Econ 398 – Directed Study

Analysis on coffee production, retail price, and weather variables

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Abstract

Coffee is one of the major productions in most developing countries located in equatorial regions of the world, and the production and quality of coffee is sensitive to changes in the weather. Additionally, fluctuations in coffee production indirectly impact coffee price in importing countries. In this report, we emphasize the relationship between weather variables and total coffee production in producing countries. Furthermore, we extend our analysis to estimate retail price in importing countries and the weather in Brazil. We organize panel data and implement linear regression models with fixed effects to examine the relationships between weather variables and coffee retail price and the total coffee production. We find that precipitation during the non-harvest season and maximum temperature during the harvest season have significant effects on total coffee production. The result also demonstrates a significant relationship between Brazil's weather and retail coffee price.

1. Introduction

Coffee is considered one of the most important commodities in the world in which almost 125 million people rely on producing or selling coffee for a living (Osorio, 2002) and with more than 50 countries producing and exporting coffee(Lewin et al., 2004; NCA, 2017). Fluctuations in the coffee market could result in a prodigious impact in the economy, especially in developing countries.

Coffee production is sensitive to changes in the weather. Already, climate changes due to global warming have raised concerns over commodity production. Early work by Bunn et al. (2005) examined the suitability in growing coffee to suggest policies that guide adaptation planning in response to climate changes. Particularly, Sachs et al. (2015) indicated coffee plant requires high level of humidity during the flowering season; moreover, weather during flowering has significant impact on the coffee production. Conversely, many exogenous factors such as policies, evolving technologies, market drivers and international trade agreements can also influence coffee production (Sachs et al., 2015).

Although, there are more than 50 countries producing coffee in the world, the top five coffee producing countries dominate 67% of the total production (Fig. 1, Fig. 2). Any fluctuations in the top 5 producing countries could lead to major shifts in the coffee market. On one hand, coffee production has an indirect influence on the coffee price because of its low supply elasticities (Ponte, 2002). Ponte (2002) suggests the reason is mainly that coffee farms take more than two years for new trees to reach their full production levels. Consequently, a shortage in coffee production results in high coffee price without any significant reduction in consumption. On the other hand, collapses of the international trade agreement and changes in international trade regimes can result in a decline of coffee price to growers which had happened in the 1990s (Igami, 2015; Ponte, 2002).

Igami (2015) suggests that the International Coffee Agreement (ICA, 1965-1989) raised the coffee price by 75% above the Cournot-competitive level but it dropped by 80 percent after its collapse in 1989. Ponte (2002) examines the changes in regulations and international coffee agreements and provides policies to address the imbalance in developing countries. Vietnam's coffee production has increased since the collapse of the ICA and was the second largest coffee producing country in 2000 (Ponte, 2002). The increased production in Vietnam has visible effects on coffee bean price (Igami, 2015).

Price volatility could be associated with many factors, for instance, fluctuations in supply and demand or shocks in the financial market. Price volatility could be problematic in the commodity market because it is usually unpredictable (Lewin et al. 2004). As a result, it creates difficulties for governments when creating policies in response to changes in price. Lewin et al. (2004) indicate that coffee price volatility is mainly because of weather shocks in Brazil and has long-term effects on livelihoods.

This report aims at estimating the coffee production from global weather variables with empirical models. Furthermore, this report addresses the impact of Brazilian weather variables on the coffee retail prices in importing countries. We combine our understanding from the estimation of coffee production with previous analysis on the global coffee market to estimate retail coffee price.

Overall, the weather variables such as maximum temperature, minimum temperature, precipitation, and humidity have direct influences on coffee including its quality, production, and prices. We use an empirical econometric model that includes precipitation, average temperature, maximum temperature, and minimum temperature to estimate the total annual coffee production. We find that the precipitation during the non-harvest season has a significant effect on coffee production and the maximum temperature during the harvest season significantly affect the production. The retail price model also shows a statistically significant relationship between Brazilian weather and retail price in importing countries.

The rest of the report is organized as follows. Section 2 provides information on data. Econometric methods are illustrated in Section 3, while the estimations and discussion are presented in Section 4. The conclusion is in Section 5.

