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Member-only story

**Explaining quality of Arabica coffee beans with Machine Learning**

SHAP values of country, processing method, and other factors

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In this article, I study the factors staying behind the quality of Arabica coffee beans. For this analysis, I used [the dataset available on Kaggle](https://www.kaggle.com/datasets/ankurchavda/coffee-beans-reviews-by-coffee-quality-institute) which contains data on coffee beans reviewed by [Coffee Quality Institute](https://www.coffeeinstitute.org/) and **scored by 10 different criteria:**

* **Aroma**;
* **Flavour**;
* **Aftertaste**;
* **Acidity**;
* **Body**;
* **Balance**;
* **Uniformity**;
* **Clean Cup**;
* **Sweetness**;
* **Cupper Points**.

The individual scores are between 0 and 10 (the higher the better), thus the total score varies from 0 to 100. Full details of the analysis can be found [in this public Kaggle notebook](https://www.kaggle.com/code/dima806/coffee-quality-explain).



Photo by [Mike Kenneally](https://unsplash.com/@asthetik?utm_source=unsplash&utm_medium=referral&utm_content=creditCopyText) on [Unsplash](https://unsplash.com/s/photos/coffee-cup?utm_source=unsplash&utm_medium=referral&utm_content=creditCopyText" \t "_blank)

**Step 1 — data preprocessing**

Here, data preprocessing consists of the following steps:

* dropping reviews without final scores;
* selecting reviews from countries that have at least 10 records in the dataset;
* rescaling mean altitudes to meters;
* replacing null values;
* finally, removing unused columns.

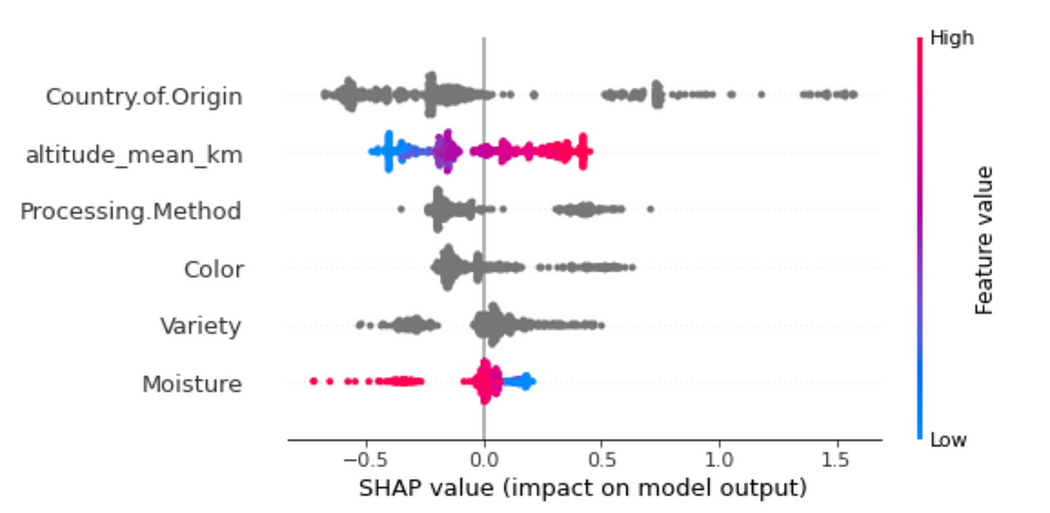
**Step 2 — setting a Machine Learning model to predict the total review scores**

The data prepared with the previous step are randomly split between training and test samples, and modelled with the [CatBoostRegressor](https://catboost.ai/en/docs/concepts/python-reference_catboostregressor" \t "_blank) model that explicitly takes into account categorical features. The [root mean squared error](https://scikit-learn.org/stable/modules/generated/sklearn.metrics.mean_squared_error.html) (RMSE) of the resulting model is **about 4.24 points**, an **improvement compared to the baseline model RMSE of about 4.38 points**(assuming the same **score of about 82.1**for **every** review).

**Step 3 — explanation of the obtained Machine Learning model**

Here, we are using the [SHapley Additive exPlanations (SHAP)](https://shap-lrjball.readthedocs.io/en/latest/index.html" \t "_blank) method, one of the most common to explore the explainability of Machine Learning models. The units of SHAP value are hence in **percentage points**.

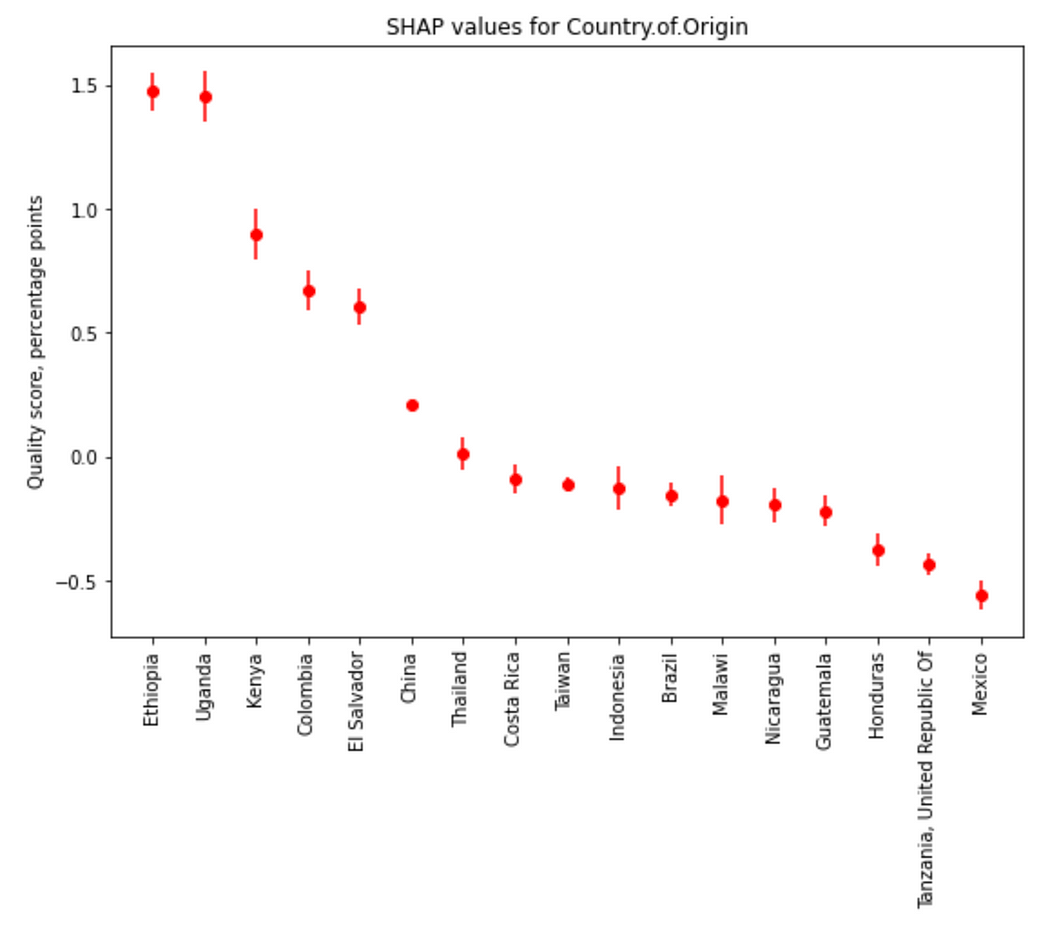
First, we look into the span of SHAP values for every feature of our interest:



