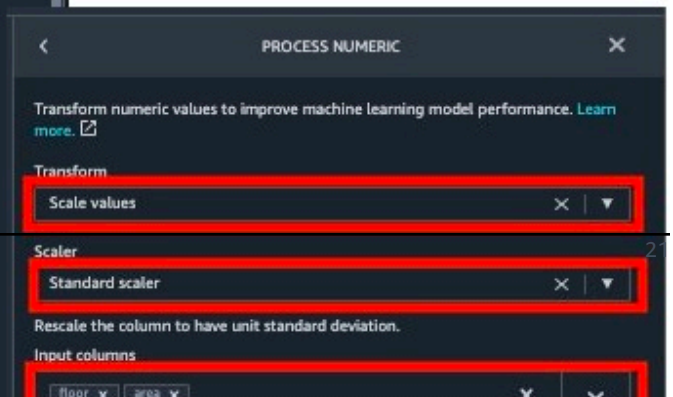


2. Configure scaling

   To scale the numerical columns area and floor, apply a scaler transformation to normalize the distribution of the data in these columns:

   Under the **ALL STEPS** pane, Choose **+ Add step**. From the **ADD TRANSFORM** list, choose **Process numeric**. For **Scaler**, select the default option **Standard scaler**. For **Input** columns, select **area** and **floor**. Choose **Preview**, and then **Add**.

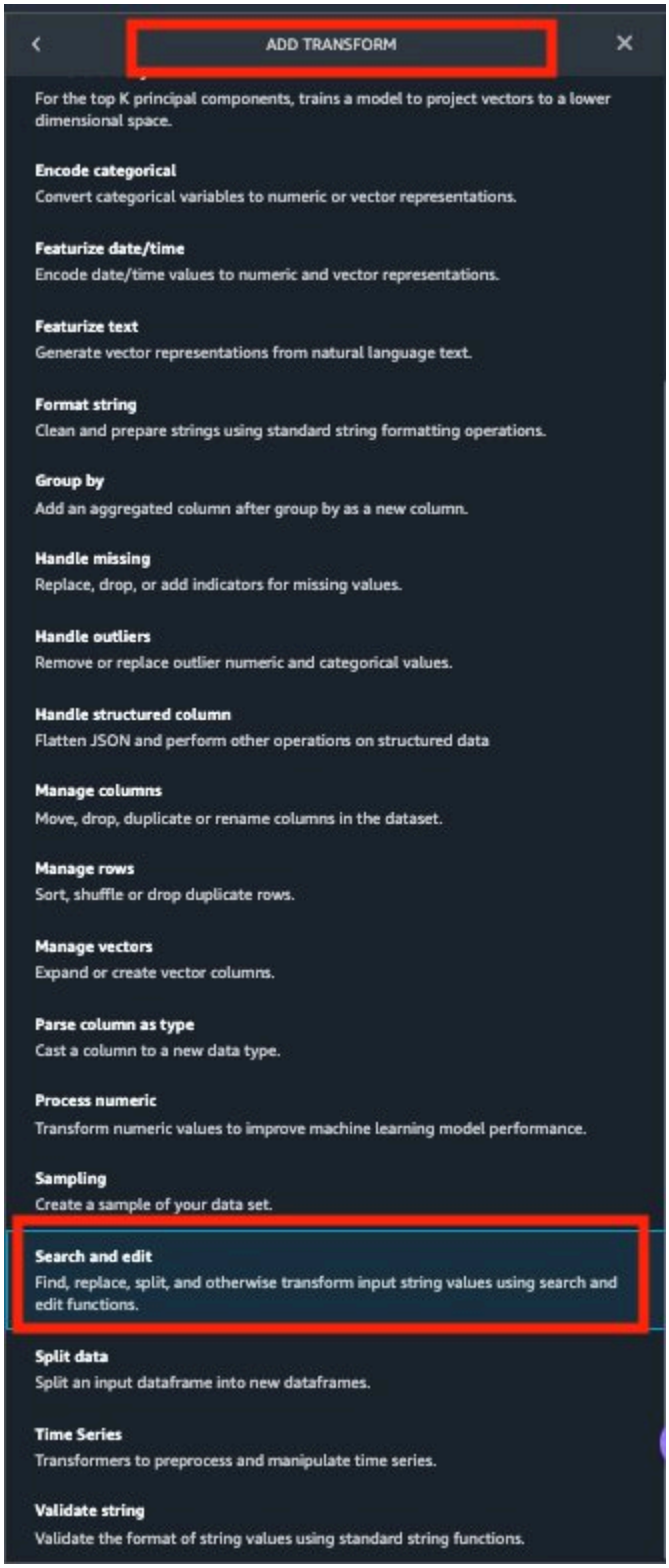

ADD TRANSFORM
Search transforms
CUSTOM
Custom formula
Define a new column using a Spark SQL expression to query data in the current dataframe.
Custom transform
Use Pyspark, Pandas, or Pyspark (SQL) to define custom transformations.
STANDARD
Balance data
Balance the data for binary classification problems using random oversampling, random undersampling or SMOTE.
Dimensionality Reduction
For the top K principal components, trains a model to project vectors to a lower dimensional space.
Encode categorical
Convert categorical variables to numeric or vector representations.
Featurize date/time
Encode date/time values to numeric and vector representations.
Featurize text
Generate vector representations from natural language text.
Format string
Clean and prepare strings using standard string formatting operations.
Group by
Add an aggregated column after group by as a new column.
Handle missing
Replace, drop, or add indicators for missing values.
Handle outliers
Remove or replace outlier numeric and categorical values.
Handle structured column
Flatten JSON and perform other operations on structured data
Manage columns
Move, drop, duplicate or rename columns in the dataset.
Manage rows
Sort, shuffle or drop duplicate rows.
Manage vectors
Expand or create vector columns.