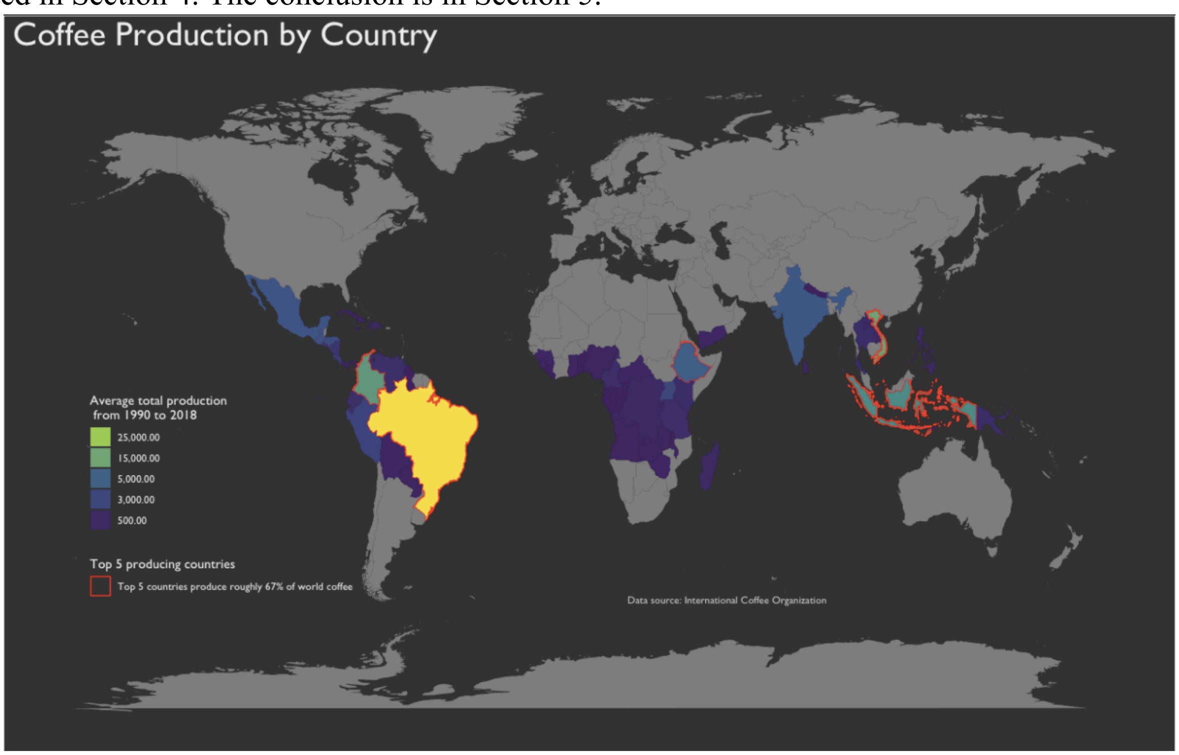

Fig 1. Geography of world coffee production countries

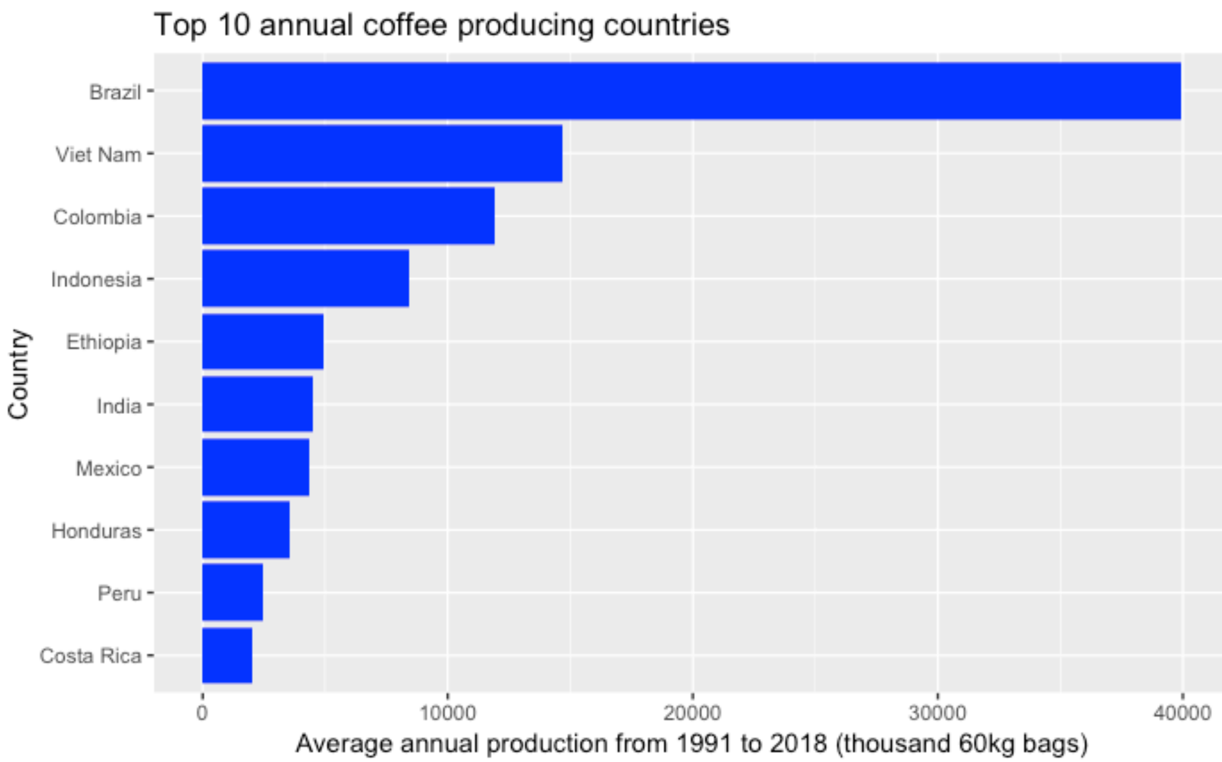

Fig 2. Top 10 average annual total coffee producing countries

2. Data description

The total productions of coffee are obtained from the International Coffee Organization (ICO, 2019). The data contains total productions of coffee from 56 different countries. The total productions of coffee are recorded in thousands of 60 kg bags for each year from1990/1991 to 2018/2019. Moreover, the coffee data includes coffee varieties produced by the country. The retail price of coffee is obtained from the ICO website which includes the retail price for roasted coffee across 29 importing countries (ICO, 2019). The retail price is adjusted to a US base price in 2000.

The weather data is extracted from an integrated database on the National Oceanic and Atmospheric Administration (NAOO, 2019). The integrated database includes Global Historical Climatology Network-Daily (GHCN-Daily) which summaries daily climate from land surface stations across the globe. The GHCN-Daily contains observations from over 100,000 stations for over 100 years. However, the record length and period of record differ by stations. The GHCN-Daily includes various weather variables such as minimum temperature, average temperature, and precipitation. For estimation purposes, we organized a panel data that combined both coffee data and weather data. GHCN data contains many stations from different countries. Only the weather stations that matched the coffee producing countries are extracted from the GHCN database.

The elevation of a coffee farm influences the coffee quality and production (Tolessa et al, 2016). Selecting reasonable elevation ranges corresponding to different coffee variety produced in the country is critical in predicting the coffee production. As a result, we filtered stations based on the range of elevation corresponding to its country's coffee variety. For instance, Colombia produces Arabica coffee beans which are mostly found at an elevation between 600 m to 2050 m (Bourke et al. 1984). After filtering the weather stations within these elevations, only 42 countries remain in our dataset. Furthermore, our report focuses on the following weather variables: precipitation, maximum temperature, minimum temperature and average temperature. The original data from GHCN contains a daily value for each of the weather variables. We arrange across days to obtain monthly values.

In respect to the retail price, we converted retail prices to USD in 2000. A different panel data is organized that contains retail prices from 29 countries and the weather variables in Brazil. The weather variables are organized the same way as in the coffee production data. The summary statistics are included in the table 5 and 6 in the Appendix.