Source: author, [coffee\_quality\_explain | Kaggle](https://www.kaggle.com/code/dima806/coffee-quality-explain" \t "_blank)

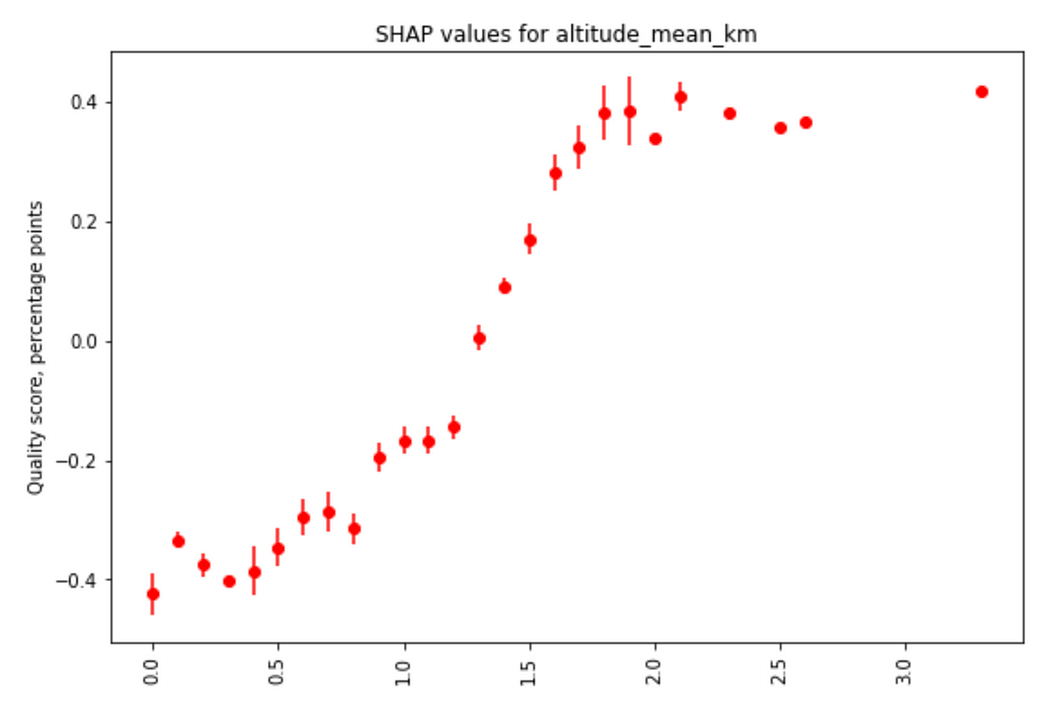
*As we see, the most important features for our model are the****country of origin****,****mean altitude****, and****processing method****.*

First, looking for countries of origin, we see that the best quality coffee beans (on average) come from **Ethiopia**, **Uganda**, and **Kenya, with 1–1.5 percentage points better than average reviews**:



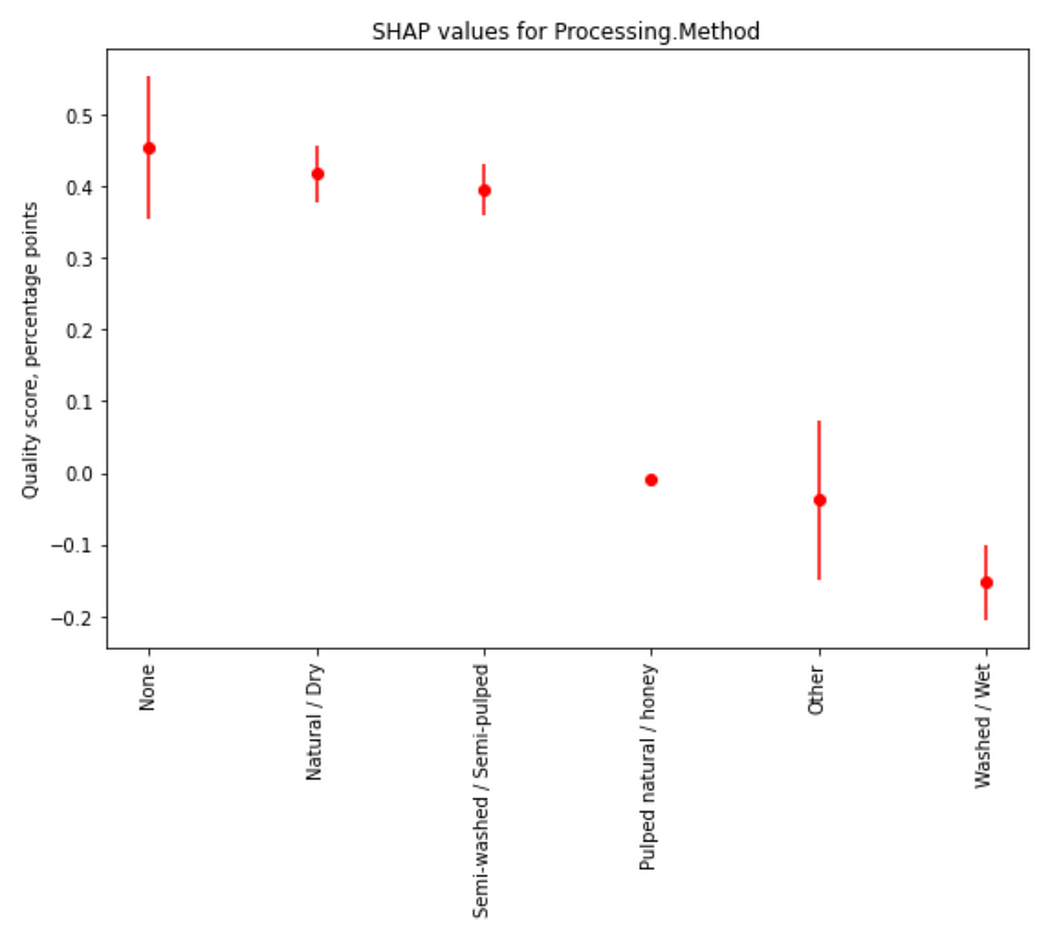
Source: author, [coffee\_quality\_explain | Kaggle](https://www.kaggle.com/code/dima806/coffee-quality-explain" \t "_blank)

*Remarkably, the****best quality coffee beans are grown at altitudes starting from approximately 1.9 kilometres****:*



