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Global Climate Change, Fair Trade, and Coffee Price Volatility

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Abstract
Fair Trade coffee sales have grown exponentially over the past fifteen years amidst a volatile and shaky coffee commodity market. This paper incorporates the prior research that global climate change will lead to more climate shocks with research on the coffee market's volatility and farmer welfare. In accordance with prior research on commodity volatility, I develop an OLS estimator of the volatility of prices received by growers and evaluate the effect of climate shocks on it. I find that, when control variables are introduced, the volatility of the coffee price does increase at a statistically significant level with a climate shock. I evaluate the claim made by the Fair Trade movement that their program is a way to mitigate climate change, and I incorporate qualitative research that confirms the concerns observed in relation to climate change and farmer welfare.

Keywords
Fair Trade, Commodities, Price Fluctuation, Fair Trade Coffee, Climate Change, Farmer Welfare

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I. Introduction

There is overwhelming consensus among climate scientists that the earth's temperature is increasing and becoming more unpredictable (IPCC 2014). Some climate scientists have suggested that agriculture over the past thirty years has been subject to more yield variability, and thus indirect changes in prices. This increased variance in temperature can also lead to higher volatility in commodity markets (Brown and Gibson 2006). Coffee growers are one group of commodity producers who are particularly affected by price volatility, and it appears to be negatively affecting their wellbeing (Mohan et al. 2014). In this paper, I

investigate the relationship between global climate change, particularly changes in temperature and climate shocks, and commodity price volatility in the coffee market. In addition, I will examine, theoretically, whether Fair Trade contracts, which offer pre-negotiated prices to growers in exchange for more sustainable agricultural practices, can mitigate some of the negative effects of commodity price volatility for coffee producers.

Why is this important, economically? In theory, many individuals will have to adapt to changing climate conditions, and many more will be unable to adapt. This research is aimed at understanding climate-related price fluctuations and shocks in the coffee market, and examining to what extent voluntary Fair Trade initiatives could improve the welfare of farmers and help them adapt

to greater uncertainty. Nevertheless, it is vital to the research since reducing the vulnerability to volatility is one of the primary goals of Fair Trade.

Existing statistical studies suggest that climate change has had a negative effect on crop yields and production (Lobell et al. 2010). Discussion on the concept of Fair Trade and climate change has focused on remarkably very few studies that have suggested a link between climate shocks and more volatility (Roache 2010, Brunner 2002). Prior literature has also incorporated climate simulation models to suggest that global climate change will create more price volatility and lead to considerable welfare losses for millions of people (Tran et al. 2012). Rather than rely on climate models or specific individual cases, this project uses data on coffee markets, and temperature variations

to empirically measure the effects of climate change on prices and thus farmer welfare (via price volatility).

To begin, I model price volatility as the primary connection between climate change and farmer welfare; that is, climate change affects farmers because it leads to increased price volatility. There is prior evidence that, in general, persistent price volatility hurts farmers (Mohan et al. 2014). I incorporate the shock of significant climate events into a regression of price volatility.

Results in this paper indicate that climate changes do have a significant impact on the volatility of coffee prices. In addition to my quantitative analysis, I also incorporate a deeper perspective on climate change by presenting the

results of the interviews I had with small-agriculture producers. This paper also presents areas for further research into volatility clustering in coffee prices.

II. Literature Review

Commodity markets are, by nature, very volatile and prices change often. This effect is easily noticeable since the liberalization of many commodity markets (rice, sugar, oil, coffee, etc.) near the end of the twentieth century (Cashin and McDermott, 2002) and even since then. The economic history of many of coffee-producing economies indicates why this is the case. Many coffee-producing countries were formerly Western-controlled colonies and are still emerging as developing economies. Thus, much of the coffee

production since the end of colonial times in many countries has been subject to various export-import schemes, market regulations, and region-wide protectionist policies. However, since the end of the International Coffee Agreement in 1989, the coffee market has largely been subject to the forces of globalization and the free market, angering some.

One “consequence” of the free market on commodity farmers has been that prices swing often at the whim of market forces and buyers. The phenomenon of commodity price volatility has been investigated in previous papers that suggest that volatility is a problematic element for farmer welfare. Cashin et al. (2001) examine the length and magnitude of price booms and slumps, coffee included, and determined that coffee prices endure more price swings, volatility, and longer periods of

lower prices than other commodities. Additionally, Cashin and McDermott (2002) conclude that short-run movements in commodity prices are highly unpredictable, and price volatility has been increasing in magnitude since the 1970s. Moledina et al. (2004) analyze multiple commodities and seek to answer whether there are any welfare gains from less volatility. They argue that eliminating price volatility very little welfare gain.