3. Methodology

3.1 Coffee production

Based on information indicated in previous studies that the production of coffee is highly dependent on the climate conditions (Decasy et al., 2003). Additionally, adequate pollination during the flowering season could increase coffee yields (Ricketts et al., 2004). We separate explanatory weather variables into two categories, harvest and non-harvest season according to the country's harvest season in table 2 in the Appendix.

We have constructed a panel data set that tracks coffee production and weather over time for 42 producing countries. The panel data structure allows us to isolate the effect of changes in weather conditions on production controlling for any time-invariant country-specific factors (e.g. different farming techniques and baseline productivity across producer countries) along with global shocks affecting coffee production (e.g. the Great Recession of 2008). By including country and year fixed effects, our parameters of interest are identified from variation in weather conditions within countries over time. This is important since average weather conditions differ across countries and could be correlated with coffee production. For example, a naive cross-sectional comparison (a regression without fixed effects) could erroneously conclude that larger amounts of precipitation are associated with increased coffee productivity solely because we see higher rainfall in Brazil and Brazil happens to be the largest coffee producing country.

We estimate the relation between total coffee production and weather variables prior to the end of harvest season. To examine total coffee production, we employ a linear regression model with fixed effects for countries and years. The general equation is:

$$Y_{it} = \beta_1 X_{1,it} + \cdots + \beta_k X_{k,it} + \alpha_i + \tau_t + \epsilon_{it} \qquad (1)$$

Our dependent variable, Y_{it}, measures total production in Logarithm form because we would like to interpret the percent change in total production from a unit change in exploratory variables. In equation 1, i indicates producing country and t indicates year. The α_i is the intercept of producing country and τ_t is the intercept of year. ϵ_{it} is the error term. X_k is the weather variables prior to the end of harvest season. The weather variables are monthly averages for each month prior to the end of harvest season in a country. The model in this report includes following variables: precipitation, average temperature, minimum temperature, maximum temperature (the variables are the monthly mean value in each country).

In order to examine the robustness of the equation, various regression models were run by varying the weather variables to understand the significance of the equation. The regression models that we tested on include: temperature difference (maximum temperature minus minimum temperature), temperature anomaly and modifications to rainy and non-rainy season. The temperature anomaly is derived as the departure of an observed value from a reference value; the reference value is the average temperature over the past 30 years. The results of these regression models are included in the table 4 and 5 in the Appendix.

In general, the current equation provides a better result in terms of explanatory power and statistical significance comparing to models we tested in the table 4 and 5 in the Appendix. It is expected that precipitation around the flowering season has an impact on fruit set process and hence the total coffee production (Damatta et al., 2007). Unsurprisingly, from regression result, precipitation during the non-harvest season has a significantly positive effect on total coffee production.

3.2 Retail price

Given the connection between weather variables and total annual coffee production, by extension, weather variables should also have an impact on retail price in each country. Negative production shocks should prompt market participants to bid up the retail price of coffee. Academic research has found that weather fluctuations such as ENSO significantly influence global commodity prices(Brunner, 2002; Cleland, 2010; Ubilava 2012).

According to our estimation from equation 1, we obtain a fundamental knowledge of the relationship between weather variables and total production in producing countries. As mentioned by Ponte (2002), coffee production has an indirect effect on coffee price. Therefore, we extend our research to understand if weather variables have an effect on retail price through fluctuations in total coffee production. Brazil is the largest coffee producing country in the past decades and therefore has the largest impact on the coffee market. In addition, coffee price volatility is mainly because of weather shocks in Brazil (Lewin et al. 2004). Consequently, we decide to focus on the effect of Brazilian weather on retail coffee price in importing countries.

We have constructed a panel data set that tracks the retail price and Brazilian weather over time for 29 importing countries for the same reason as indicated in section 3.1. By including importing country fixed effects our parameters of interest are identified from variation in time-invariant condition within importing countries. This is important since time-invariant condition differ across importing countries and could be correlated with the retail coffee price.