PROCESS NUMERIC
Transform numeric values to improve machine learning model performance. Learn more.
Transform
Scale values
Scaler
Standard scaler
Rescale the column to have unit standard deviation.
Input columns

3. Choose transformation type

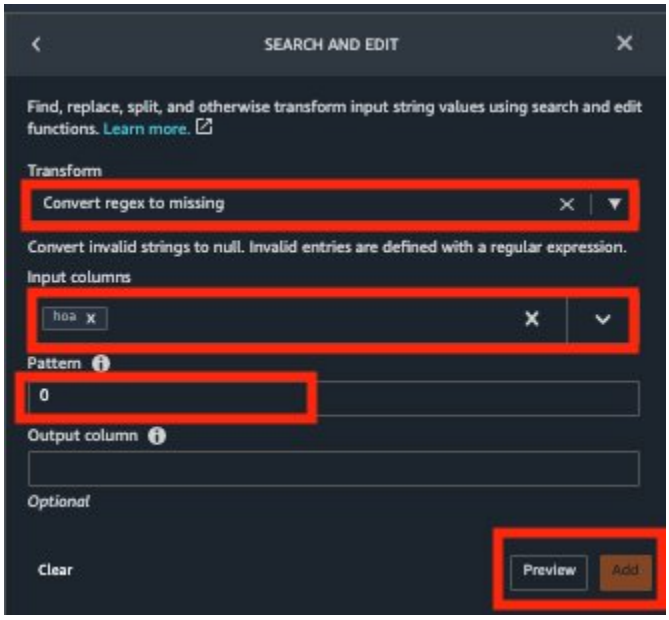
   Finally, we will follow another recommendation from the Data Insight report and replace the 0s in the Home Owner Association (hoa) feature with **NaN** because they indicate missing data and should not be treated as valid inputs that might skew the model.

   Under the **ALL STEPS** pane, choose **+ Add step**. From the **ADD TRANSFORM** list, choose **Search and edit**.



4. Replace zero values

   Choose **Convert regex to missing**. Choose **hoa** as the **Input** column, specify **0** as the **Pattern**. Click **Preview**, and then choose **Add**.



Step 6: Check for data bias

In this step, check your data for bias using Amazon SageMaker AI Clarify, which provides you with greater visibility into your training data and models so you can identify and limit bias and better explain predictions.

1. Create a bias report

   Choose **Data flow** in the upper left to return to the data flow diagram. Choose the **+ icon**, **Add analysis**.

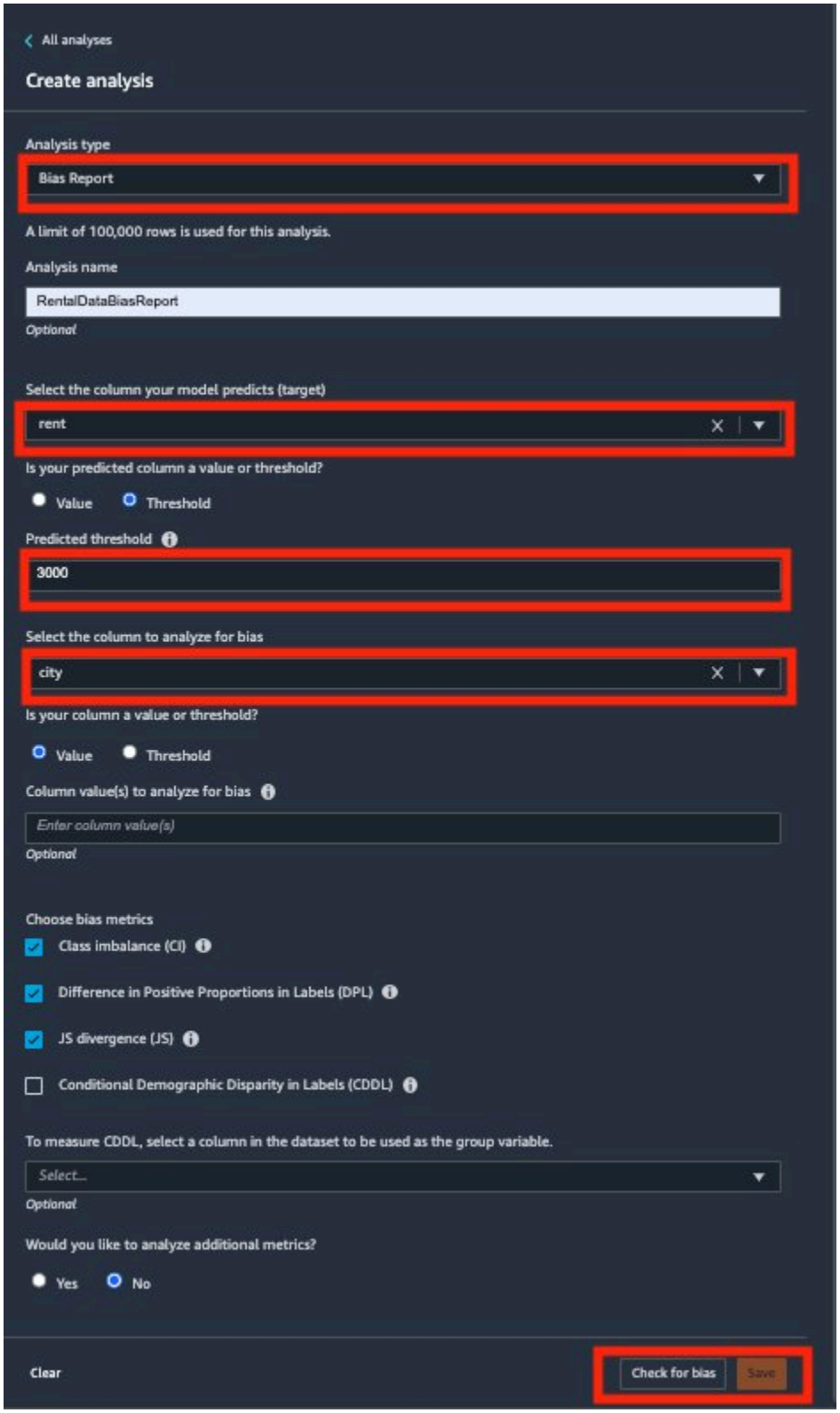
   In the **Create analysis** pane, for **Analysis type**, select **Bias Report**.

   For **Analysis name**, enter **RentalDataBiasReport**.

   For **Select the column your model predicts (target)**, select **rent**. Then select **Threshold** as the predicted column type since this is a regression problem.

   Specify **3000** as the **predicted threshold** which corresponds to the average of the **rent** column in the dataset. Then select **city** as the column to analyze for bias because we are interested in whether the dataset is imbalanced and over-represents some cities instead of others.

   Then for **Choose bias metrics**, keep the default selections. Then choose **Check for bias** and then **Save**.