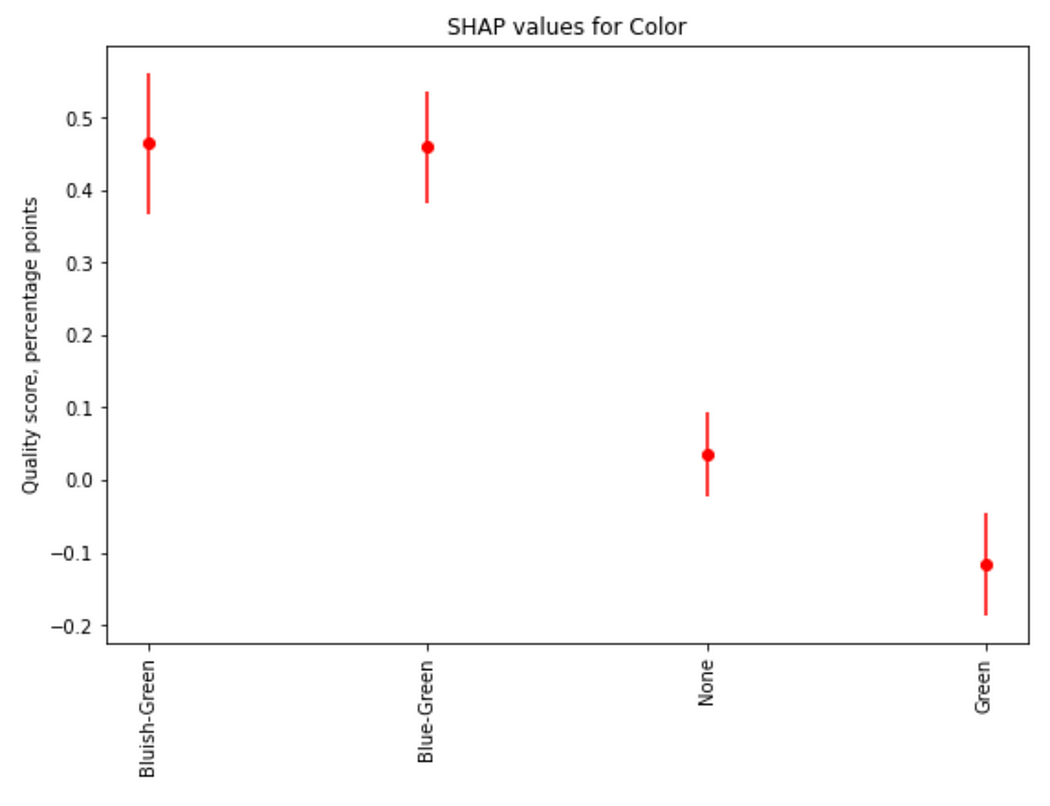
Source: author, [coffee\_quality\_explain | Kaggle](https://www.kaggle.com/code/dima806/coffee-quality-explain" \t "_blank)

Interestingly, according to these reviews, the **best processing methods for coffee beans are**[**Natural / Dry**](https://www.movingbeans.com/blogs/news/what-is-the-natural-dry-process)**and**[**Semi-washed / Semi-pulped**](https://k-agriculture.com/semi-washed-coffee/):



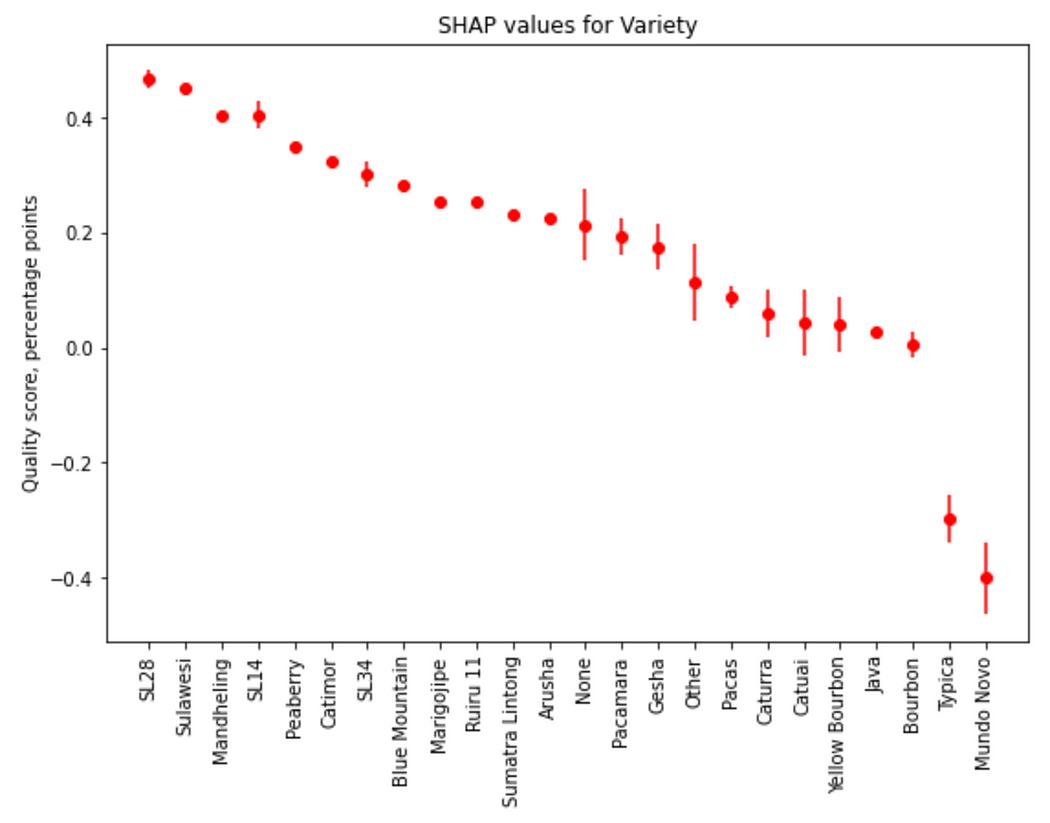
Source: author, [coffee\_quality\_explain | Kaggle](https://www.kaggle.com/code/dima806/coffee-quality-explain" \t "_blank)

while the preferred bean colours are **Bluish-Green** and **Blue-Green**:



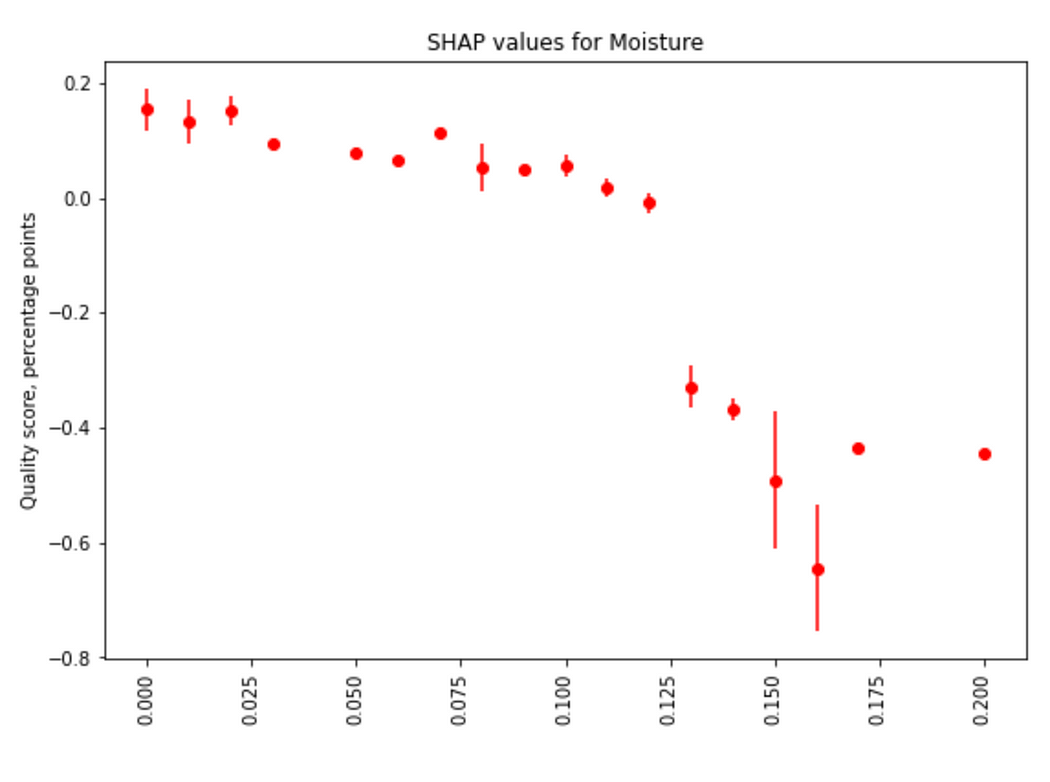
Source: author, [coffee\_quality\_explain | Kaggle](https://www.kaggle.com/code/dima806/coffee-quality-explain" \t "_blank)