In order to examine the impact of Brazilian weather variables on retail price, a linear regression model is employed.The general equation is:

$$Y_i = \beta_1 X_{Brazil,t} + \cdots + \beta_k X_{Brazil,t} + year_t + \alpha_i + \in_i \quad (2)$$

Our dependent variable, Y_i, measures the retail price in Logarithm form because we would like to interpret the percent change in retail coffee price from a unit change in exploratory variables. In equation 2, i indicates importing country. The α_i is the intercept of importing country. $\in_i$ is the error term. $X_{Brazil,t}$ is the weather variables in Brazil in different year, t. The value of weather variables are the same in equation 2 but we focus on Brazil's weather.

4. Estimations and discussions

4.1 Coffee production

Parameter estimation for our regression equation 1 are presented in table 1. For total production, maximum temperature during the harvest season and precipitation during the non-harvest season are statistically significant. Our model explains most of the variations in the response variables.

Average temperature and maximum temperature during the harvest season and average temperature during the non-harvest season have a negative impact on total coffee production. Other variables have positive impact on total coffee production. As a result of relatively high standard error compared to the estimated value, the impact of following variables on total coffee production is unclear: average temperature during the harvest season, maximum temperature and minimum temperature during the non-harvest season.

One degree Celsius increase in maximum temperature during harvest season results in a 7.2% decrease in total coffee production (measured in thousand 60 kg bags). One unit increase in precipitation (measured in mm) during non-harvest season results in a 1.54% increase in total coffee production (measured in thousand 60 kg bags). According to the results in table 1, variables with negative coefficients tend to have a greater impact (magnitude of coefficients) on total coffee production in comparison to positive coefficients.

It is unexpected that the maximum temperature during harvest season would have the largest impact on total coffee production. Usually, coffee fruit process ends when entering harvest season; therefore, fluctuations in the weather have less effect on coffee production. One of the explanations is that the high temperature reduces workers' efficiency. Another possible explanation is that maximum temperature may influence coffee processing. The coffee fruits are processed and dried to be stored before transport. A higher temperature could speed up the drying process. Additionally, the method of coffee process determines the quality and production of coffee.

Overall, our regression model provides an estimation on total coffee production given its high R squared, no significant outliers and the normality of residuals.

Table 1. Regression Result (total production and weather)

	Dependent variable:		
	log(total.prod + 1)		
Country fixed effect	N	Y	Y
Year fixed effect	N	N	Y
Harvest season			
Precipitation	0.007 (0.008)	0.002 (0.002)	0.002 (0.001)
Average temperature	0.356 (0.179)**	-0.041 (0.042)	-0.031 (0.042)
Maximum temperature	-0.613 (0.111)***	-0.083 (0.030)***	-0.072 (0.032)**
Minimum temperature	-0.076 (0.087)	0.032 (0.026)	0.042 (0.026)

Non-harvest season			
Precipitation	-0.036 (0.021)*	0.010 (0.005)*	0.015 (0.004)***
Average temperature	-0.434 (0.197)**	-0.083 (0.050)*	-0.074 (0.050)
Maximum temperature	0.856 (0.142)***	0.010 (0.042)	0.047 (0.044)
Minimum temperature	-0.033 (0.109)	0.026 (0.032)	0.030 (0.031)
Constant	2.658 (1.627)		
Observations	881	881	881
R^2	0.148	0.994	0.995
Adjusted R^2	0.140	0.994	0.994
Residual Std. Error	2.446 (df = 872)	0.494 (df = 833)	0.487 (df = 806)
F Statistic	18.901*** (df = 8; 872)	3,091.116*** (df = 48; 833)	2,041.091*** (df = 75; 806)
Note:			*p<0.1; **p<0.05; ***p<0.01

4.2 Retail price

Parameter estimation for our regression equation 2 are presented in table 2. For equation 2, precipitation, average temperature and maximum temperature during harvest season and precipitation and minimum temperature during non- harvest season are statistically significant. By including importing country fixed effects, we are able to control difference from time-invariant conditions across importing countries. For example, the retail coffee price in Canada can be generally higher than the price in the USA because of different cost for shipping.