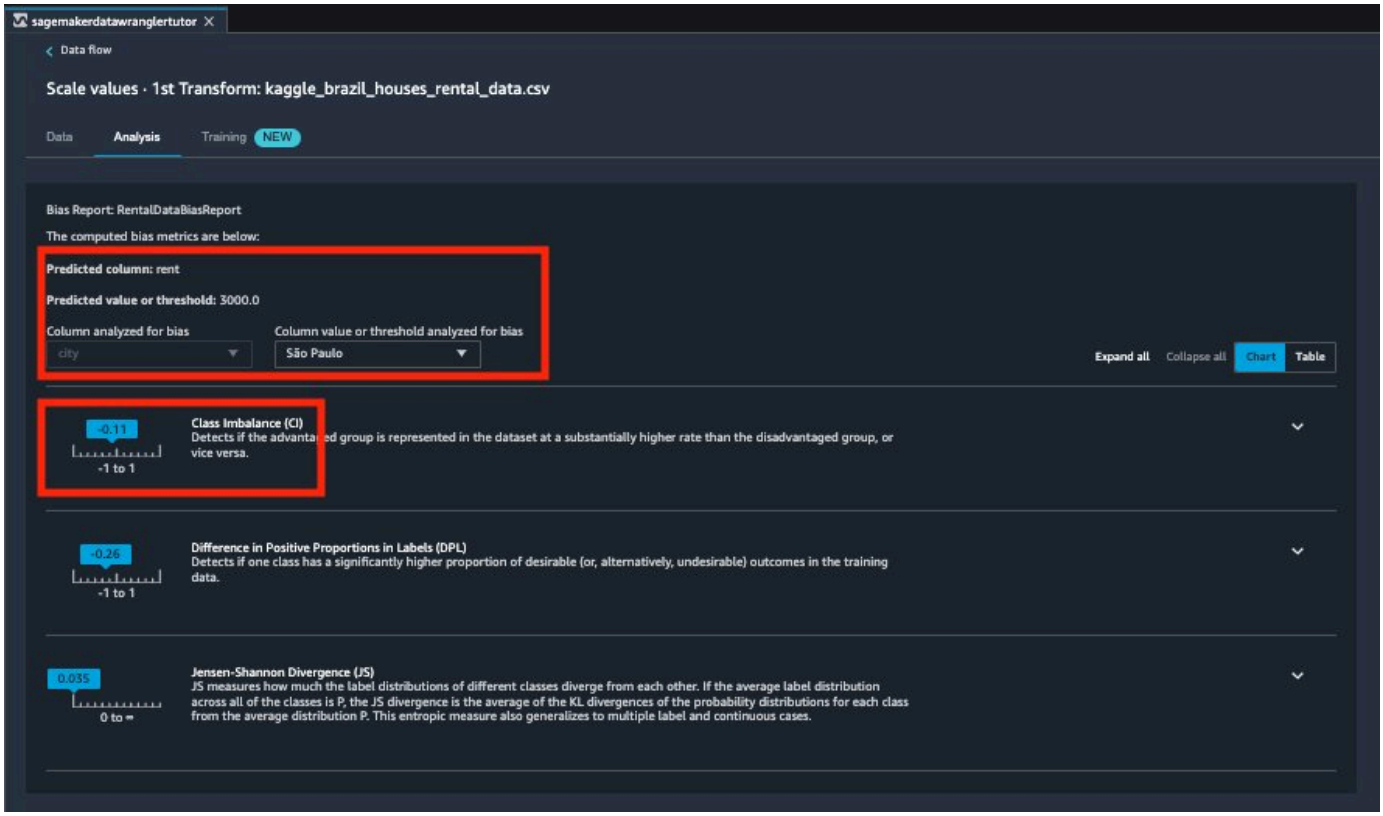


2. Review bias metrics

After several seconds, SageMaker AI Clarify generates a report, which shows how the target and feature columns score on a number of bias-related metrics including Class Imbalance (CI) and Difference in Positive Proportions in Labels (DPL).

In this case, the data is slightly biased with regards to rents in Sao Paolo (-0.11), and increasingly skewed for the cities of Rio de Janeiro (0.72), Belo Horizonte (0.77), and Porto Alegre (0.78).

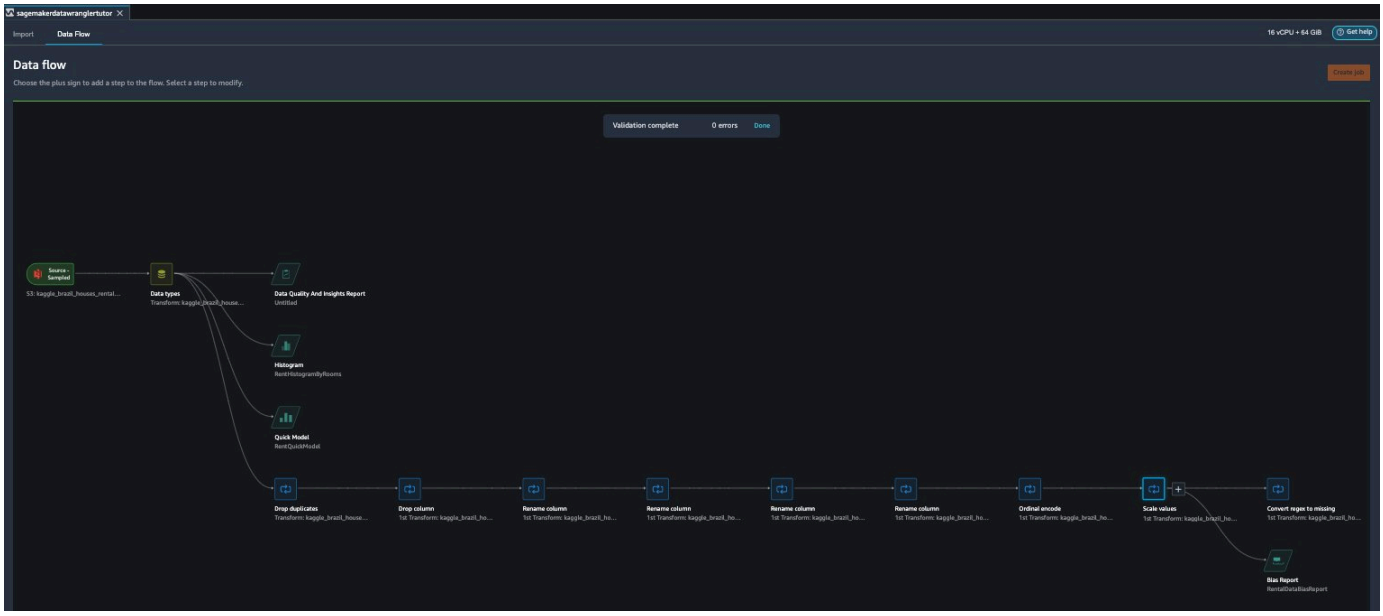
Based on this report, you might consider a bias remediation method, such as using SageMaker AI Data Wrangler's built-in SMOTE transformation. For the purpose of this tutorial, skip the remediation step. Choose **Save** to save the bias report to the data flow.



