5-5-2017

The Impact of Coffee Production on the Economy of Colombia

Luke Alexander Ferguson

Director of Thesis: Dr. Robert Gozalez
Second Reader: Dr. Hildy Teegen

I. ABSTRACT

This senior thesis seeks to determine the impact that the level of coffee production in Colombia has on economic wellbeing in the country. As a proxy for economic wellbeing in different arenas, I look at the income, health, and education variables of GDP, infant mortality rate, and secondary education enrollment. I use a Two-Stage Least Squares regression model to estimate this impact, with lagged international coffee prices and the occurrence of the fungal plant disease *coffee leaf rust* as instruments to account for endogeneity. The data which I use in this project include country-level indicators from the World Bank and monthly coffee production quantities from Colombia's National Federation of Coffee Growers. I find that a 10 percent increase in coffee production is significantly associated with a roughly 3.4% increase in GDP. I find the estimated effect of coffee production on the infant mortality rate, given a 10 percent increase in coffee production, to be a decrease of .6 deaths per thousand live births, but this result is not statistically significant. Lastly, I find that a 10 percent increase in coffee production is associated with a statistically significant decrease in the ratio of secondary educational enrollment by 2.4 points, while the current baseline is around 40 points.

TABLE OF CONTENTS

II. PROJECT SUMMARY

Colombia is a country of roughly 50 million people, located at the northern end of South America. Due in part to its rich geography and volcanic soil, factors on which the coffee plant thrives, the country is the world's third largest coffee exporter. Throughout Colombia there are over 500,000 coffee farms; due to the geographic demands of the plant, they tend to be small and managed by families, as opposed to the giant coffee plantations operated by multinational corporations in Brazil and Indonesia.

This project seeks to estimate the impact of Colombia's coffee production on the country's economic wellbeing. To do this, I use statistical modeling to estimate the effects of coffee on Colombia's gross domestic product (GDP), infant mortality rate, and secondary education enrollment. To account for the unmeasurable error term, I use the occurrence of coffee leaf rust, a plant disease that destroyed 31 percent of Colombia's coffee yield between 2008 and 2011, in order to isolate the effects of coffee production on the outcome variables.

I find through this project that there is a significant relationship between coffee production in Colombia and country's levels of GDP and secondary enrollment. I find that there is not a significant relationship, however, between coffee production and the infant mortality rate in the country.

III. INTRODUCTION

The purpose of this project is to estimate the impact of coffee production on the economic wellbeing of Colombia. I explore this question using an instrumental variable approach. I use the 1987-1988 and 2008-2011 outbreaks of a crop-destroying fungus called coffee leaf rust as a shock to the coffee industry, where outbreaks of this disease are my chief instrument. I then estimate the effects of the coffee industry on Colombia at a national level, looking at health, income, and education outcomes.

To the best of my knowledge, there is no existing literature that specifically studies such an effect. Barón (2010) shows that coffee cultivation in Colombia is associated with improved economic wellbeing, but his study focuses more on the inter-departmental dispersion of prosperity and poverty in relation to coffee cultivation than on the impact at a national level. Schlewitz (2004) studies the impact of coffee development on the economy of Guatemala and notes positive effects, but his research deals largely with the political sway of the crop and its relation to militarization. Sánchez and Hernández (2004) study the diversification of Colombia's economy, specifically the decreasing reliance on coffee exports, but their analysis does not study coffee as a proponent of growth.

My motivation for choosing this topic comes from my own studies in Economics and International Business, which have permitted me to travel throughout and live in Latin America, seeing coffee cultivation and production firsthand. I also work as a barista for Starbucks, which has interested me in the coffee supply chain and in the potential for coffee to be used as a proponent of economic growth. The purpose of this investigation is to estimate the impact of the coffee industry on Colombia's economy. More broadly, I look to answer whether there is a significant link between the growth of the coffee industry in a given country and that country's general level of economic wellbeing. My personal goal through this project is to determine whether the coffee industry in Latin America may be a suitable niche where I can work in the future to promote economic development.

In this study, I find that a 10 percent increase in the level of coffee production is associated with a roughly 3.4% increase in GDP when controlling for year and coffee price, an estimate which is significant at the 10 percent level. I find the estimated effect of coffee production on the infant mortality rate, again given a 10 percent increase in coffee production, to be a decrease of .6 deaths per thousand live births, but this result is not statistically significant. The education returns to coffee production yield interesting results; indicating that a 10 percent increase in coffee production is associated with a statistically significant decrease in the ratio of secondary educational enrollment by 2.4 points. With a current gross secondary enrollment rate of around 40 percent, this estimated drop of 2.4 points is equal to a six percent decrease in the rate of secondary enrollment.