A decrease in following variables have negative impacts on retail price: precipitation and average temperature during the harvest season, minimum temperature during the non-harvest season and year. Other variables have positive impacts. As a result of relatively high standard error compared to the estimated value, the impact (direction of the effect) of maximum temperature during the non-harvest season is unclear.

It is interesting to notice that weather variables not significant to coffee production have a significant effect on retail price. One possible reason is that these significant weather variables on retail coffee price may be associated with coffee quality but not production.

The largest effect from weather variables is the average temperature during harvest season. One degree Celsius increase in average temperature during harvest season results in a 21.7 % decrease in retail price (USD in 2000). The reason for having this significantly large effect from our model is unclear. A possible explanation is that if the average temperature during harvest season significantly increases the total production, the increase in production can drive down retail price. However, our production model does not provide a significant relationship between total production and average temperature during harvest season.

More importantly, from the results in table 2, it appears that Brazil weather variations seem to have significant impacts on the retail price. If we could predict future weather variation, then by extension, we could estimate the retail price.

Table 2. Regression Result with Fixed Effects (retail price and Brazil weather)

	Dependent variable:
	log(adjusted retail price)
Harvest season (Brazil)	
Precipitation	-0.088 (0.017)***
Average temperature	-0.217 (0.082)***
Maximum temperature	0.060 (0.026)**
Minimum temperature	0.056 (0.034)
Non-harvest season (Brazil)	
Precipitation	0.099 (0.023)***
Average temperature	0.115 (0.078)
Maximum temperature	0.012 (0.071)
Minimum temperature	-0.112 (0.056)**
year	-0.007 (0.006)
Observations	405
R^2	0.982
Adjusted R^2	0.980
Residual Std. Error	0.185 (df = 368)
F Statistic	529.966*** (df = 37; 368)
Note:	*p<0.1; **p<0.05; ***p<0.01

Conclusion

The economics of coffee production has changed in the past decades due to changes in the demand for specialty coffee, technology innovation, and policy. These changes in the global coffee industry have tremendous influence on both producers and consumers (Lewin et al. 2004). Understanding these changes and its effects is important in preventing damage from market failures, such as imbalances in the trading chain and unstable price in the commodity market.

In exporting countries, price volatility leads to instability in producer incomes and uncertainty of export earnings and tax revenues. In importing countries, price volatility affects profit margins for roasters, traders, and stockholders, and consumer's satisfaction and confidence in markets (ICO, 2014; Kane et al. 2015). Changes in consumer markets and roaster behavior due to paradigm shifts in importing countries have affected production patterns in producing countries (Lewin et al. 2004). For instance, farms adapt sustainable and environmental friendly farming methods as consumers raise their awareness for fair trade and sustainable environment in importing countries.

Our report modeled the relationships between weather variables and coffee production, and weather variables in Brazil and retail price. The results from coffee production model suggest that precipitation during the non-harvest season and maximum temperature during the harvest season have a significant effect on total coffee production. This impact from precipitation during the non-harvest season could support the assumption that weather during flowering season, which happens in non-harvest season, has an impact on coffee fruit set process, and hence, coffee production.

The analysis of the impact of Brazil's weather variables on retail price provide statistically significant results; however, the causation of the relationship is unclear. Potentially, the coffee retail price could have interaction effect with other commodities in which coffee price may not be directly influenced by the weather. For instance, negative shocks in the weather may decrease tea production and increase the price of tea; however, it may have no effect on coffee production. As a result, changes in tea price could result in changes in the demand for coffee, and by extension, coffee price.

The results of this report revealed general ideas about how weather variables are associated with coffee production and retail price. Nonetheless, the weather dataset we modified only contains a general area of coffee growing regions. It is difficult to capture and categorize an accurate location of coffee farms. As such, we suggests further analysis with detailed locations of coffee producing regions or to narrow the analysis to a single country.