Step 7: Review, integrate, and export your data flow

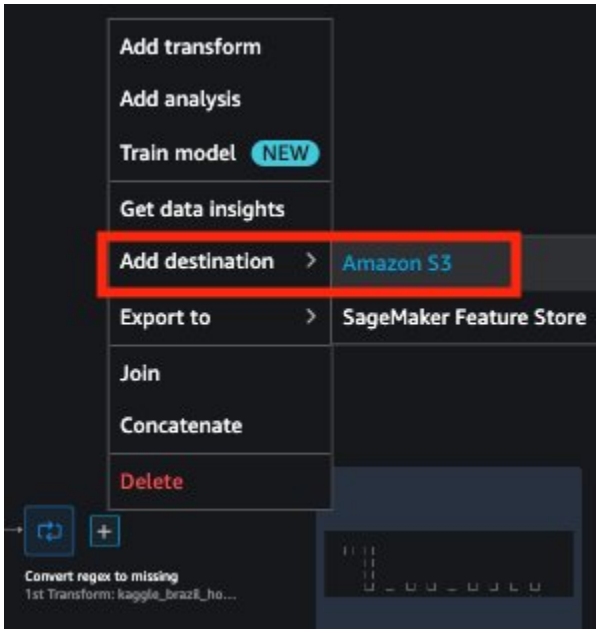
1. View your data flow

   From the **Data Flow** tab, review your end-to-end data flow graph including the data source, analytical artifacts, and data transformations. You can easily navigate, view, modify, and delete data flow steps iteratively.



2. Export to Amazon S3

   Data Wrangler further streamlines the automation process of exporting the output of the data flow to a persistent destination and can orchestrate the schedule of the flow's execution. First, set the storage destination to Amazon S3.



3. Specify output settings

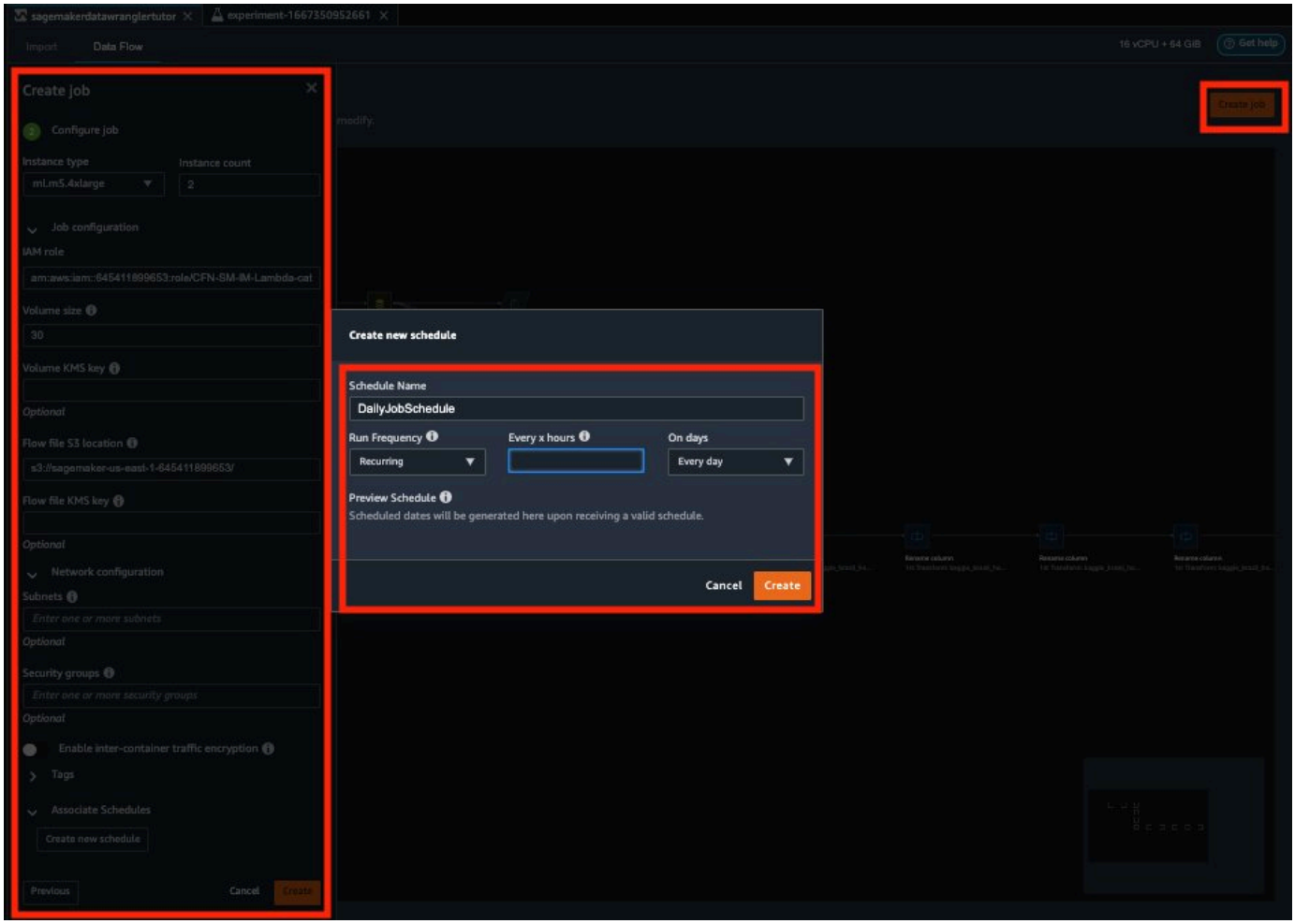
   Then specify the output dataset name (**kaggle_brazil_houses_rental_data_dw_processed.csv**) and the Amazon S3 location as your preferred S3 bucket. Then choose **Add destination**.

4. Create job

   Lastly, create the scheduled job that will export the data flow output to Amazon S3 by choosing the **Create job** button from the **Data Flow** diagram pane, and then choosing **Configure job**.