No study has focused on climate change on the coffee market. Older studies have found links between climate shocks like the El-Niño Southern Oscillation Index (Brunner 2002, Frechette and Delavan 1998). More recent studies indicate projected changes in the coffee "suitability", or ability of Arabica coffee to grow in pre-existing coffee regions (Ovalle-Rivera 2015). With

potential changes in supply due to climate change, coffee prices and volatility will change too. Tran et al. (2012) use complex climate simulations of multiple commodities to predict that changes in global temperatures in the coming years will lead to more price volatility leading to a welfare loss for millions of people. This news can seem rather alarming, so it is imperative that the relationship between climate changes and coffee prices be investigated empirically to see what negative welfare effects it has had on farmers.

Preliminary estimates by Bacon (2005) and Dragasanu and Nunn (2014) show that Fair Trade farmers do in fact receive slightly higher prices than non-Fair Trade farmers. As Mohan (2010) argues, Fair Trade can only establish long-term benefit for farmers if revenues, in contrast to price increases,

can be stabilized. Volatility is important, nevertheless, and much of the prior literature suggests that it is a variable of interest in econometric analysis of farmer welfare.

This research paper incorporates these previous observations about the climate and market. It relates these concepts via estimation of volatility using standard deviation as authors have previously conducted using various standard control variables also used in prior findings. With these estimations, this paper contributes statistical findings on volatility of coffee market that were previously only measured on other commodities.

III. Theory

Volatility indicates how much a price varies from previous prices. Volatility also measures an

inherent risk, financially, that exists when farmers must make seasonal production and investment decisions. The more variation from previous values, the more of a welfare decrease for farmers, so to speak. Farmers do not welcome volatility, in theory, because of the wider range of expected returns on crops. Thus, increased volatility and farmer welfare have a negative relationship with each other because famers have a more difficult time making production decisions as predicting future prices is more challenging.

Consistent with Roache (2010), in this paper I examine the determinants of volatility by running a standard ordinary least squares (OLS) regression. Within this OLS regression, I measure climate volatility in several ways, the effects of frost and drought by introducing dummy variables.

Theoretically, a frost or drought will reduce market supply and increase the coffee price. Since farmers cannot prepare very adequately for a frost or drought occurrence as crops are outdoors and the climate effects are out of their control, if frosts and droughts do occur more frequently with global climate change, this higher level of volatility will lead to a decrease in their welfare. Volatility in this context is measured by the rolling standard deviation of the monthly log price difference: $d = \ln(p_t) - \ln(p_{t-1})$. This method to measuring volatility is adopted by several commodity-related studies (Mohan et al. 2014, Roache 2010). I also introduce several control variables in the regression that account for other world market changes that could explain increased volatility, just as Roache (2010) does. Thus, the regression model looks like:

(1) $$\sigma(d) = B_0 + weathervariable_i + real_i + dusgdp_i + \sigma(\pi)_i + \sigma(3mo)_i + \sigma(\varepsilon)_i$$

Within, real represents the real inflation rate for a particular country, dusgdp represents the first difference of USGDP, a commodity-literature measure for demand changes, the level and standard deviation of the US inflation rate, the standard deviation of the US risk-free rate, and the standard deviation of the US exchange rate. This modeling takes into account changes in world demand, measured broadly via USGDP, and other factors that might influence the volatility of coffee prices to growers identified by Roache (2010).

IV. Data

The prices included in this paper are from the International Coffee Organization (ICO) and

represent nominal monthly prices to growers in a panel of Arabica coffee producing nations from the period 1980-2013. Prices are quoted in US cents/lb, and to derive a real price series, the prices are deflated using a UN "unit value index" obtained from the International Monetary Fund to keep consistent with Mohan et al. (2010). This is done to keep measurement of prices consistent over time in real terms. Monthly prices are also obtained from the IMF for index commodity prices.

Weather data is taken from publicly available data from the US National Oceanographic and Atmospheric Administration (NOAA) and is shown on the website's map. Weather dummy variables (0 or 1) used to indicate frost, or drought in a given month are derived from coffeeresearch.org. Weather data about the

standard deviation of maximum temperature is taken from a weather station in Belo Horizonte, Brazil, a popular coffee-producing region in Brazil and combined with the coffeeresearch.org information. Brazil has a very large market share of global Arabica coffee production, and many changes in coffee news, and prices are centered around Brazilian coffee production and climate. While the data as a whole are from a panel for price changes, the very large effect of Brazilian climate shocks has a noticeable effect in the news and changes in prices traded in financial markets are directly observed as a result. Unfortunately, panel data on frosts and droughts cannot be completely traced and relied upon in NOAA data available as many weather archive reports from developing countries are incomplete. However, the data from

Brazil and the website do work well with the other data.