IV. BACKGROUND ON COLOMBIA AND COFFEE LEAF RUST

A. Colombia and Coffee

Coffee was introduced to Colombia in the first part of the nineteenth century, most likely by Jesuit missionaries. By 1860, coffee became one of Colombia's chief exports (Hanratty and Meditz, 1988). Since then, coffee has been one of Colombia's primary exports and – through tariffs – a dominant source of the country's income. Figure 1 shows the annual value of

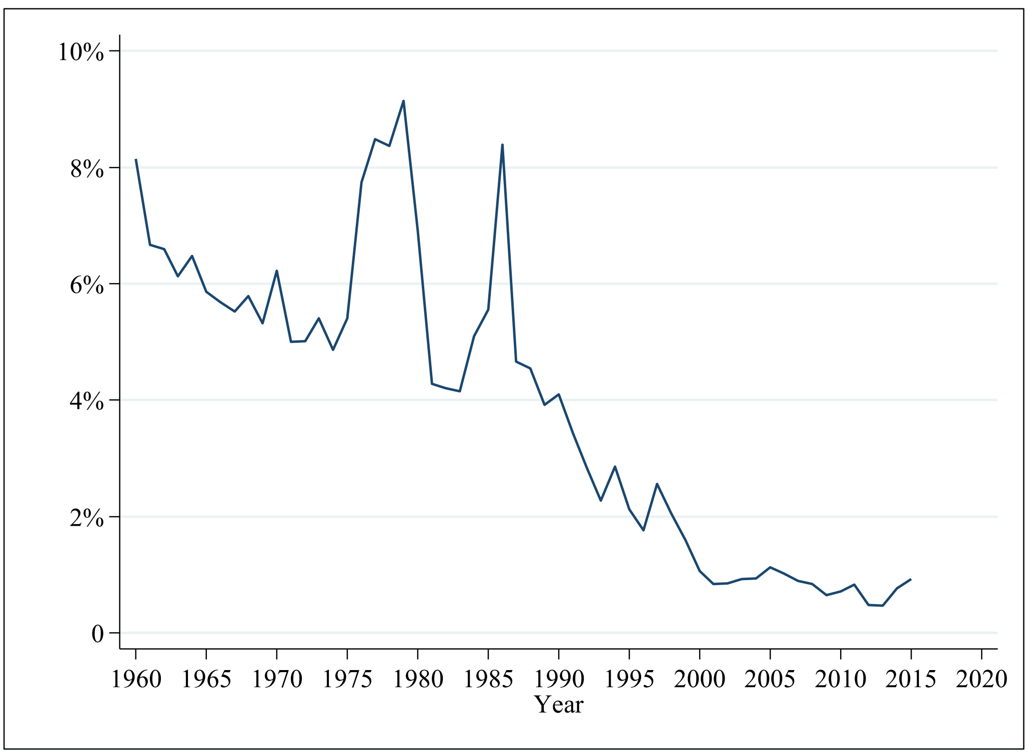

FIGURE 1. VALUE OF COFFEE EXPORTS AS A PERCENTAGE OF GDP, 1960-2015
Sources: Federación Nacional de Cafeteros, 2017; World Bank, 2015.

Colombian coffee exports as a percentage of GDP. Note that in the 1980s, the coffee industry accounted for roughly 8 percent of the GDP of Colombia, and 12 percent of its government revenues (Hanratty and Meditz, 1988). Since the 1980s, Colombia has diversified its economy and does not rely as much on the crop, but modern coffee exports still account for between one and two percent of Colombia's GDP in 2015 (World Bank, 2015).

Today, Colombia is the third largest producer of coffee in the world after Brazil and Vietnam, and the world's largest producer of *C. Arabica* beans (World Bank, 2015). A large part of the prosperity in the coffee industry is due to the country's geography, which contains many valleys, mountains, and volcanos that create the rich soil and high elevation upon which the coffee plant thrives (Barón 2010). Due to these geographic demands, the coffee industry in Colombia is made up of mostly small, family-owned farms. Over 500,000 coffee plantations, or *fincas*, exist in Colombia, with almost 95 percent of them being five hectares or less in size (García, 2003). Most of the production of coffee in Colombia occurs in a region known as the

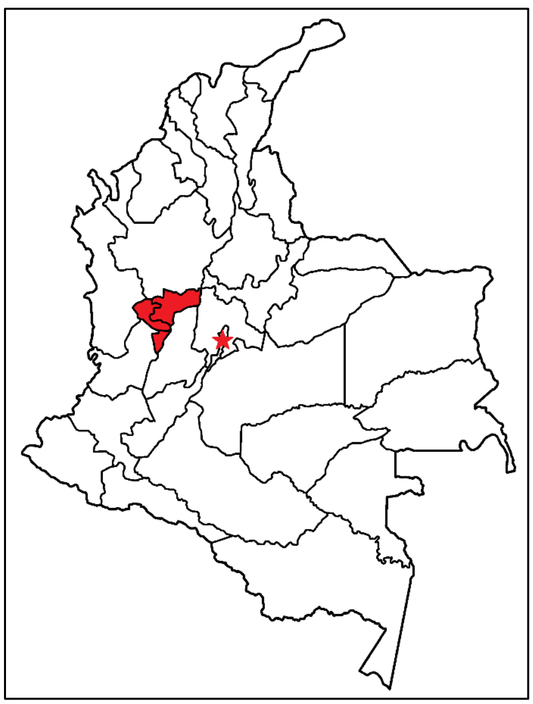

FIGURE 2. THE COFFEE-GROWING AXIS IN COLOMBIA
Source: Federación Nacional de Cafeteros, 2017.
Note: blank map retrieved from https://commons.wikimedia.org/ and modified by author.