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Appendix

Country	Variety	Country	Variety
Angola	(R/A)	El Salvador	(A)
Bolivia	(A)	Equatorial Guinea	(R)
Brazil	(A/R)	Ethiopia	(A)
Burundi	(A)	Gabon	(R)
Ecuador	(A/R)	Ghana	(R)
Indonesia	(R/A)	Guatemala	(A/R)
Madagascar	(R)	Guinea	(R)
Malawi	(A)	Guyana	(R)
Papua New Guinea	(A/R)	Honduras	(A)
Paraguay	(A)	India	(R/A)
Peru	(A)	Jamaica	(A)
Rwanda	(A)	Kenya	(A)
Timor-Leste	(A)	Lao, People's Dem. Rep. of	(R)
Zimbabwe	(A)	Liberia	(R)
Congo, Rep. of	(R)	Mexico	(A)
Cuba	(A)	Nepal	(A)
Dominican Republic	(A)	Nicaragua	(A)
Haiti	(A)	Nigeria	(R)
Philippines	(R/A)	Panama	(A)
Tanzania	(A/R)	Sierra Leone	(R)
Zambia	(A)	Sri Lanka	(R)
Benin	(R)	Thailand	(R/A)
Cameroon	(R/A)	Togo	(R)
Central African Republic	(R)	Trinidad & Tobago	(R)
Colombia	(A)	Uganda	(R/A)
Congo, Dem. Rep. of	(R/A)	Venezuela	(A)
Costa Rica	(A)	Vietnam	(R/A)
Côte d'Ivoire	(R)	Yemen	(A)

Table 1. Country and coffee variety (R indicates Robusta, A indicates Arabica, red indicates countries removed)

Country	Latitude	Harvest season		Rainy season		Country	Latitude	Harvest season		Rainy season	
		Start	End	Start	End			Start	End	Start	End
India	28.6	10	2	6	9	Colombia	4.6	10	3	4	5
Nepal	27.7	11	1	6	8	Central African Republic	4.4	11	2	5	10
Viet Nam	21.0	12	1	5	10	Cameroon	3.9	11	12	5	9
Mexico	19.4	10	3	5	11	Gabon	0.4	5	9	2	5
Lao People's Democratic Republic	18.0	12	2	5	11	Ecuador	-0.2	6	10	5	10
Philippines	14.6	12	3	6	10	Kenya	-1.3	10	12	3	5
Honduras	14.1	10	3	10	2	Rwanda	-2.0	4	6	3	5
Thailand	13.8	10	3	7	10	Congo Republic	-4.3	9	10	10	5
El Salvador	13.7	11	3	5	10	Congo Democratic Republic	-4.3	5	7	10	5
Venezuela	10.5	10	1	4	11	Indonesia	-6.2	6	12	11	3
Costa Rica	9.9	10	2	5	11	Tanzania	-6.8	10	12	3	5
Guinea	9.5	12	3	6	9	Angola	-8.8	6	10	9	5
Nigeria	9.1	11	3	6	9	Papua New Guinea	-9.5	5	9	12	3
Ethiopia	9.0	10	12	3	5	Peru	-12.1	4	10	11	4
Sierra Leone	8.5	12	2	6	9	Malawi	-14.0	12	2	3	5
Sri Lanka	6.9	8	8	5	9	Zambia	-15.4	10	3	10	4
Guyana	6.8	10	3	5	7	Brazil	-15.8	4	9	10	3
Benin	6.5	11	2	6	9	Bolivia	-16.5	4	8	9	5
Liberia	6.3	11	3	6	9	Zimbabwe	-17.8	7	10	10	4
Togo	6.1	12	2	6	9	Madagascar	-18.9	6	9	3	5
Ghana	5.6	11	3	6	9	Paraguay	-25.3	6	9	10	4

Table 2. Country, latitude, harvest season, and rainy season

Table 3. Regression Result with Fixed Effects (temperature difference)