The highest scores are assigned to coffee beans varieties [SL28](https://varieties.worldcoffeeresearch.org/varieties/sl28), [Sulawesi](https://coffeefactories.com/sulawesi-coffee/), and [Mandheling](https://espressocoffeeguide.com/gourmet-coffee/asian-indonesian-and-pacific-coffees/indonesia-coffee/sumatra-coffee/sumatra-mandheling-coffee/):



Source: author, [coffee\_quality\_explain | Kaggle](https://www.kaggle.com/code/dima806/coffee-quality-explain" \t "_blank)

Finally, beans with **small and moderate moisture** have the highest average quality scores:

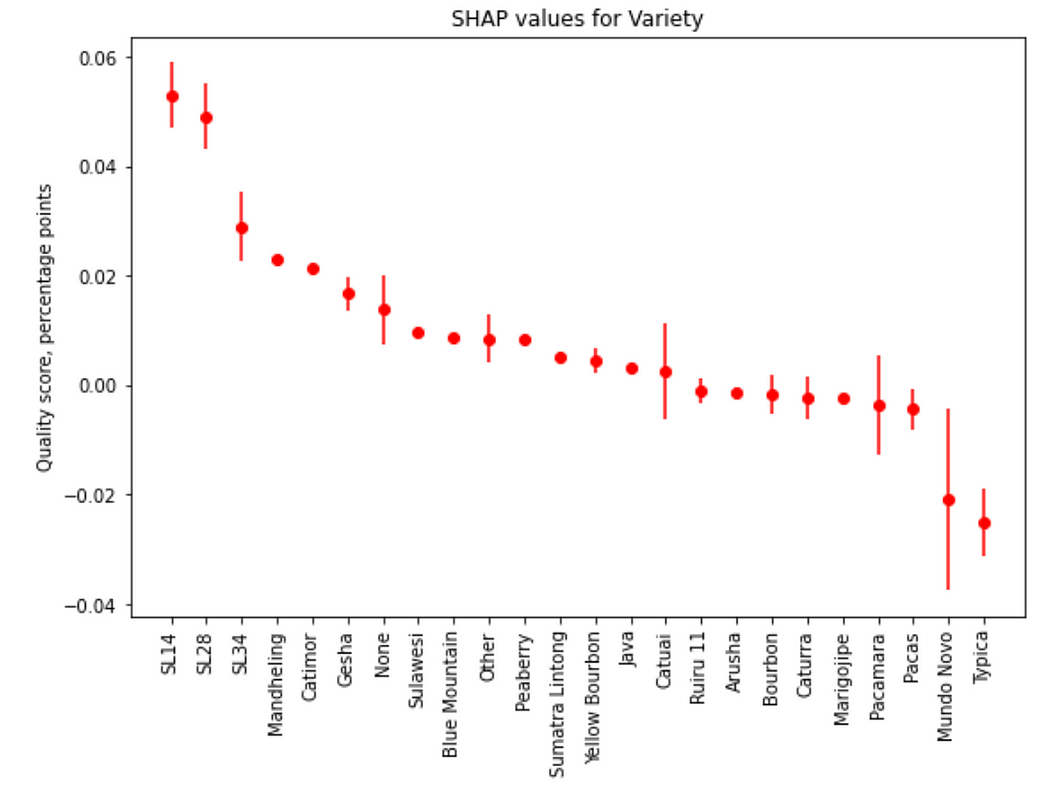


Source: author, [coffee\_quality\_explain | Kaggle](https://www.kaggle.com/code/dima806/coffee-quality-explain" \t "_blank)

**Step 4— modelling of individual scores and their explanations in terms of SHAP values**

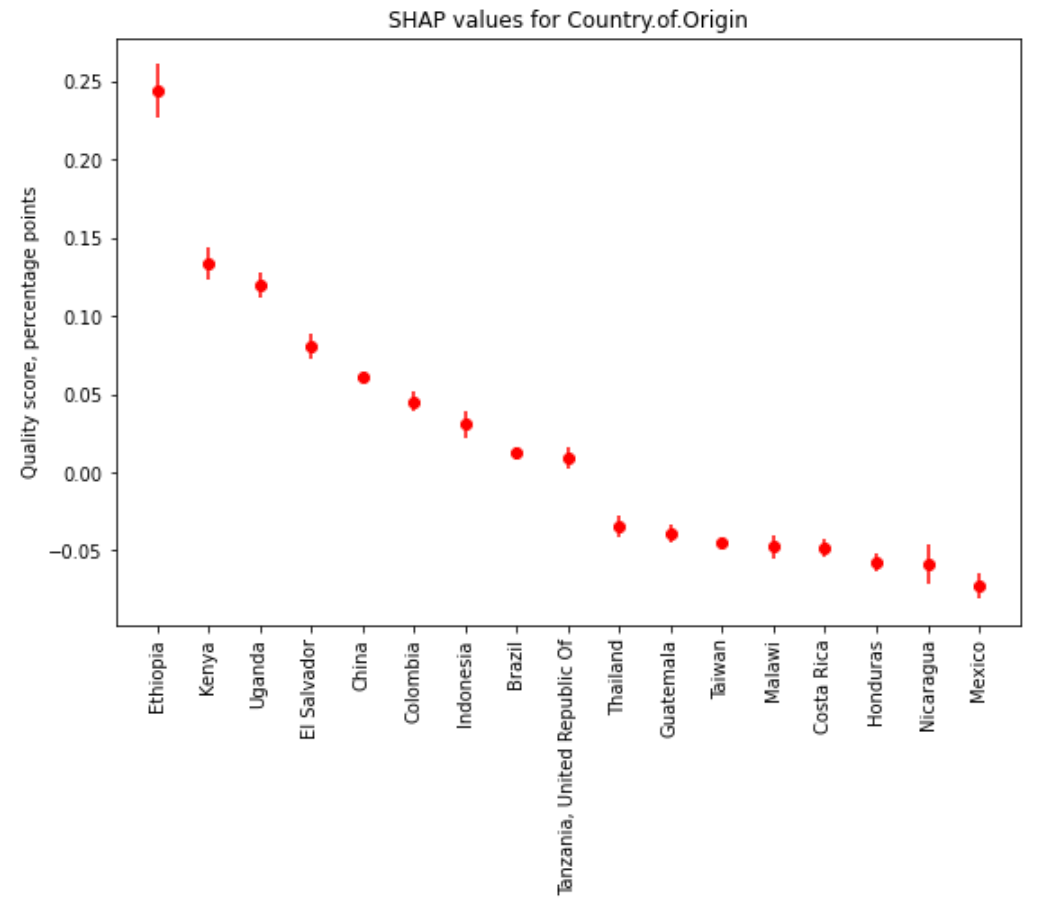
Here, I present only the most remarkable differences of individual scores modelling from the behaviour of combined scores. Full details can be found in [a public notebook on Kaggle](https://www.kaggle.com/code/dima806/coffee-quality-explain).