Eje Cafetero or Coffee Axis, which contains the departments of Caldas, Risaralda, and Quindío. Figure 2 shows the Coffee Axis within Colombia, in red, as well as the nation's capital, Bogotá.

Additionally, it is worth noting that the coffee plant yields fruit on a biannual cycle, where the plant will have a high-yield harvest in year *t,* followed by a low-yield year *t+1* and a higher yield again in year *t+2* (Kalmanoff et al. 1967).

In 1927, the coffee growers of Colombia organized the National Federation of Coffee Growers (Spanish: Federación Nacional de Cafeteros), or FNC, which today is the world's largest rural nonprofit (Federación Nacional de Cafeteros, 2017). The FNC consists of nearly 3,000 employees, and represents over 500,000 coffee growers in its offices which span across four continents. The FNC's chief goals are the protection and promotion of coffee production and exportation in Colombia. Some of the initiatives which it has created to achieve this goal include the highly popular Juan Valdez coffee chain, and its "Guarantee of Purchase" policy which promises to buy all coffee which its farmers harvest (Federación Nacional de Cafeteros, 2017).

B. Coffee Leaf Rust

Coffee leaf rust (CLR) is a plant disease which is caused by the fungus *Hemileia vastatrix,* which affects most varietals of coffee but *C. Arabica* plants most severely (Avelino et al. 2015). The disease causes the plants to lose their leaves, which can then lead to the loss of entire branches or trees, causing severe crop losses. CLR was first recorded in Colombia in the 1970s, but effective use of pesticides prevented heavy losses, until the first outbreak of the disease from 1987-1988 (Avelino et al. 2015). The CLR outbreak which took place in Colombia from 2008 to 2011 was particularly devastating, causing an average crop loss of 31 percent (Bebber et al. 2016). Figure 3 shows yearly coffee production in Colombia, highlighting the years in which there was an outbreak of CLR in the country.

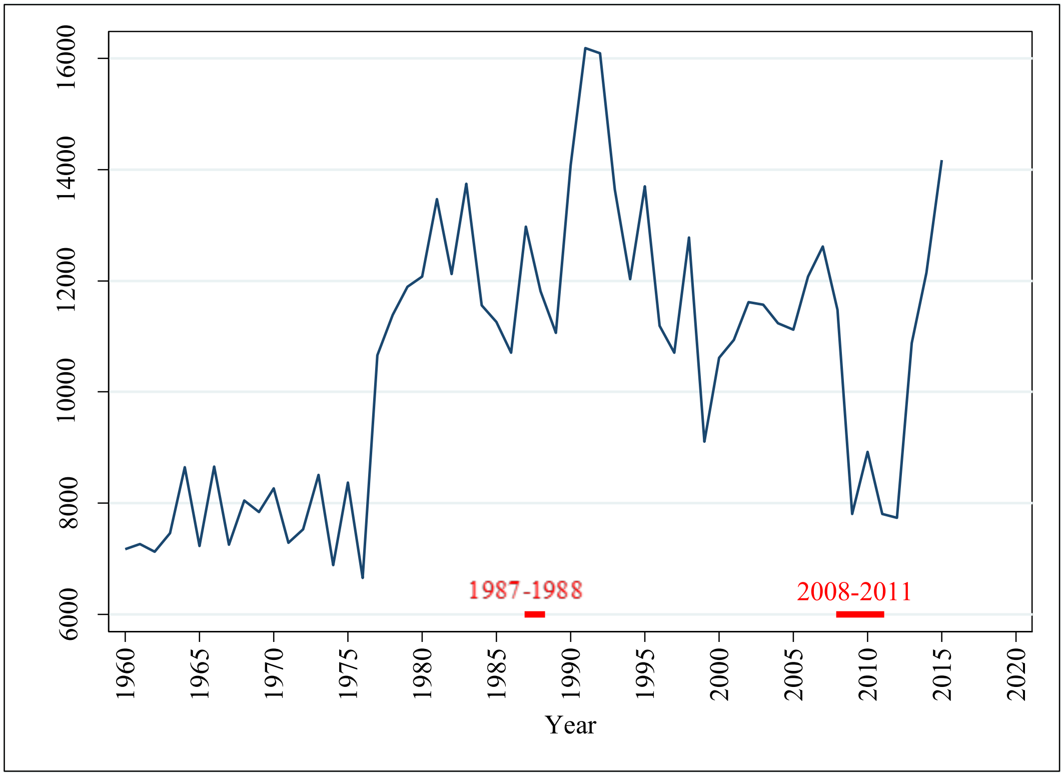

FIGURE 3. ANNUAL COFFEE PRODUCTION AND CLR OUTBREAKS, 1960-2015
Source: Federación Nacional de Cafeteros, 2017.