V. Results

The results of estimating equation (1) yields some very interesting results about volatility. Using the regression model testing weather variables, the standard deviation of the grower price of coffee to producers in a panel of countries, and other important covariates, the results indicate that frost and drought have an immediate impact on coffee prices and volatility. Additionally, the results indicate that it is not directly higher temperatures, commonly thought of with climate change, that lead to higher volatility levels, but rather shocks to the climate via droughts and frosts. These weather events, which are thought to increase in the future with climate change, are crucial to understanding

why coffee prices are volatile. Regression results are described in Table 1, below.

Within the table, regression (1) tests the standard deviation of the maximum temperature of the Brazil location. The coefficient on this term (0.00023) is not statistically significant at any level, while other covariates are – this supports the understanding that higher temperatures are not directly relevant to coffee price volatility. Rather, regression (2) tests, in Latin American countries and South America, whether climate shock weather changes such as drought and frost, which can kill crops and eliminate much of a farmer's income. This term is statistically significant and positive (0.03717), meaning that on average, the standard deviation of the monthly log difference of prices received by growers increases. Practically, this

means that the expected returns of the coffee price differs more with a higher coefficient. With more spread-out expected returns, coffee farmers' welfare is decreased.

The term is also lagged to account for changes that occur in the month before that will affect farmers and their expected returns. A similar regression (3) introduces a frost lag with the covariates and is statistically significant at the 5% level. This coefficient is also positive (0.23180), meaning that volatility increases with a frost (lagged for the same reason). These results support the belief, generally given by the farmers that I have interviewed and environmental economic researchers, that frosts and droughts are incredibly serious and affect volatility even when introduced with other explanatory variables for volatility.

While the R-squared values of these regressions are rather low, the low value is to be expected of time

Dependent Variable:	St. Dev. Of Grower Price

series, fixed effects regressions.

Table 1 - Measuring Volatility of Grower Prices

Variable:	(1)	(2)	(3)
Inflation Level	-0.00864 (0.00197)***	-0.00332 (0.001539)**	-0.003667 (0.001196)***
Real Interest Rate	0.0023 (0.00097)*	0.00386 (0.000811)***	0.002036 (0.000622)***
dUSGDP	-0.00006 (0.000028)**	-0.0001 (0.00002)***	-0.000026 (0.0000178)
Inflation Volatility	-0.03586 (0.008221)***	-0.04075 (0.006413)***	-0.030799 (0.00497)***
Exchange Rate Vol.	-1.7736 (0.4642)***	-0.00205 (0.004301)	-1.01318 (0.30070)***
SDMaxTemp Lag	0.00023 (0.000197)	-	-
Frost Lag	-	-	0.23180 (0.007854)**
Frost or Drought Lag	-	0.03717 (0.00739)***	-
Constant	0.1715 (0.103)***	0.1356 (0.00833)***	0.14396 (0.00647)***
Fixed Effects?	Yes	Yes	Yes
R-Squared	0.031	0.031	0.020
N	4370	4854	9935
,**, indicate significance at the 10%, 5%, 1% levels respectively.**			

VI. Qualitative Effects

Qualitative research is a key aspect of market coffee research, and Fair Trade. Research into the coffee market on the societal effects and opinions of those directly affected is often pushed to the wayside, even though it can reveal much of what cannot be quantified. To get a taste of what

was out there, I decided to get ahold of some agricultural producers in Adams County, PA that I knew I could get ahold of.

Through a publication on agriculture and Adams county farming and tips from a college at Gettysburg College, I was able to get in contact with a Honduran farmer named Emilo Garcia, living in central PA. Garcia and the other Adams county participants interviewed mentioned that price volatility is an important production concern. Additionally, frost and drought were concerning and a contemporary issue to all subjects interviewed. These results confirm that climate change is indeed a serious issue addressing coffee farmers. Furthermore, with research indicating that "suitability" of coffee farms becoming more difficult (Ovalle-Rivera 2015), as coffee must be

cultivated in a very specific climate that is, as of now, rapidly changing, more volatility may be expected.

VII. Analysis of Regression Data and Further Research

While the quantitative results are significant, they could be subject to some unforeseen complications. It is possible that in evaluating volatility, the regressions omit key variables that have not been accounted for that might implicate the regression to misestimate the effects of frost and/or drought. This would lead to a misestimating of the coefficients. Measurement error, whether it be through how frost data and weather data are collected or how grower prices are gathered, is also a very likely problem that could occur in the regression results. It is possible that Brazil is not

necessarily the only determinant for large-scale price fluctuations and volatility for coffee farmers due to frost and drought. While these climate-related events may happen elsewhere, Brazil still has such a large market share that it can capture many of these effects.