5. Configure job

   Then you can decide on the job instance type, instance count, the job's IAM security role, and the job schedule.

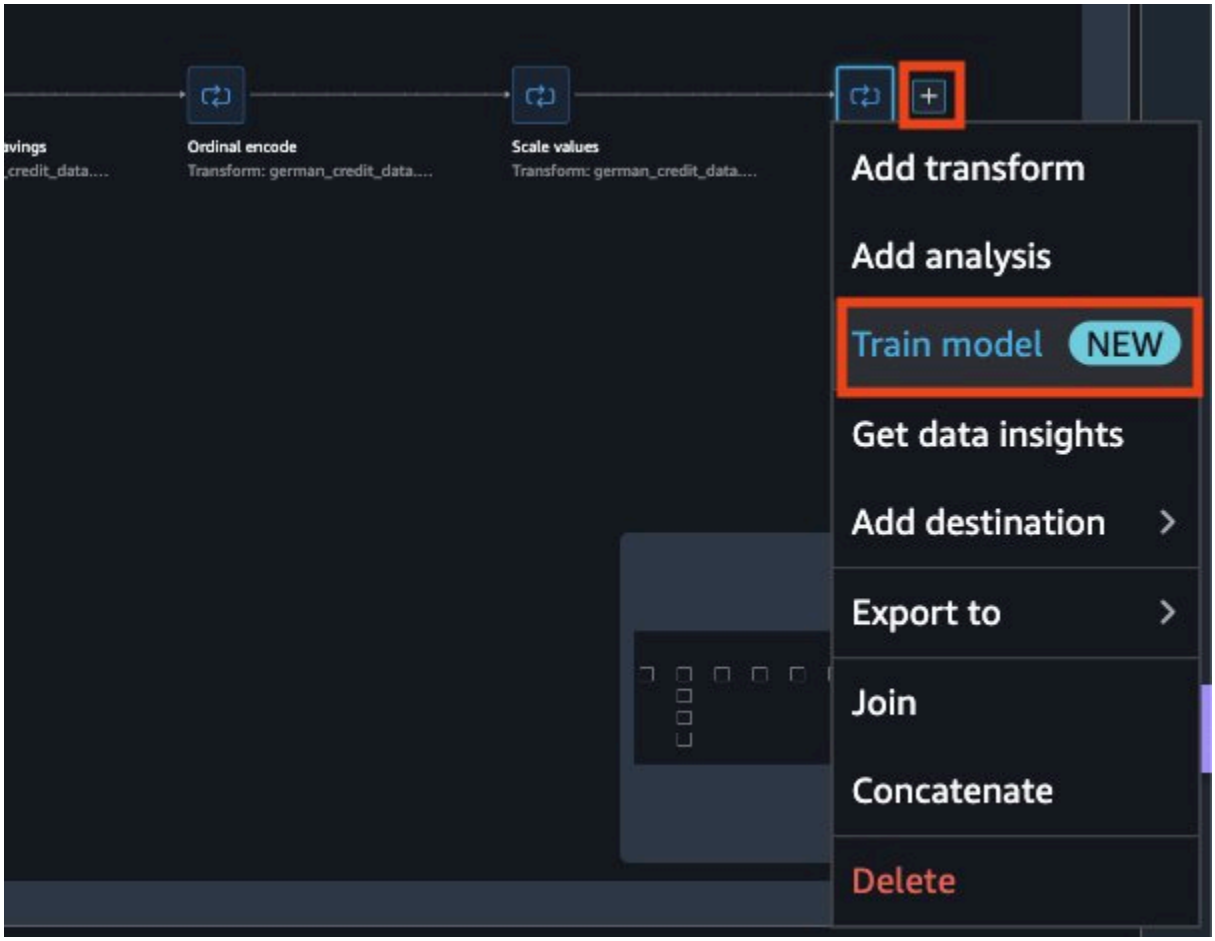


Step 8: SageMaker AI Autopilot integration

You can also integrate your data flow with SageMaker AI Autopilot which automates key tasks of training and deploying a machine learning model.

1. Open model training

   From the **Data Flow** tab, choose the **+ icon** and then choose **Train model**.



2. Configure and start Autopilot experiment

   Choose **Export and Train** to export the Data Wrangler flow and associate its output with the Autopilot Experiment input.

   Choose the **S3 location** where the Data Wrangler flow saved the processed input dataset and specify the **target** column as **rent** for the Autopilot model.

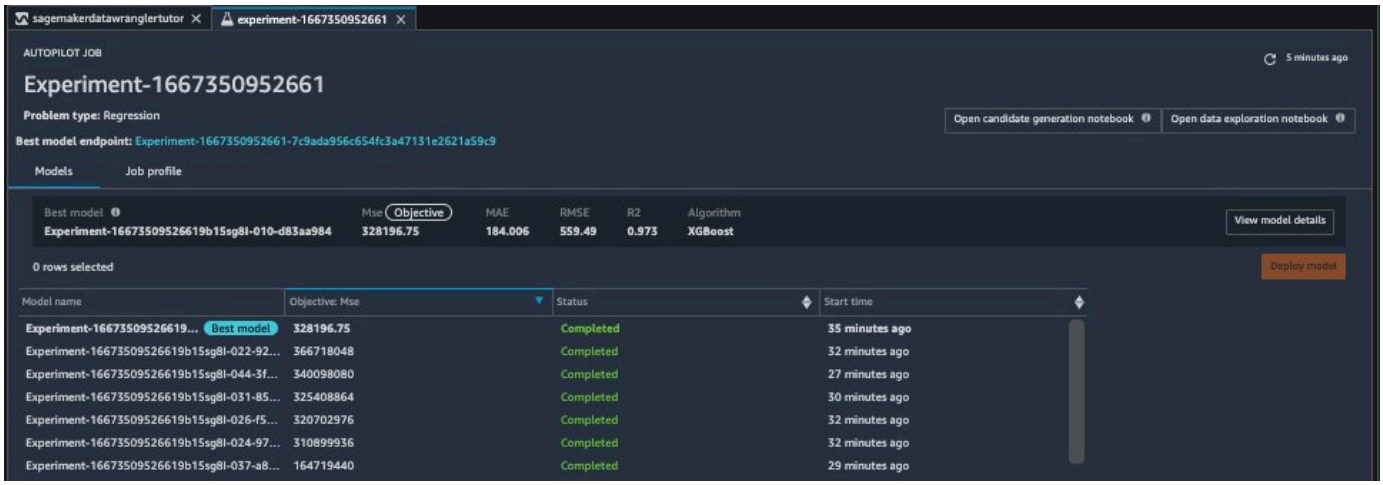
   Specify the Autopilot **Training method**. You can choose Ensembling, Hyperparameter Optimization, or Auto. For the purposes of this tutorial, choose **Auto**.