One of the chief causes of coffee leaf rust outbreaks is poor crop management in the past (Avelino et al. 2015). This is explained by the fact that all instances of outbreak – not just for Colombia but also for CLR outbreaks in Peru and Central America – follow drops in coffee commodity prices. Since coffee prices are known to be correlated with the intensity of the management of coffee plantations (Taugourdeau et al. 2014), lower prices contribute to lower investment in fertilizers and pesticides (Avelino et al. 2015), which in turn facilitate outbreaks of CLR. Yearly coffee prices per kg are shown in Figure 4. In both instances of CLR outbreak, there is a significant drop in coffee price in the years leading up to the outbreak. With the outbreak from 1987-1988, the fall in prices and the outbreak occurrence is almost immediate. The 2008-2011 outbreak, however, follows a several-year stagnation of low coffee prices, although prices had begun to rise again when the CLR outbreak began in Colombia.

In addition to affecting the likelihood of an outbreak of CLR, past coffee prices have a direct impact on the level of coffee production, since a lower coffee price in a past harvest means less profits for the *finca*, which correlates with less investment into the farm in the form of labor, pesticides, and fertilizers, and therefore a less successful yield at the farm during harvest. For these reasons, I will use lagged coffee prices as another instrument in my regressions. In this study I have used a one-year lag, but if I were to revise this project further, I would use a three-year lag.

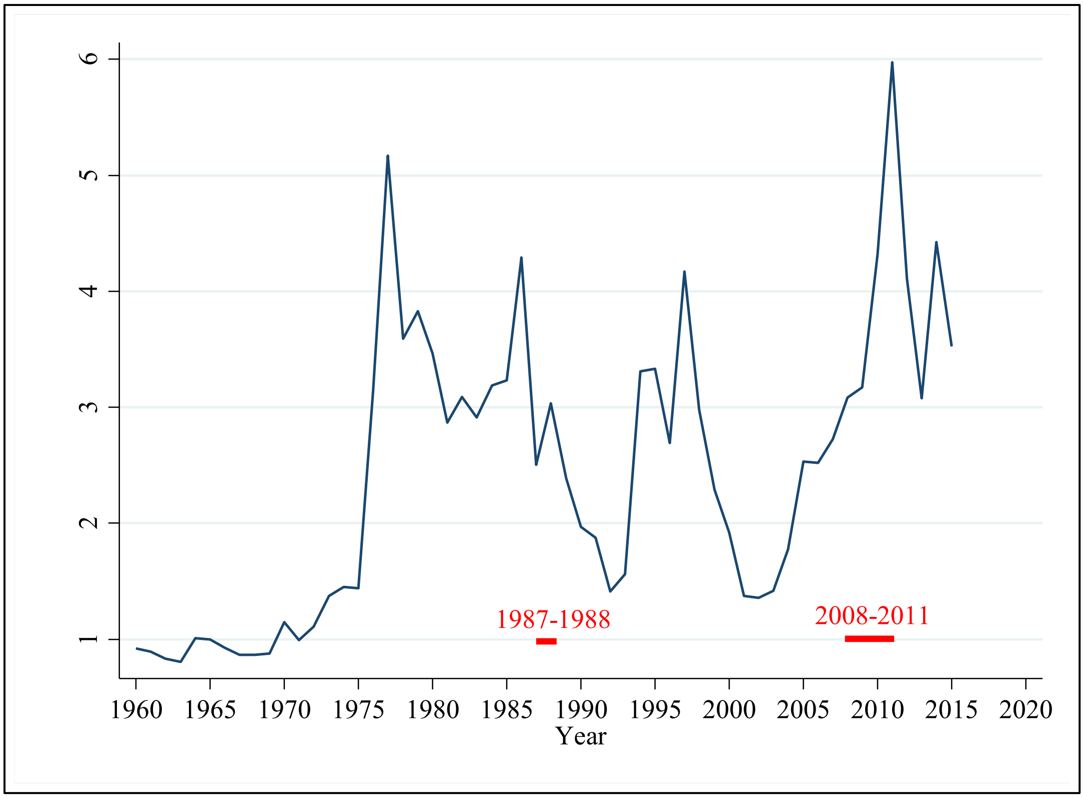

FIGURE 4. ANNUAL COFFEE ARABICA PRICES AND CLR OUTBREAKS, 1960-2015

Source: World Bank, 2015.