For the **Aroma** score, the **top scored variety is**[**SL14**](https://varieties.worldcoffeeresearch.org/varieties/sl14)**followed by**[**SL28**](https://varieties.worldcoffeeresearch.org/varieties/sl28)**and**[**SL34**](https://varieties.worldcoffeeresearch.org/varieties/sl34):



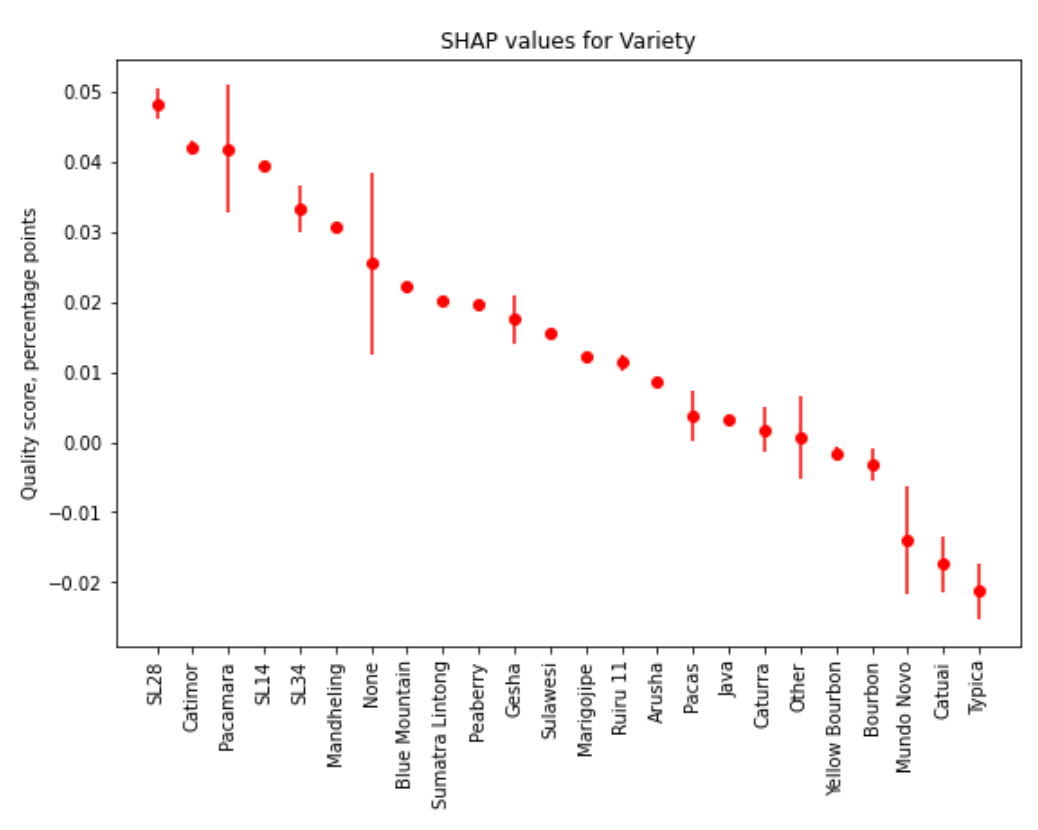
Source: author, [coffee\_quality\_explain | Kaggle](https://www.kaggle.com/code/dima806/coffee-quality-explain" \t "_blank)

Among countries with the best **Flavour** score, **Ethiopian coffee beans are well ahead, followed by beans from Kenya and Uganda**:



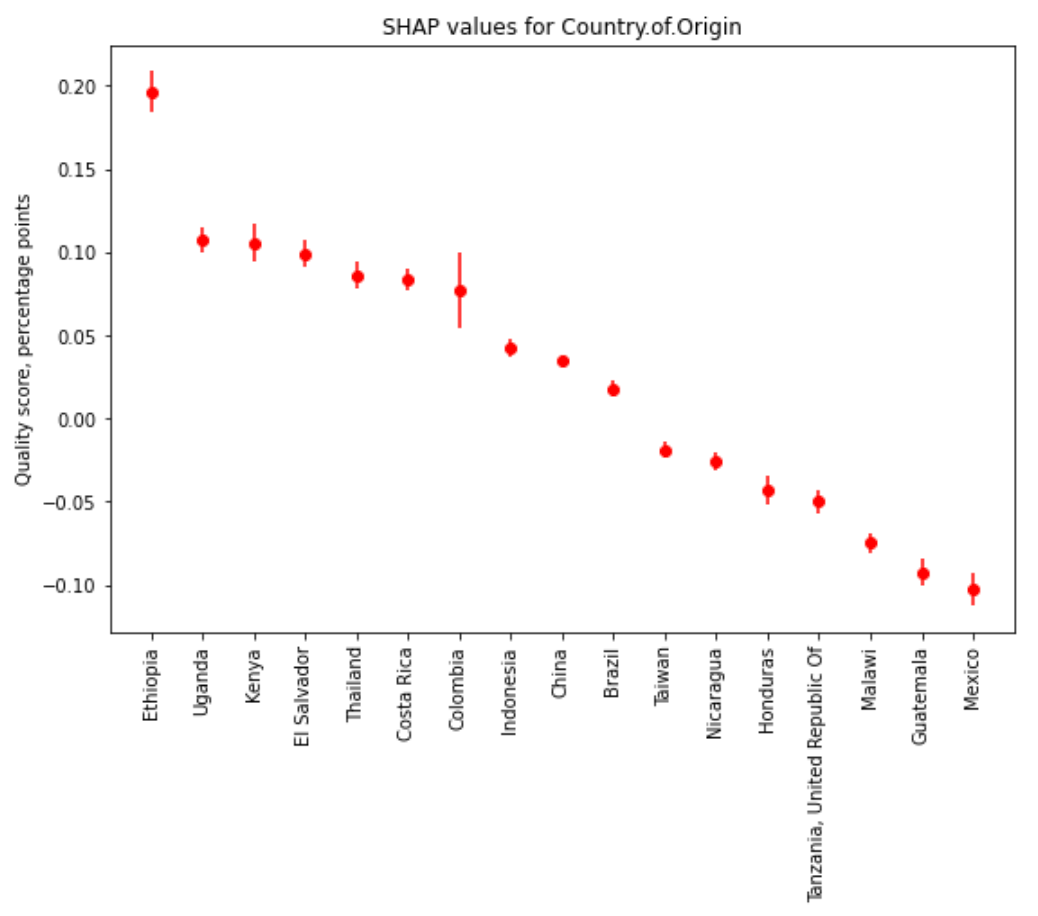
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and the top-3 varieties for **Flavour are**[**SL28**](https://varieties.worldcoffeeresearch.org/varieties/sl28)**, [Catimor](https://varieties.worldcoffeeresearch.org/varieties/catimor-129" \t "_blank), and [Pacamara](https://varieties.worldcoffeeresearch.org/varieties/pacamara" \t "_blank)**:



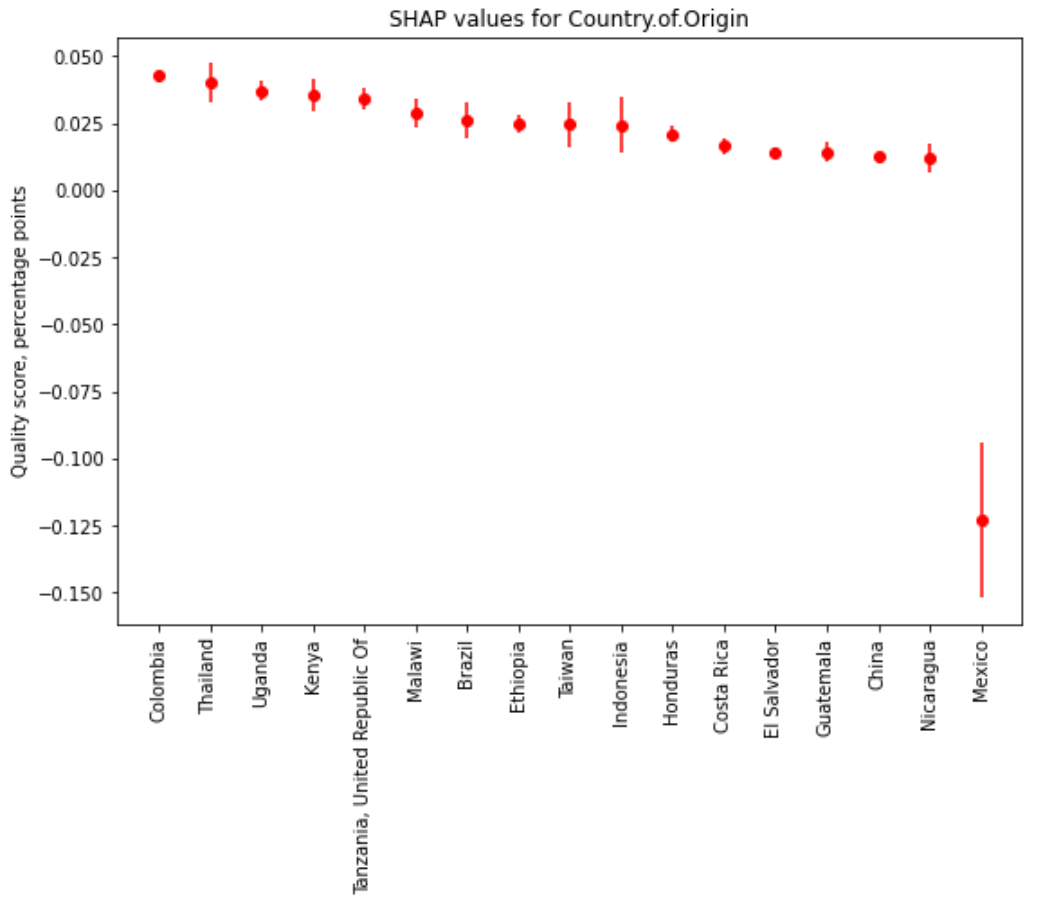
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In terms of **Aftertaste**, **Ethiopian coffee beans are also scored well ahead of the beans from other countries, followed by beans from Uganda and Kenya**:



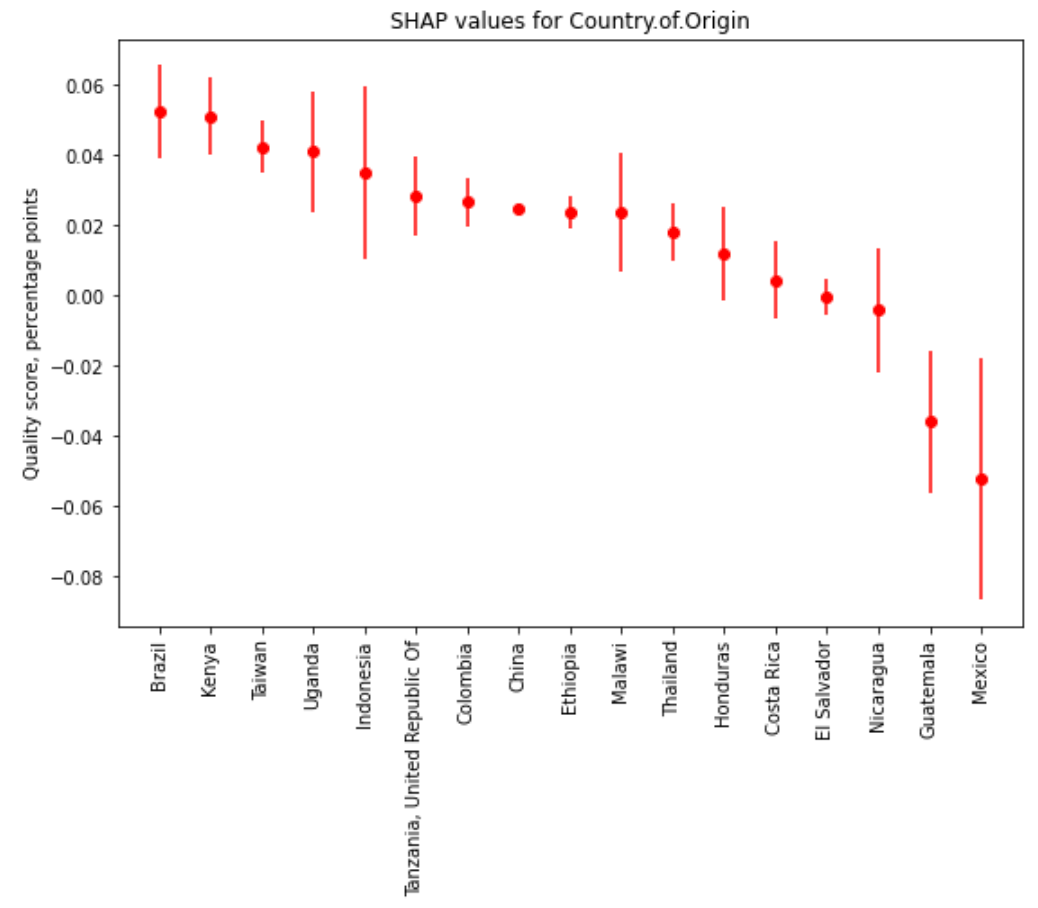
Source: author, [coffee\_quality\_explain | Kaggle](https://www.kaggle.com/code/dima806/coffee-quality-explain" \t "_blank)

In terms of **Uniformity**, **coffee beans from Mexico have score well below beans from other countries**:



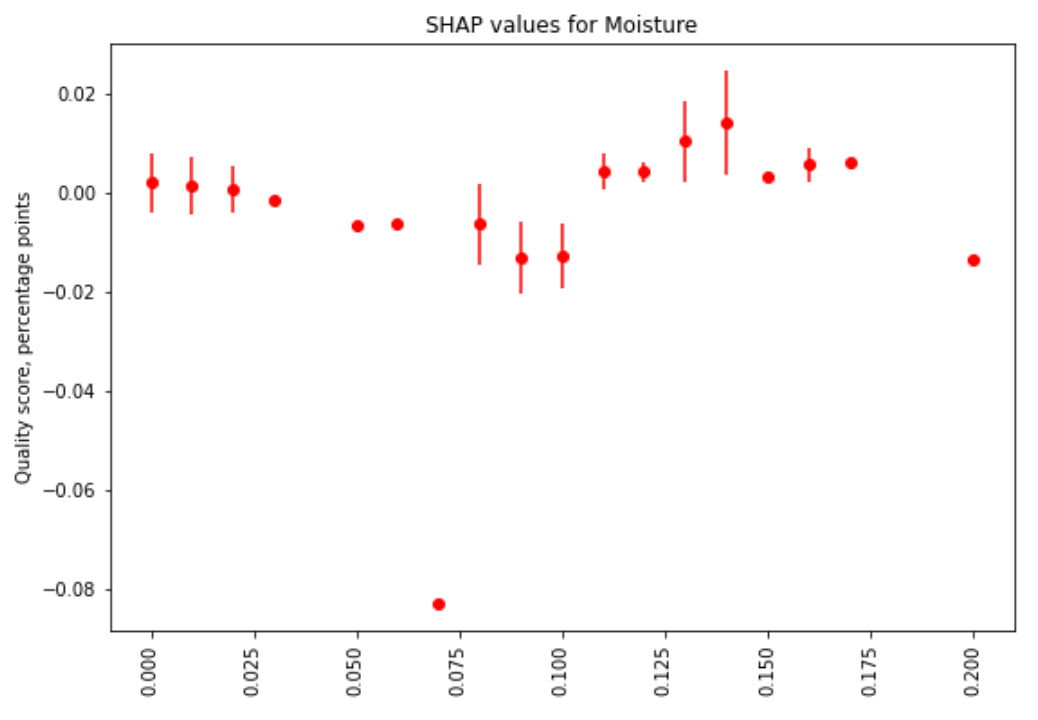
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In terms of **Clean Cup** score, **the highest scores on average received coffee beans from Brazil, Kenya and Taiwan**:



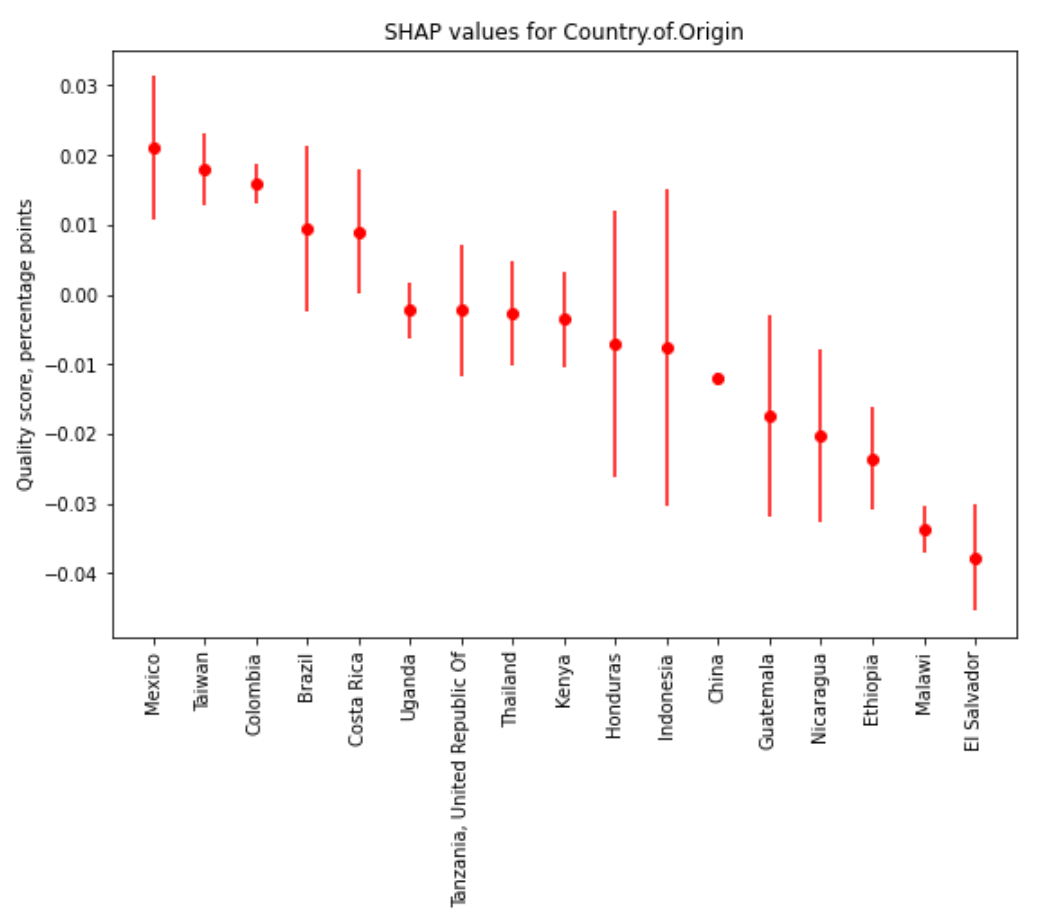
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and **there is almost no trend of Clean Cup score on moisture**:



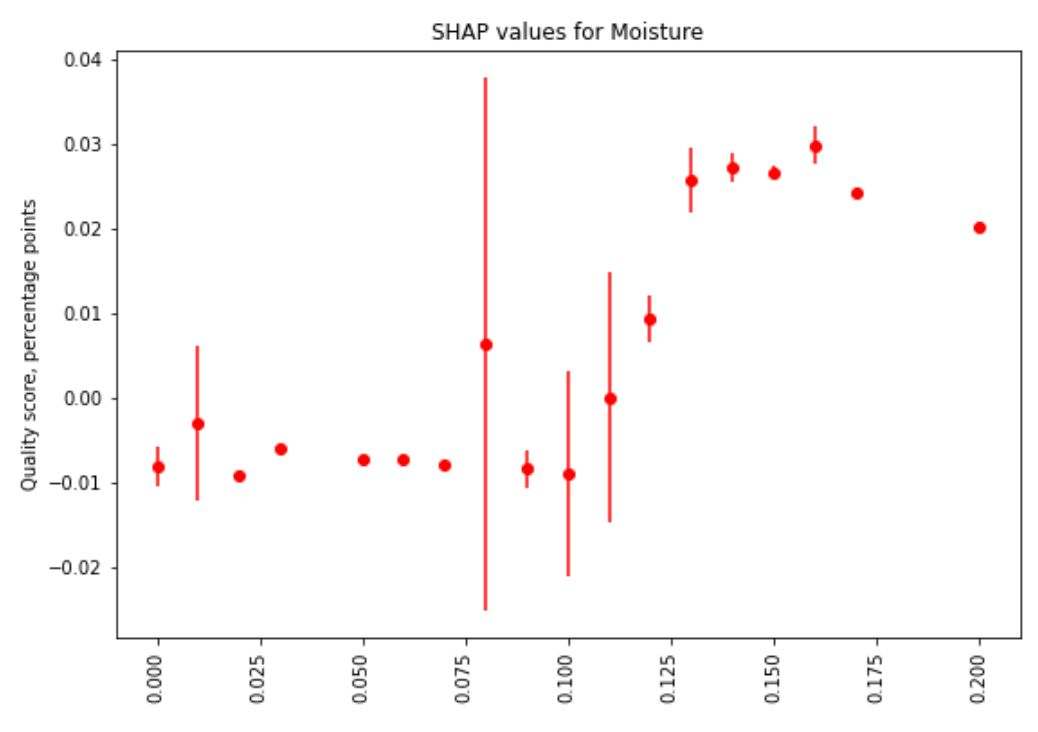
Source: author, [coffee\_quality\_explain | Kaggle](https://www.kaggle.com/code/dima806/coffee-quality-explain" \t "_blank)

Also, coffee beans with the largest **Sweetness** score **come from Mexico, Taiwan, and Colombia**:



Source: author, [coffee\_quality\_explain | Kaggle](https://www.kaggle.com/code/dima806/coffee-quality-explain" \t "_blank)

while beans with **higher moisture have received higher Sweetness scores**:



Source: author, [coffee\_quality\_explain | Kaggle](https://www.kaggle.com/code/dima806/coffee-quality-explain" \t "_blank)

I hope these results can be useful for you. In case of questions/comments, do not **hesitate to write in the comments below** or **reach me directly** through [LinkedIn](https://www.linkedin.com/in/dima806/) or [Twitter](https://twitter.com/dima806_dima).