   For **Deployment**, select the machine learning problem type as **Regression** with the object metric as **MSE**.

   Confirm the Autopilot Experiment deployment settings and then choose **Create experiment**.

This action launches a SageMaker AI Autopilot job that inspects the input data, generates and evaluates multiple ML models, and then selects the best model for subsequent deployment according to the desired performance metric (such as MSE in this tutorial).

The Autopilot job may take several minutes to run and complete. Autopilot provides full visibility into how the models were selected, trained, and tuned through a visual leaderboard and programmatic APIs. Finally, Autopilot explains how models make predictions using feature attribution and explainability statistics using SageMaker AI Clarify.

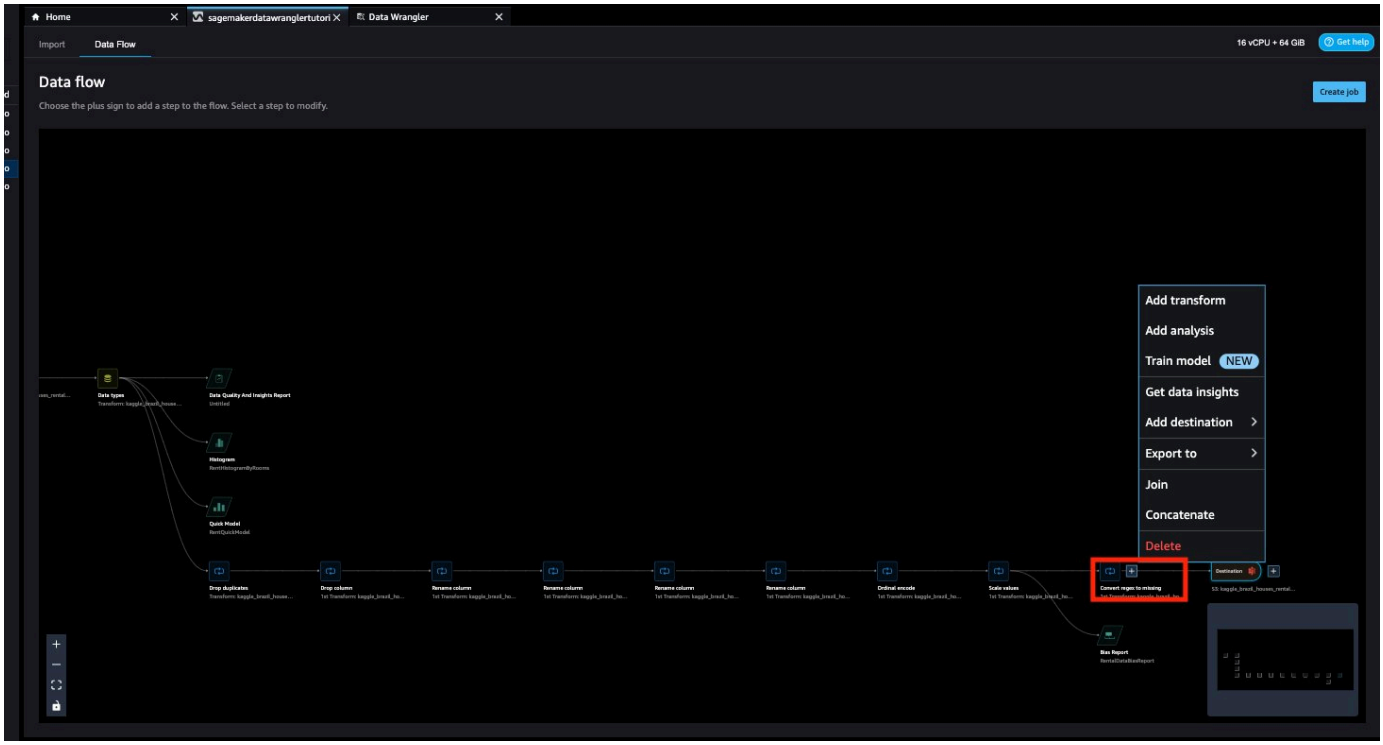


Step 9: SageMaker AI Pipeline integration

Data Wrangler can also be integrated with SageMaker AI Inference Pipelines to process data at the time of inference, thereby streamlining the steps between data processing and model inference. When you export one or more steps from the data flow to an inference endpoint, Data Wrangler creates a Jupyter notebook that you can use to define, instantiate, customize, run, and manage the inference pipeline.