V. CONCEPTUAL FRAMEWORK

A. Conceptual Framework

In this study, I estimate the effects of coffee production on GDP, infant mortality rate, and secondary education enrollment. The chief explanatory channel for this is that as coffee production increases, coffee exports and the farmers' income increase. By definition, a rise in these components causes the nation's GDP to rise. And as farmers have more income, they can spend a larger proportion of their earnings on healthcare, which is expected to be seen through the infant mortality rate. For secondary education, there are two potential explanatory channels: first, it is possible that as farmers' incomes rise, they can afford to send their children away from the farms and into schools, increasing the enrollment rate. Or, by contrast, it is also possible that the opportunity cost of education is lower than that of coffee profits, and so when the farm increases coffee production, given that a large majority of Colombia's coffee farms are family-run (García, 2003) the farmers' children must help on the farm instead of going to school, thereby lowering the secondary enrollment rate.

Although in many developing countries, farmers face the risk of not being able to sell their crops, the FNC in Colombia has removed this threat for their farmers through the Guarantee of Purchase program. Because of this, it can be definitively said that coffee production directly influences private income, because farmers can sell all of their product to the FNC each harvest. Additionally, it is important to note that although the crop will always be purchased, the international coffee price fluctuates regularly, and therefore so does the price which the FNC offers to its farmers. Because of this, I will control for coffee price in all of my regression models.

B. Project Revisions

Were I to revise this project to make it more comprehensive, I would first amend my outcome variables. Since my motivation for studying coffee in Colombia is economic development for the poor, a potential way in which I could more directly assess this impact would be through a study of the income inequality in the coffee-growing regions over time. Since coffee production is heavily centralized in three departments (Kalmanoff et al. 1967), a regional analysis within Colombia could more precisely shed light on the relationship between coffee production and prosperity. This has also been studied by Barón (2010), but his paper focuses more on the geographic and climatic factors which contribute to these effects than on the effects themselves. A potential way in which I could study this is through the Gini coefficient, which measures income inequality in a given region, where the coefficient is zero in a region with perfect equality and one in a region where a single individual holds all of the wealth. I could gather Gini coefficient data over time for the coffee-growing departments, as well as some departments where coffee is not grown to use as controls, and then perform regressions to see if the regions' coffee production has an impact on improvements in equality.

There are two logic channels through which I could test the relationship between coffee production and regional income equality: private incomes and government expenditures. The theory for private incomes is the same that I have already utilized in this paper: as coffee production increases, so too do the farmers' incomes. When their income levels rise, the farmers gain access to better education and healthcare, which in theory lowers inequality in the region. The second potential explanatory channel is that of government expenditures. The theory would be that as coffee production rises, coffee exports rise and the government of Colombia's income rises through tariffs. As mentioned before, coffee tariffs have historically constituted large portions of Colombia's government revenues (Hanratty and Meditz, 1988). When government revenues rise as a result of coffee production, I could then test this channel by looking into the magnitude of government spending into education and healthcare in the coffee-producing regions, and then assess whether that investment then affects the Gini coefficient of inequality inside and outside of the coffee-growing departments. While altering my regression models, I would also add in more controls to account for improvements in wellbeing and inequality in the coffee-growing regions, such as foreign direct investment, unemployment, or even a lagged GDP level. These would help to better isolate the impact of coffee production on inequality in Colombia and to remove bias from my results.

In future revisions of this project, I would also like to take into consideration the social factors which may influence the effects of coffee production in the region over time. For example, Baron (2010) mentions that the climate in which coffee thrives is also a desirable climate for the *coca* plant. The Coffee Axis is bordered closely by the cities of Medellin and Cali, which were both home to large cocaine cartels at the end of the 20th century. This could impact my study in two ways: one, coca could be an opportunity crop for coffee farmers, and so there could be a relationship between coffee production and cocaine production in the country. Additionally, the existence of the cartels also made the regions extremely volatile and dangerous; this is perhaps something that I could measure through crime statistics or a corruption indicator and control for in my regressions.

VI. DATA AND METHODOLOGY

A. Data and Measurement

The data used in this paper includes monthly coffee production and export levels between 1960 and 2015, obtained from Colombia's Federación Nacional de Cafeteros. The dataset also includes national-level indicators for GDP, infant mortality, adult literacy, population growth, and coffee commodity prices, for the years 1960 to 2015 as available (World Bank 2015). To perform the regressions, monthly data have been aggregated to the yearly level. The instrumental is a binary indicator for CLR, set to one for the years in which there was a recorded outbreak of the disease: 1987-1988 and 2008-2011. Further, because coffee plants yield fruit on a biannual cycle as mentioned previously, and because the coffee production data used was originally monthly and then aggregated, the CLR variable is equal to one in the years immediately preceding and following the outbreaks. The CLR variable is equal to zero otherwise.

