Pricing in the Coffee Industry: An Econometric Model of Prices to Growers

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Introduction: Not only do the farmers at origin play an integral part in your morning cup of coffee but they also depend on coffee as a means to provide for their families. The global price of coffee is characterized by extreme volatility—leading one to question if farmers' lives are inherently tied to this unreliable market. This research paper seeks to answer this using econometrics: does the global commodity price of coffee impact prices paid to growers? An econometric model is developed for the use of hypothesis testing to address this question.

Literature Review: There is a large existing literature which examines the global coffee market and the role of commodity markets in pricing. While examining the role of institutional arrangements in transmitting prices to coffee producers, Cárdenas (1994) finds that market price volatility affects producers at varying degrees dependent on domestic government intervention. This research provides a launching point for investigating the relationship between global coffee prices and the prices paid to growers, as it illustrates the interconnectedness of the two.

In their 2007 book, Benoit Daviron and Stefano Ponte illustrate the paradox of "the coffee boom in consuming countries and the coffee crisis in producing countries," in which producers find themselves trapped in the 'commodity problem' so long as they do not control any of the intangible aspects of the experience that retailers possess. The authors break down the global coffee market and provide insight into the value chain, suggesting that commodity market prices have a significant impact on the farmgate prices growers receive.

Model: The dataset used for this model provides data for fifteen countries from the years of 1990 to 2017. The dependent variable in this model is the price paid to growers at the farmgate level, *GrowerPrices*. The independent variables in this model are the global price of coffee, *WorldPrice*, the average world retail price, *RetailPrice*, and the United States producer price index for coffee, PPI. Definitions of these variables can be found in Table 1 below.

Table 1
Variable definitions and descriptive statistics

Variable	Definition	Mean	Min	Max	Std Dev
GrowerPrices	Annual average price paid to grower at farmgate level*	83.7	17.6	239.7	40.7
WorldPrice	Annual average for global price of coffee (arabica) **	127.8	60.4	273.2	52.2
RetailPrice	Annual world avg. consumer price paid at commercial outlets †	5.3	3.7	7.0	1.0
PPI	Annual average for U.S. producer price index by coffee ††	155.1	100.5	223.9	36.7

Notes: *indicates data from the International Coffee Organization (ICO) and are in (US cents/lb),
** indicates data from the International Monetary Fund, retrieved from FRED and are in (USD/ton),
† indicates data from the International Coffee Organization (ICO) and are in (USD/lb),
†† indicates data from the U.S. BLS, retrieved from FRED and represent an index where 1982=100

The empirical model takes the following form:

$$GrowerPrices_{it} = \alpha_i + \beta_2 WorldPrice_t + \beta_3 RetailPrice_t + \beta_4 PPI_t + u_{it}$$

This paper intends to determine if farmgate prices paid to growers are dependent upon the global commodity price of coffee. As such, the main hypothesis this paper seeks to test is that the global price for coffee does have a significant impact on the prices paid to growers at farmgate level. The hypothesis test will be set up with the null stating that *WorldPrice* does not have a significant effect on *GrowerPrice.* A significance level of 5% will be used for testing this hypothesis. The null and alternative hypotheses can be written as:

$$H_0: \hat{\beta}_2 = 0$$

$$H_A: \hat{\beta}_2 \neq 0$$

In addition to the main independent variable of the global market price, *WorldPrice*, the developed model also includes *RetailPrice* and *PPI*. The expected signs of the coefficients are as follows. One would expect $\hat{\beta}_2$ to be positive—as the global market price of coffee increases, the prices growers receive should increase. $\hat{\beta}_3$ is expected to be positive—as the average world retail price of coffee increases, the prices growers receive should increase. The expected sign of $\hat{\beta}_4$ is not as clear, though one would expect it to be positive. This would be because as the prices final coffee goods producers in the U.S. receive increase, the prices growers receive increase—perhaps an indication of increased total value in the supply chain.

Potential econometric issues with the specified model are addressed as followed. This model employs a linear functional form. A calculation of a pairwise correlation matrix indicates there may be some multicollinearity between *WorldPrice, RetailPrice,* and *PPI* (refer to *Appendix 3*). Graphs of residuals for individual cross sections may show potential autocorrelation, though it does appear to be severe (refer *Appendix 4*). In case of any inconsistencies in the variance of errors and thus heteroscedasticity, this model has been adjusted to provide robust standard errors, clustered by countries. A Ramsey RESET test was conducted to test for any indication of model specification error (see *Appendix 5* for details). The obtained F statistic of 0.1035 fails to reject the null hypothesis that the model has no omitted variables. There may be some concern over endogeneity in this model as *GrowerPrices* may have some effect on independent variables, such as *WorldPrice* or *RetailPrice*. It is important to acknowledge these potential econometric issues in the model as the results are discussed.