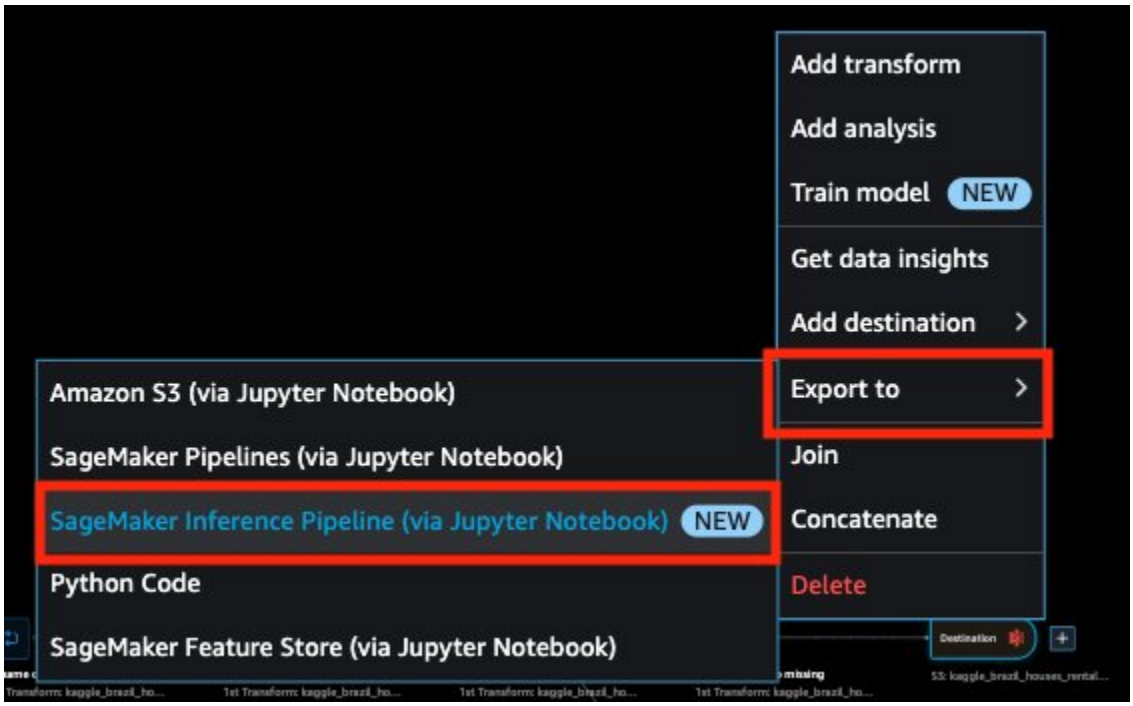
1. Create an inference endpoint

   To create the inference endpoint, choose the **+** next to the final transformation step (Convert regex to missing) and choose **Export to**, and then choose **SageMaker AI Inference Pipeline (via Jupyter Notebook)**. Then inspect and run that Jupyter notebook.



2. (Optional) Export your data flow

   You can optionally export your Data Wrangler data flow to a Jupyter notebook to run the flow steps as a SageMaker AI Processing job.



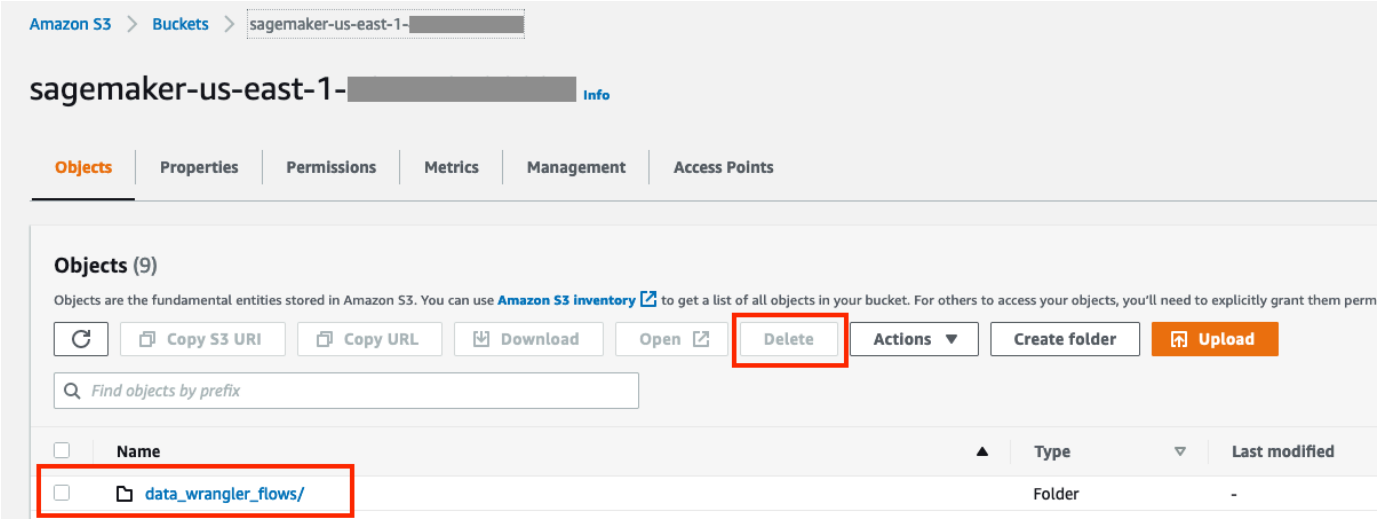
Clean up resources

It is a best practice to delete resources that you are no longer using so that you don't incur unintended charges.

1. Empty and delete S3 bucket

   To delete the S3 bucket, do the following:

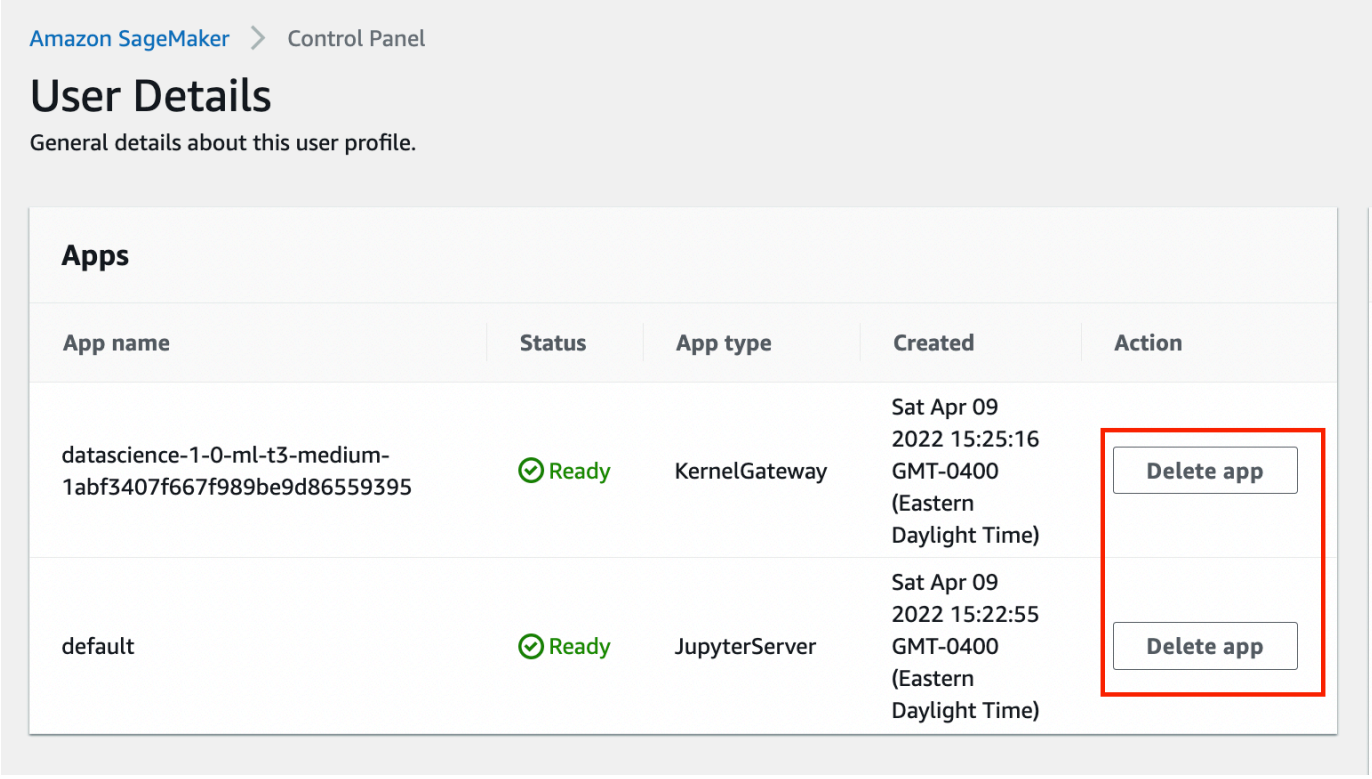
   - Open the Amazon S3 console. On the navigation bar, choose **Buckets**, **sagemaker-<your-Region>-<your-account-id>**, and then select the checkbox next to **data_wrangler_flows**. Then, choose **Delete**.
   - In the **Delete objects** dialog box, verify that you have selected the proper object to delete and enter **permanently delete** into the **Permanently delete objects** confirmation box.
   - Once this is complete and the bucket is empty, you can delete the **sagemaker-<your-Region>-<your-account-id>** bucket by following the same procedure again.