B. Empirical Methodology

As coffee production is likely an endogenous explanatory variable, the regression method used to estimate the impact of coffee in Colombia and account for endogeneity is a Two-Stage least squares regression. My instrumental variable is the outbreaks of CLR. Additionally, as I mention above, since coffee prices in year *t-1* are shown to affect the likelihood of an outbreak in year *t* (Avelino et al. 2015), I also use lagged coffee prices as an instrument. My 2SLS model (1) is thus the following:

$$\begin{aligned} \log y_t &= \mu + \alpha \log P_t + X_t'\gamma + \varepsilon_t , \\ \log P_t &= \zeta + \beta CLR_t + \lambda C_{t-1} + X_t'\delta + \upsilon_t , \end{aligned} \tag{1}$$

where y_t is Colombian GDP in year *t*. P_t is coffee production in year *t*. CLR_t is a binary variable equal to one if there was an outbreak in year *t* and zero otherwise. C_{t-1} is the lagged coffee price; that is, the average price of coffee in the previous year. X_t' is a vector variable which consists of other controls, such as life expectancy, year, and coffee price in time *t*. Additionally, after performing the regression with economic outcomes, I change the outcome variable for infant mortality rate and gross secondary-level educational enrollment rate, to estimate the impact of coffee on health and education in Colombia, respectively. Since these regressions do not use a logarithmic model, the regression model (2) is as follows:

$$\begin{aligned} y_t &= \mu + \alpha \log P_t + X_t'\gamma + \varepsilon_t , \\ \log P_t &= \zeta + \beta CLR_t + \lambda C_{t-1} + X_t'\delta + \upsilon_t , \end{aligned} \tag{2}$$

where each piece of the formula is the same, except y_t now refers to the health and education outcomes in place of GDP.

VII. REGRESSION RESULTS AND ANALYSIS

A. *Income Returns to Coffee Production*

First, I show the first-stage results, which test the strength of my instruments. The first stage of my 2SLS regression is summarized below, in Table 1. Notice that both of my instruments are relevant. CLR is statistically significant at the five percent level, and lagged coffee prices is statistically significant at the 10 percent level. Additionally, the magnitude of the CLR coefficient is worth noting: occurrence of CLR is associated with a decrease in coffee production of nearly 19 percent.

TABLE 1. FIRST STAGE REGRESSIONS

First-stage regressions

Number of obs	= 55
F(4, 50)	= 6.75
Prob > F	= 0.0002
R-squared	= 0.3506
Adj R-squared	= 0.2986
Root MSE	= 0.2008

lcoffeeprod	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
coffee	-.0192614	.0367951	-0.52	0.603	-.0931666	.0546438
year	.006774	.0021375	3.17	0.003	.0024807	.0110672
CLR	-.1894243	.0791071	-2.39	0.020	-.3483157	-.030533
coffee						
L1.	.0697113	.0365746	1.91	0.062	-.0037509	.1431735
_cons	-4.316964	4.210838	-1.03	0.310	-12.77468	4.140753

Notes: Variables are as follows: "coffee" is coffee price per kg, "year" is the time set, "CLR" is the binary CLR variable, "L1.coffee" is one-year lagged coffee prices, and "_cons" is the coefficient.

TABLE 2. ESTIMATED EFFECTS OF LOG COFFEE PRODUCTION ON LOG GDP

	(1) logGDP	(2) logGDP	(3) logGDP	(4) logGDP
lcoffeeprod	2.620***	0.467*	0.256*	0.344
	(3.62)	(2.29)	(2.08)	(1.79)
year		0.0328***	0.0317***	0.0494***
		(18.26)	(28.42)	(4.18)
coffee			0.0618***	0.0735***
			(6.47)	(6.32)
lifexp				-0.0584
				(-1.38)
_cons	-22.58***	-67.99***	-63.93***	-95.99***
	(-3.38)	(-29.78)	(-41.28)	(-4.30)
N	55	55	55	54

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Notes: Variables are as follows: "lcoffeeprod" is log coffee production, "year" is the time set, "coffee" is annual coffee price per kg "lifexp" is life expectancy, and "_cons" is the coefficient.

Table 2 summarizes the regression results from the second stage of the instrumental variable analysis, using equation (1). First, I run the regression without any control variables in column (1). Then, I add a control for year in column (2), the annual average coffee price per kilogram in (3), and finally life expectancy in (4). In (1), the estimated effect of a one percent increase in coffee production is a 2.6 percent increase in GDP, and this result is significant at the .001 level. However, by adding controls for year, coffee commodity price, and life expectancy, this estimator drops to .467 in (2), .256 in (3), and .344 in (4). However, as more controls are added, the statistical significance of the results diminishes; (2) and (3) are statistically significant at the five percent level, and (4) is only statistically significant at the 10 percent level. In general, however, these regression estimates show that there is a significant, positive relationship between the production of coffee and Colombian GDP.