One area for future research would be to introduce a study of volatility clustering. Volatility clustering implies that periods of high volatility are often followed by other periods of high volatility and vice versa, is often noticeable in financial markets (Engle 1982). In this paper, I account for volatility clustering by introducing a generalized autoregressive conditionally heteroskedastic model (GARCH model) used by many economists to account for this phenomenon. The GARCH model, which analyzes what goes into monthly log price

changes and takes account for the error variance of the model $var(u_t) = h_t$. Thus:

$$(2)\ p_t = B_0 + B_1 p_{t-1} + B_2 X_{t-1} + u_t$$

$$(3)\ h_t = \alpha_0 + \alpha_1 u_{t-1} + \phi_1 h_{t-1} + \cdots.$$

where *p* represents the monthly log price difference and all coefficients are unknown. The error variance of the equation is modeled because the variance of the term can be estimated as a function of the previous period's variance, thus implying conditional heteroskedasticity. Conditional heteroskedasticity means that the variance of our price, over time, can be related to a function of the time-period it is in. For example, p_t is a function of p_{t-1}. In this paper, I develop prices to be a function of the monthly log price difference, as seen with Mohan et al. (2014) but where I introduce control

variables into the regression to account for other factors that might influence price changes. (eqns 3,4)(4) $\ln(p_t) - \ln(p_{t-1}) = d_t = B_0 + B_1 d_{t-1} + B_2 controls + u_t$

$$(5) \qquad h_t = \alpha_0 + \alpha_1 u_{t-1} + \phi_1 h_{t-1} + controls$$

Within this set of regression equations, equation (5) is measuring the variance of the error term in (4). This set of regressions would estimate the effect of climate shocks on the price changes in coffee, and also estimates the effect of heteroskedasticity in the data.

VIII. The Contribution of Fair Trade

Much of this paper has been dedicated to exploring the theme of climate change and its effect on the coffee market. It is noticeable in the coffee

market that farmers are susceptible to price volatility. The Fair Trade movement has made a claim about climate change that is quite notable and well intentioned. The Fairtrade Foundation, a major Fair Trade non-governmental organization (NGO) states on its website:

> Given the lack of fairness found within the conventional trading system, consumers support farmers so they can receive a fair price by buying Fairtrade products. Farmers are paid an amount that aims to cover the costs of sustainable production, which allows them to do future business projections. This is especially important in times of instability and volatility, as prices can significantly fluctuate. (Fairtrade Foundation)

This quotation beckons a discussion of what is exactly “fair”. After a careful review of the literature surrounding Fair Trade, it does not appear that the can do much about the price volatility effects due to climate shocks. Fair Trade lacks a mechanism to mitigate the price volatility found from the effects of climate change.

Fair Trade NGOs often only discuss prices in policy position papers, pamphlets, and other sources. The biggest fallacy with discussing only “fair” prices is that farmers only care about prices, instead of income. Simplistically, income for a farmer is price multiplied by quantity. Mohan (2010) observes that “producers are not concerned with price per se, but price is important to them to the extent that it affects their income”. While it is documented that Fair Trade producers do get earn

higher incomes according to many studies (Bacon 2004, Raynolds 2009 and others), Fair Trade cannot completely insulate farmers from price volatility caused by global climate change and other factors. Dragasanu and Nunn (2014) also note that even with Fair Trade coffee, no farmer actually sells his entire crop as Fair Trade.

In fact, price volatility will probably get worse in the coming years with increased variability in the climate. While the efforts by Fair Trade are laudable when it comes to sustainability, all coffee farmers are still going to be subject to price volatility unless the Fair Trade movement creates a strong system of income assurances.

IX. Conclusions

Overall I find that climate change does

indeed affect the coffee market. Global climate change, via droughts and frosts leads to higher price volatility for coffee farmers. The data seem to indicate this trend This statistically significant trend is noticeable in coffee prices to growers, and supports prior research suggesting that global climate change will affect commodity producers via droughts and frosts. With increased droughts and frosts, there is an increased variability of expected returns for coffee farmers, and uncertainty.

Fair Trade proponents are keen to notice this relationship between global climate change and coffee price volatility, and it is supported through the interviews conducted in Adams County with Emilio Garcia and others. Further research into the topic of coffee price volatility would include an investigation between the persistence and

conditional heteroskedasticity of coffee price fluctuations. While Fair Trade seems to have a lot going for it on the charitable side, there is not theoretical justification for it preventing volatility or insulating farmers from climate related price swings.

There are many policy implications to the results of this study. Agricultural scientists have been warning about the potential changes awaiting the production of coffee. This research confirms suspicions that droughts and frosts have affected volatility. Thus, volatility is just a catalyst for lower farmer welfare as a result of climate change. If Fair Trade, as a movement, truly wants to mitigate climate change, it would require fundamental changes to its models of supporting farmers to ensure income stability. Nevertheless, if

Fair Trade coffee is a product that people want, they should go ahead and buy it – they just should be more weary of its ambitious public statements.

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