Results: In this section, the effects of independent variables on *GrowerPrices* are examined, and then the results from the main hypothesis test are discussed. A Fixed Effects OLS model with robust standard errors was run to test the main hypothesis—refer to Table 2 below for the results.

Table 2

Results of FE Regression, clustered by group, number of groups=15, N=336

Variable	Coefficient (Std Err)	t-stat	p-value
WorldPrice	.6113516*** (.0741229)	8.25	<0.000
RetailPrice	6.146251*** (1.892088)	3.25	0.006
PPI	-.0362522 (.1378161)	-0.26	0.796
F statistic for country FE	72.34		

Notes: *p<0.1, **p<0.05, ***p<0.01 Standard errors are in parentheses. Estimates for country fixed-effects are not shown. The F statistic refers to the joint significance of the country fixed effects.

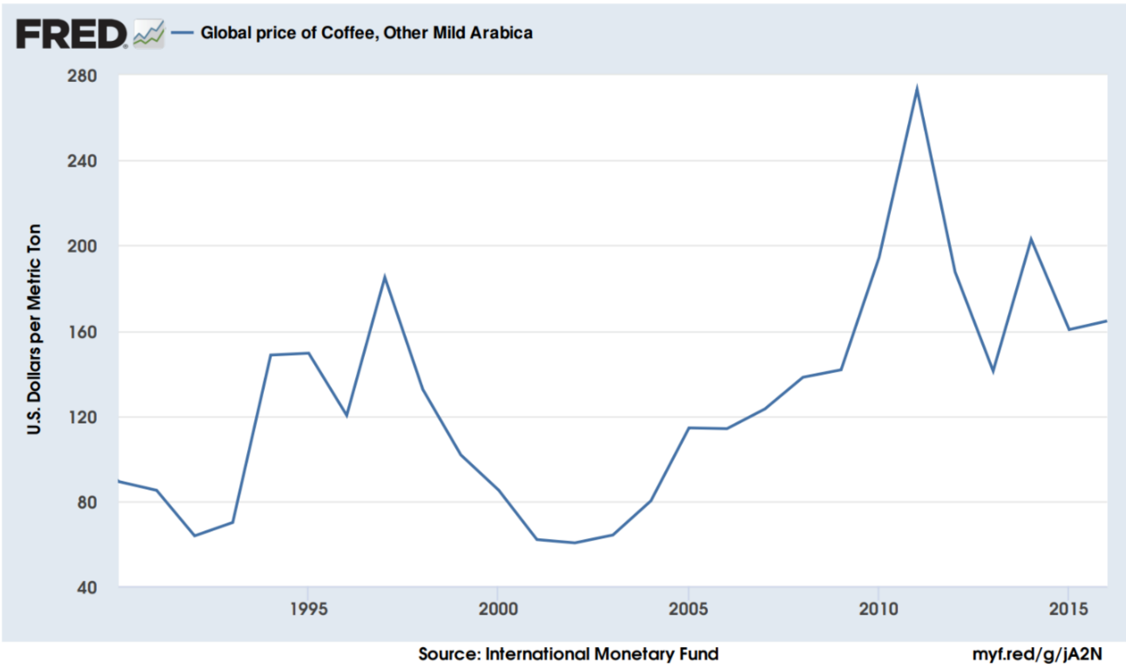
A t-test was calculated for the main hypothesis (refer to *Appendix 6* for details) and the calculated t-statistic (8.248) was larger than the critical t-value (~1.97). Subsequently, this result rejects the null hypothesis that the global price of coffee, *WorldPrice*, does not impact prices to growers, *GrowerPrice*, in favor of the alternative hypothesis. This is in line with our primary hypothesis and our data suggest that the global price of coffee has a significant effect on the prices growers receive at farmgate level. Refer to *Appendix 7* for the conditional plot of *WorldPrice* on *GrowerPrices*, which indicates a positive trend between the two.

The results of our regression show that the signs of the coefficients for *WorldPrice* and *RetailPrice* are positive, which is consistent with our initial expectations. The coefficient for *PPI* is negative, which goes against our initial expectation; however, this term is not statistically significant at the selected 5% level. The significant coefficient estimates can be interpreted as follows. As the average world retail price increases by one-cent per pound, the prices growers receive can be expected to increase by roughly six-cents per pound, all else constant. As the global price of coffee increases, the prices that growers receive can be expected to increase, all else constant. Interpreting the magnitude of the *WorldPrice* coefficient estimate requires some additional steps as the data is reported in US Dollars per ton. After conversion, the coefficient estimate can be interpreted as such: a five-cent increase in the world price can be expected to lead to a three-cent increase in the prices growers receive, all else constant. While these estimates are shown to be statistically significant, they also appear to have economic, or practical significance. Increases in the global coffee price will lead to a less than one for one increase in the prices growers receive; however, those increases would still have a considerable impact on the livelihood of farmers. Increases in average retail prices have a surprisingly large practical impact on the prices growers receive—an increase of one-cent would lead to a five fold increase in the prices farmers receive.