B. Health Returns to Coffee Production

Using the same processes as before, I perform the same regression, but now substitute the outcome variable for the infant mortality rate in Colombia. The effect of coffee production on infant mortality is not statistically significant when controlling for other factors. In (1), before controlling for year or coffee prices, the effect appears to be high in intensity and statistically significant, showing that for every one percent increase in coffee production, the infant mortality rate decreases by 101.3 deaths per 1000 live births. This does not make sense, however; since 1960, the level of coffee production in Colombia has risen by around 100 percent, yet the infant mortality rate has dropped only from 89.3 deaths per 1000 live births in 1960 to 13.6 in 2015. This mentioned, the intensity of the effect diminishes greatly once controls are included in the regression. With all the controls added in (4), the impact of a 10 percent increase in coffee production is a decrease of .6 deaths per 1000 live births, but this effect is not statistically significant. Coffee production and infant mortality rate in Colombia are not significantly correlated.

TABLE 3. ESTIMATED EFFECTS OF LOG COFFEE PRODUCTION ON INFANT MORTALITY

	(1) infmort	(2) infmort	(3) infmort	(4) infmort
lcoffeeprod	-101.3***	-19.53*	-14.52	-6.349
	(-4.15)	(-2.32)	(-1.74)	(-1.26)
year		-1.273***	-1.240***	0.888**
		(-17.14)	(-16.46)	(2.86)
coffee			-1.594*	-0.0581
			(-2.47)	(-0.19)
lifexp				-7.203***
				(-6.48)
_cons	975.8***	2750.6***	2643.8***	-1183.6*
	(4.33)	(29.17)	(25.26)	(-2.01)
N	55	55	55	54

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Notes: Variables are as follows: "lcoffeeprod" is log coffee production, "year" is the time set, "coffee" is annual coffee price per kg "lifexp" is life expectancy, and "_cons" is the coefficient.

C. Education Returns to Coffee Production

Repeating the same processes again, yet this time substituting the outcome variable for the gross rate of secondary education attainment, the regression summary statistics are provided in Table 4:

TABLE 4. ESTIMATED EFFECTS OF LOG COFFEE PRODUCTION ON GROSS SECONDARY ENROLLMENT

	(1) secedu	(2) secedu	(3) secedu	(4) secedu
lcoffeeprod	-19.30	-18.95*	-20.69**	-24.21**
	(-0.32)	(-2.48)	(-2.94)	(-2.66)
year		1.833***	1.802***	1.461*
		(40.20)	(38.80)	(2.34)
coffee			1.251**	1.072
			(2.60)	(1.69)
lifexp				1.230
				(0.54)
_cons	239.4	-3414.5***	-3339.8***	-2711.6*
	(0.43)	(-42.11)	(-40.76)	(-2.32)
N	41	41	41	41

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Notes: Variables are as follows: “lcoffeeprod” is log coffee production, “year” is the time set, “coffee” is annual coffee price per kg “lifexp” is life expectancy, and “_cons” is the coefficient.

The estimated effects of log coffee production on the rate of secondary school enrollment are interesting; with all controls added, the estimated coefficient says that for a 10 percent increase of coffee production in Colombia, the gross ratio of enrollment decreases by roughly 2.4 points, and this result is statistically significant. With a baseline secondary enrollment ratio of around 40 percent in 2015, this decrease is equivalent to a drop in enrollment of six percent (World Bank 2015).

There are several potential reasons for these estimations. First, the gross enrollment rate conveys nothing of the actual quality of education or attendance by students; rather, it conveys only the number of yearly enrollees. The World Bank notes that in many developing countries, this rate may surpass 100 percent because of the high incidence of students who repeat grades (World Bank 2015). So it is possible that the negative estimated coefficient refers not to less students enrolling in school, but rather to a lower rate of grade-repeaters. The most likely explanation for this result, however, is that when coffee production increases, it is correlated with a higher number of secondary-age children staying home from school in order to help their parents on the *fincas.* As mentioned above, the large majority of coffee farms in Colombia are managed by families and operate on less than five hectares of land, and are therefore managed by families or small communities (García, 2003). There might also be a problem with my instruments being weak. For example, although CLR is shown to be a good instrument in the first-stage regression (not shown), lagged coffee price is not. The reason that the first-stage regressions have changed here is that there are less available observations for secondary enrollment than for GDP and infant mortality rate.

VIII. CONCLUSION AND COMMENTS

This study seeks to estimate the effects of coffee production in Colombia on income, health, and education, through the variables of GDP, infant mortality rate, and secondary school enrollment respectively. A 10 percent increase in the level of coffee production is associated with a statistically significant increase in GDP of approximately 3.4 percent. The level of coffee production is not significantly associated with infant mortality in Colombia. Lastly, a 10 percent increase in the level of coffee production is associated with a statistically significant decrease in the rate of secondary school enrollment of about 2.4 points, which is about six percent when compared to the baseline level of 40. For these reasons, I conclude that coffee production in Colombia is a proximate cause of GDP growth, while its impact on health is not significant and its impact on education is ambiguous and worth exploring more.