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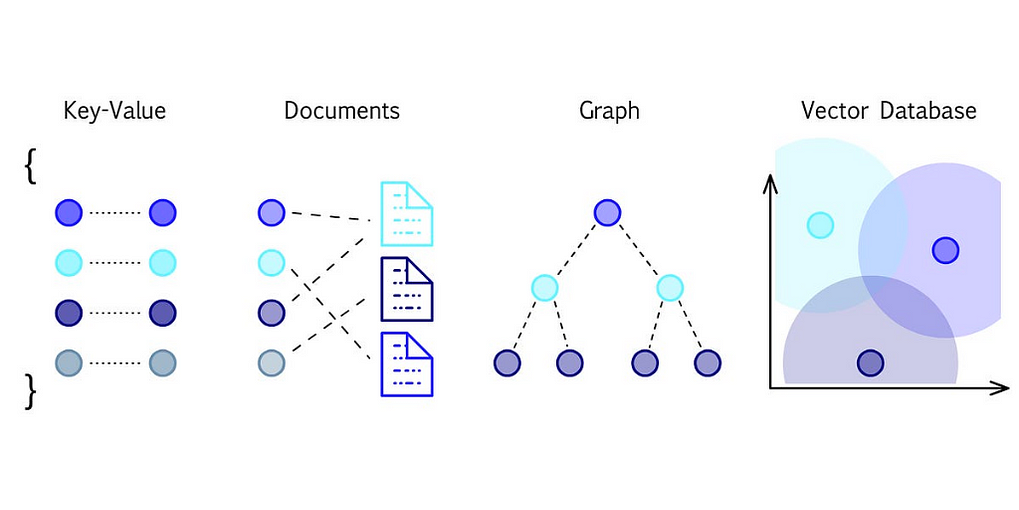
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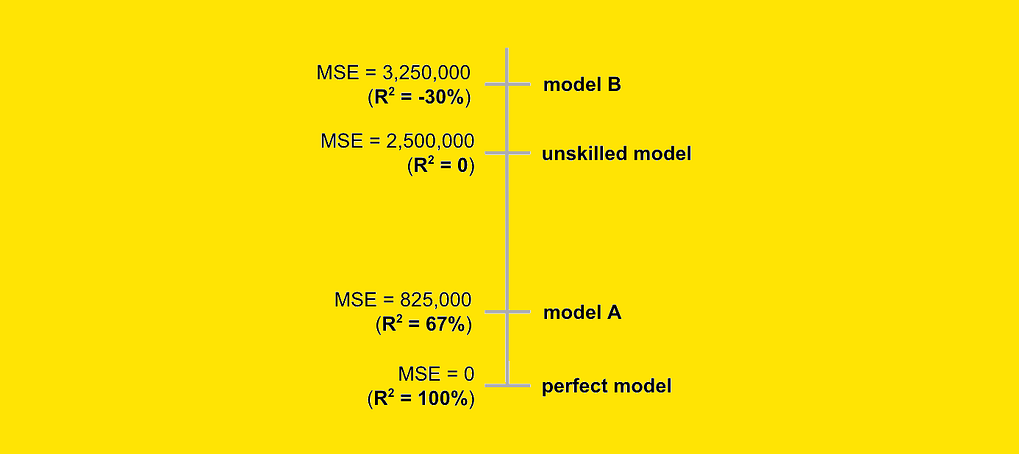
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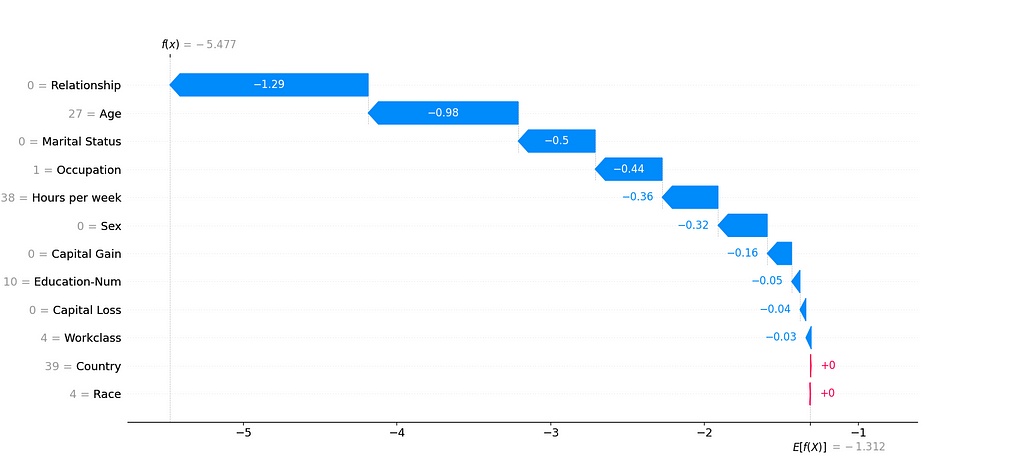
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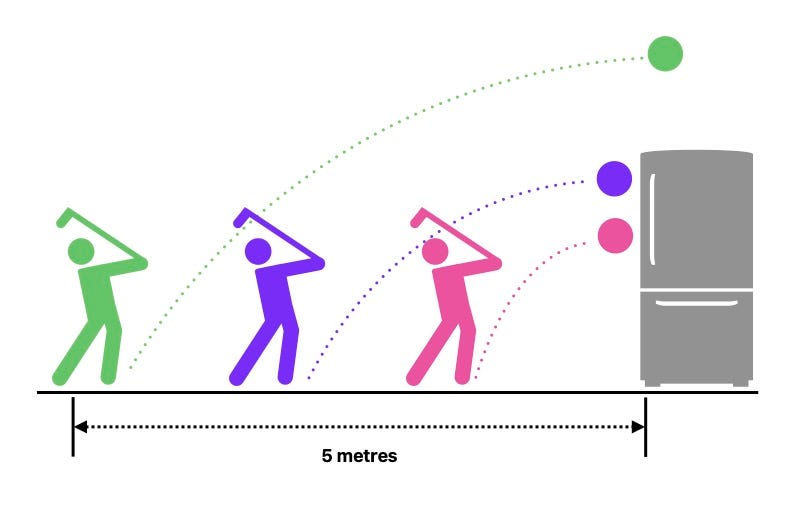
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