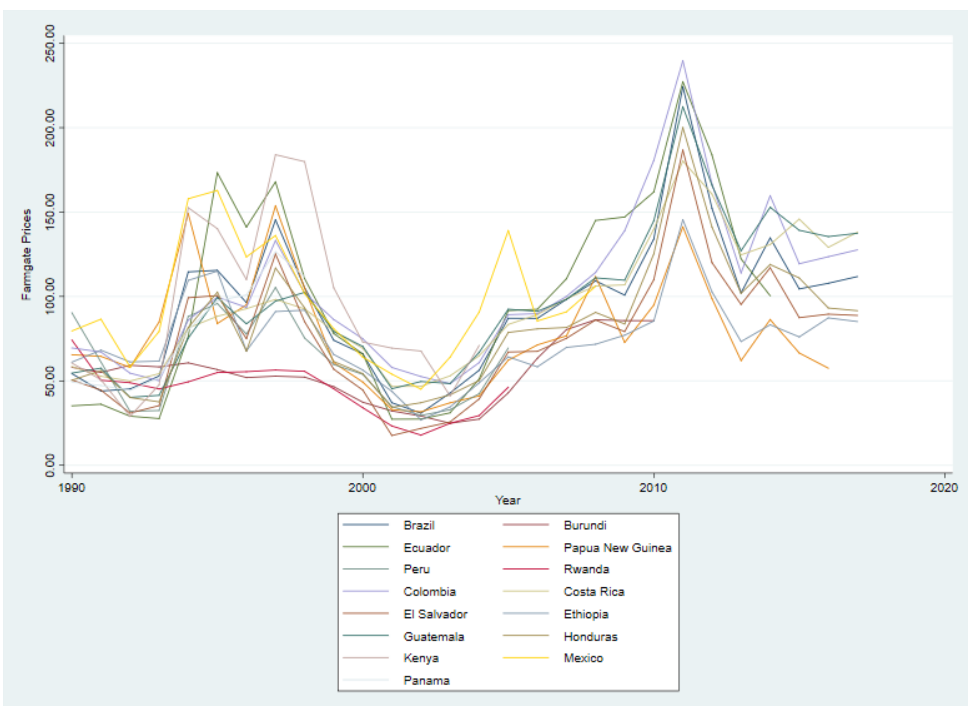
Conclusion: The results of regression model developed in this paper are consistent with the initial hypothesis, suggesting that the global market price of coffee has a significant impact on the prices that growers receive. The model also suggests that average world retail prices have a significant effect on the prices that growers receive. The practical implications of the model suggest that increases in retail price could be far more impactful in increasing farmgate prices than increases in global price of coffee. While these results make intuitive sense, they should be concerning to those of us who care about equality and economic development. This paper's findings suggest that the livelihoods of coffee farmers—primarily in the southern hemisphere—are a plaything of the global commodity market for coffee's incredible volatility, while surrounding literature suggests that the roasters and cafés—primarily in the northern hemisphere—are more immune to this volatility. As such, this research could be useful for scholars hoping to explain pricing dynamics in the coffee sector as well as those in the specialty coffee industry hoping to improve conditions for farmers. Future research might attempt to hone in on these effects using monthly data rather than annual data, as this could have been a limitation of this paper's model.

Appendices:

Appendix 1: Plot of annual average global price of coffee (arabica)



Appendix 2: Plot of annual average farmgate prices to growers



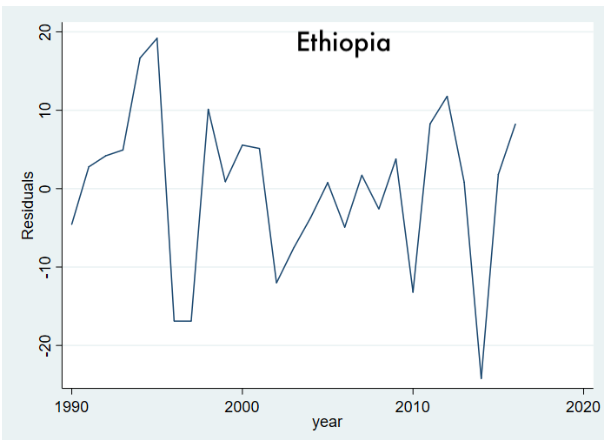
Appendix 3:

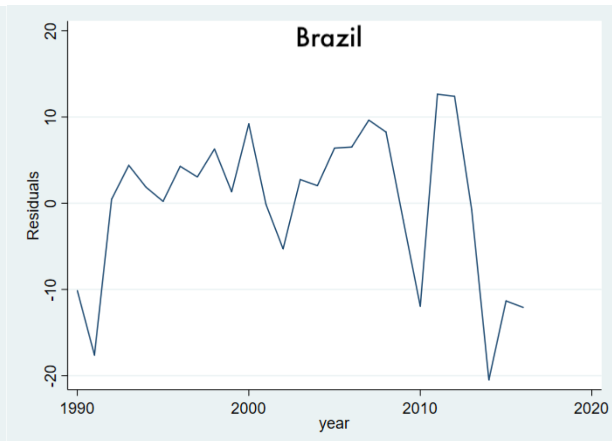
Table 3

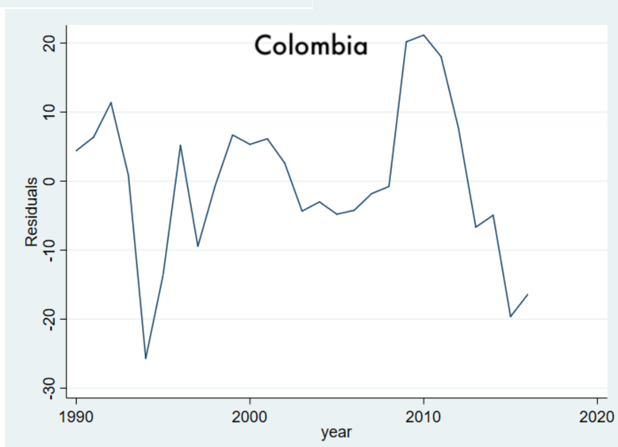
Pairwise correlation coefficients for individual cross section (Brazil)

Variable	*year*	*WorldPrice*	*RetailPrice*	*PPI*
year	1.0000			
WorldPrice	0.5620	1.0000		
RetailPrice	.6487	0.8546	1.0000	
PPI	.8909	0.8448	0.8800	1.0000

Appendix 4: Residual graphs for individual cross sections







Appendix 5: Results of Ramsey RESET test

H_0: Model has no omitted variables

F(3, 329) = 2.07

Prob > F = 0.1035

Appendix 6:

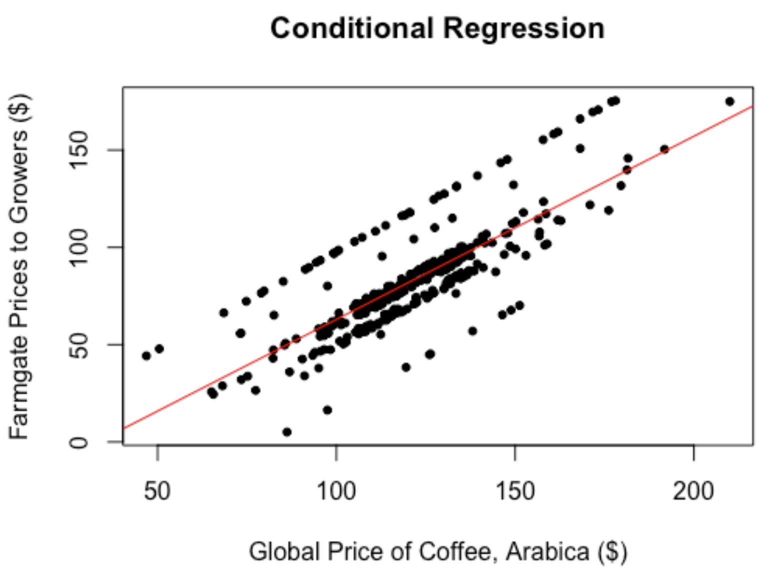
Hypothesis test for *WorldPrice*, $\hat{\beta}_2$

$H_0: \hat{\beta}_2 = 0$
$H_A: \hat{\beta}_2 \neq 0$

The t statistic is $t = \frac{\widehat{\beta}_2}{se(\widehat{\beta}_2)} = \frac{.6113516}{.0741229} = 8.248$

With $n - k = 336 - 4 = 332$ degrees of freedom and assuming a 2-tailed test, the critical t value for a 5% significance level is $1.96 \leq t_{crit} \leq 1.98$ and we reject the null hypothesis in favor of the alternative.

Appendix 7: Conditional plot of *WorldPrice* on *GrowerPrice*



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