	Dependent variable:		
	log(total.prod + 1)		
Country fixed effect	N	Y	Y
Year fixed effect	N	N	Y
Harvest season			
Precipitation	0.010 (0.010)	0.002 (0.002)	0.003 (0.002)
Average temperature	-0.335 (0.039)***	-0.078 (0.028)***	-0.053 (0.029)*
Temperature difference (Max – Min)	-0.204 (0.044)***	-0.057 (0.019)***	-0.056 (0.019)***
Non-harvest season			
Precipitation	-0.047 (0.019)**	0.010 (0.004)**	0.015 (0.004)***
Average temperature	0.343 (0.056)***	-0.059 (0.034)*	-0.029 (0.036)
Temperature difference (Max – Min)	0.324 (0.068)***	-0.011 (0.027)	0.004 (0.027)
Constant	4.502 (1.541)***		
Observations	881	881	881
R^2	0.124	0.994	0.995
Adjusted R^2	0.118	0.994	0.994
Residual Std. Error	2.476 (df = 874)	0.494 (df = 835)	0.487 (df = 808)
F Statistic	20.714*** (df = 6; 874)	3,227.289*** (df = 46; 835)	2,095.424*** (df = 73; 808)
Note:			$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table 4. Regression Result with Fixed Effects (temperature anomaly)

	Dependent variable:		
	log(total.prod + 1)		
Country fixed effect	N	Y	Y
Year fixed effect	N	N	Y
Harvest season			
Precipitation	-0.005 (0.007)	0.002 (0.002)	0.002 (0.001)
Average temperature anomaly	-0.242 (0.198)	-0.041 (0.042)	-0.031 (0.042)
Maximum temperature anomaly	0.043 (0.163)	-0.083 (0.030)***	-0.072 (0.032)**
Minimum temperature anomaly	0.039 (0.125)	0.032 (0.026)	0.042 (0.026)
Non-Harvest season			
Precipitation			
Average temperature anomaly	-0.077 (0.023)***	0.010 (0.005)*	0.015 (0.004)***
Maximum temperature anomaly	0.100 (0.225)	-0.083 (0.050)*	-0.074 (0.050)
Minimum temperature anomaly	-0.174 (0.193)	0.010 (0.042)	0.047 (0.044)
Constant	0.118 (0.174)	0.026 (0.032)	0.030 (0.031)
Harvest season	6.449 (0.184)***		
Observations	881	881	881
R^2	0.024	0.994	0.995
Adjusted R^2	0.015	0.994	0.994
Residual Std. Error	2.617 (df = 872)	0.494 (df = 833)	0.487 (df = 806)
F Statistic	2.676*** (df = 8; 872)	3,091.116*** (df = 48; 833)	2,041.091*** (df = 75; 806)

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table 5. Descriptive statistics of total coffee production

Variable	Observations	Mean	Std. dev.	Min.	Median	Max.
Total production	881	3,242.880	7,951.205	0.000	624.000	56,764.000
Harvest season						
Precipitation	881	5.365	8.491	0.000	4.150	181.100
Average temperature	881	23.868	3.140	12.347	24.096	29.437
Maximum temperature	881	29.614	3.013	19.386	29.456	36.054
Minimum temperature	881	18.282	4.034	4.630	18.880	25.378
Non-harvest season						
Precipitation	881	7.186	4.738	0.000	6.542	83.100
Average temperature	881	25.177	2.469	18.815	25.886	29.437
Maximum temperature	881	30.461	2.003	24.654	30.757	34.997
Minimum temperature	881	20.195	3.487	9.477	21.485	25.149

Table 6. Descriptive statistics of retail coffee price

Variable	Observations	Mean	Std. dev.	Min.	Median	Max.
Adjusted retail price (USD in 2000)	646	3.571	2.096	1.324	3.007	15.053
Harvest season (Brazil)						
Precipitation	728	5.611	2.448	1.271	5.676	13.760
Average temperature	728	23.472	0.467	22.657	23.539	24.453
Maximum temperature	728	29.889	0.735	28.599	29.955	31.064
Minimum temperature	728	19.075	0.956	17.014	19.274	20.737
Non-harvest season (Brazil)						
Precipitation	728	7.136	2.105	1.656	7.650	9.781
Average temperature	728	25.868	0.401	25.185	25.868	26.791
Maximum temperature	728	31.855	0.491	31.040	31.890	32.883
Minimum temperature	728	21.582	0.610	20.526	21.651	22.848