There are several factors that may hamper the robustness of the results presented. First, despite having annual or monthly data for most indicators from 1960 to 2015, for most of the variables used there were only 55 observations – and for some, even less. This lack of historical data is typical of developing nations, and as such the small size of this sample has a negative impact on the internal validity of this study. Further, when estimating the impact of coffee on GDP, there were also other controls that I originally included, such as unemployment, adult literacy, agricultural value added per worker and percentage of employment in agriculture. However, since some of these statistics had as few as ten or twelve observations, I was forced to omit them to have a manageable sample size. It is, therefore, worth exploring whether these results hold once other controls are added to the analysis.

Since the scope of this study is restricted only to Colombia, the external validity may be compromised in terms of the applicability of my findings to other countries. Also, as mentioned in the Introduction, coffee production in Colombia is focused most heavily in the three Departments which make up the Coffee Axis: Quindío, Risaralda, and Caldas. However, I was unable to find reliable data with which I might have isolated these regions and the effects of coffee production therein.

Regarding my personal motivation to study this topic, I have found through this study that the level of coffee production is correlated with increases in the GDP of Colombia. Additionally, through studying coffee leaf rust I have learned more about the relationship between agricultural efficiency and economic growth. Through this study, I have gained greater understanding of how coffee can affect the economy of a developing nation over time, which I plan to utilize in my own career to foster further economic development in Latin America.

IX. SOURCES

Avelino, J., Cristancho, M., Georgiou, S., Imbach, P., Aguilar, L., Bornemann, G., Läderach, P., Anzueto, F., Hruska, A. J., and Morales, C. (2015). The coffee rust crises in Colombia and Central America (2008-2013): Impacts, plausible causes and proposed solutions. Food Sec. 7:303-321.

Barón, J. D. (2010). Geografía, café y prosperidad en los Andes Occidentales de Colombia. Revista de Economía del Rosario. *13*(1), 117-190.

Bebber, D. P., Castillo, Á. D., & Gurr, S. J. (2016). Modelling coffee leaf rust risk in Colombia with climate reanalysis data. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *371*(1709), 20150458. http://doi.org/10.1098/rstb.2015.0458

Coffee in Colombia: Waking Up to an Opportunity. *Knowledge@Wharton* 2013, January 02. Retrieved from http://knowledge.wharton.upenn.edu/article/coffee-in-colombia-waking-up-to-an-opportunity/

FAO Statistical Coffee Pocketbook: 2015. (2015). Food and Agriculture Organization of the United Nations.

Estadísticas históricas. (2017). Federación Nacional de Cafeteros. Retrieved from https://www.federaciondecafeteros.org/particulares/es/quienes_somos/119_estadisticas_historicas/

García, J. (2003). Evolución de la distribución de las fincas cafeteras: hacia una regionalización de la caficultura colombiana. Federación Nacional de Cafeteros.

Gómez Sánchez, A. M., & Cadena Durán, O. L. (2016). Técnicas y tecnologías en campesinos caso de estudio: caficultores cocaleros en Miranda, Cauca, Colombia. *Revista Ingenierías Universidad De Medellin*, *15*(28), 13-33.

Hanratty, D. and Meditz S., editors. (1988). *Colombia: A Country Study*. Washington: GPO for the Library of Congress.

Historical Data on the Global Coffee Trade. (2017). International Coffee Organization. Retrieved from http://www.ico.org/new_historical.asp/

Kalmanoff, G., van Teutem, O., Egli, R., Griffin, K. B., and de Rosayro, R. A. (1967). The Coffee Economy of Colombia. International Bank for Reconstruction and Development. Catalog No. 68.

Otero, J. G. (2000). Coffee, economic fluctuations and stabilisation: an intertemporal disequilibrium model with capital market imperfections. Journal of Development Economics, *62* (2000) 105-129. doi:

Ramírez Bacca, R. (2010). Estudios e historiografía del café en Colombia, 1970-2008. Una revisión crítica. *Cuadernos De Desarrollo Rural*, *7*(64), 13-31.

Raju, S. S., & Melo, A. (2003). Money, real output, and deficit effects of coffee booms in Colombia. *Journal Of Policy Modeling*, *25*(9), 963. doi:10.1016/j.jpolmod.2003.09.001

Sánchez, F. J., & Hernández, G. A. (2004). Colombia: aumento de las exportaciones y sus efectos sobre el crecimiento, empleo y pobreza. *Desarrollo Y Sociedad*, (53), 193-226.

Schlewitz, A. (2004). States Make Coffee and Coffee Makes States: The Case of Guatemala, 1871-1966. *Conference Papers -- Midwestern Political Science Association*, N.PAG.

Taugourdeau, S., le Maire, G., Avelino, J., Jones, J. R., Ramirez, L. G., Jara Quesada, M., et al. (2014). Leaf area index as an indicator of ecosystem services and management practices: an application for coffee agroforestry. Agriculture, Ecosystems & Environment, 192, 19–37.

The Global Coffee Economy in Africa, Asia, and Latin America, 1500-1989. (2006). *Journal of Third World Studies*, *23*(1), 294-296

World Bank. (2015). *Country Indicators.* Retrieved from http://data.worldbank.org/