2. Delete Studio apps

   The Data Science kernel used for running the notebook image in this tutorial will accumulate charges until you either stop the kernel or perform the following steps to delete the apps. For more information, see Shut Down Resources in the **Amazon SageMaker AI Developer Guide**.

   To delete the SageMaker AI Studio apps, do the following: On the SageMaker AI Studio console, choose **studio-user**, and then delete all the apps listed under **Apps** by choosing **Delete app**. Wait until the **Status** changes to **Deleted**.

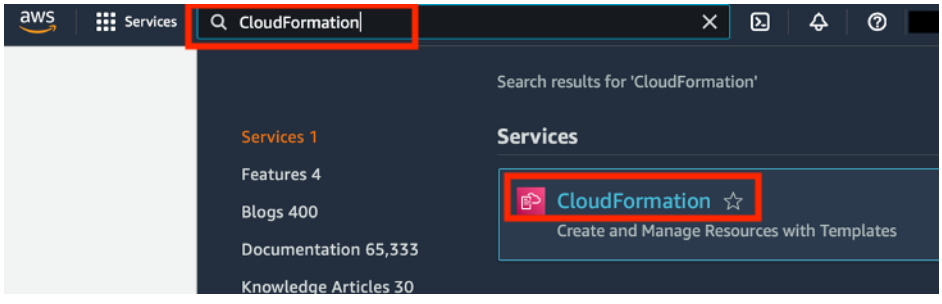


Delete the Studio domain

- If you used an existing SageMaker AI Studio domain, proceed directly to the conclusion section.
- If you ran the CloudFormation template to create a new SageMaker AI Studio domain, continue with the following steps to delete the domain, user, and the resources created by the CloudFormation template.

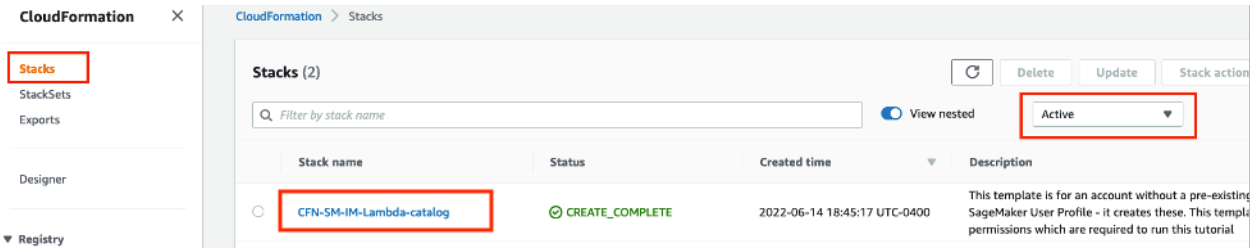
1. Open CloudFormation

   To open the CloudFormation console, enter **CloudFormation** into the AWS console search bar, and choose **CloudFormation** from the search results.



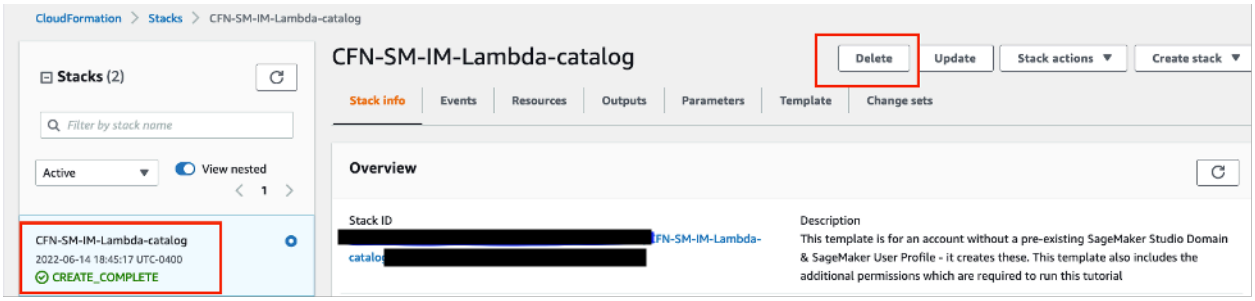
2. Choose the stack

In the **CloudFormation** pane, choose **Stacks**. From the status dropdown list, select **Active**. Under **Stack name**, choose **CFN-SM-IM-Lambda-catalog** to open the stack details page.



3. Delete the stack

   On the **CFN-SM-IM-Lambda-catalog** stack details page, choose **Delete** to delete the stack along with the resources it created.



Conclusion

Congratulations! You have completed the **Prepare Training Data for Machine Learning with Minimal Code** tutorial.

You have successfully used Amazon SageMaker AI Data Wrangler to prepare data for training a machine learning model. SageMaker AI Data Wrangler offers 300+ preconfigured data transformations, such as convert column type, one-hot encoding, impute missing data with mean or median, re-scale columns, and date/time embeddings, so you can transform your data into formats that can be effectively used for models without writing a single line of code.