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IS MORTALITY IN DEVELOPING COUNTRIES PROCYCLICAL? HEALTH PRODUCTION AND THE VALUE OF TIME IN COLOMBIA'S COFFEE-GROWING REGIONS

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Abstract:

The inability to smooth consumption in developing countries is thought to make health vulnerable to sudden economic downturns. However, studies suggesting this relationship often examine events that influence health independently of economic conditions. This paper investigates how world coffee price shocks influence infant and child mortality in Colombia's coffee-growing regions. As in wealthy country studies, we find evidence of *procyclical* mortality and *countercyclical* health investments that appear linked to changes in the opportunity cost of time. These results suggest that in rural Colombia, (1) any adverse health consequences of reduced transitory income during bad economic times are dominated by increases in time-intensive health investments, and (2) the relative price of health may be a more powerful determinant of mortality than income.

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1. Introduction

A growing but controversial body of evidence documents pro-cyclical mortality in wealthy countries –death rates rise during times of economic prosperity and fall during recessions (Eyer 1977, Ruhm 2000, Chay and Greenstone 2003, Neumayer 2003, Deaton and Paxson 2004, Dehejia and Lleras-Muney 2004, Neumayer 2004, Fishback, Haines, and Kantor 2005, Ruhm 2005a and 2005b, Tapia Granados 2005).[1] Explanations for this phenomenon emphasize that economic downturns reduce the opportunity cost of time, moderate the consumption of harmful normal goods (like alcohol and tobacco), decrease pollutant emissions, and lower traffic fatality rates. If this empirical regularity extended to poor countries, it could modify traditional views about the harms caused by economic volatility and the inability to smooth consumption (Sen 1981, Behrman and Deolalikar 1988, Sen and Drèze 1989).

The institutional setting in developing countries is of course very different. In particular, the absence of mature insurance and inter-temporal markets suggests that mortality might instead be counter-cyclical. Informal insurance arrangements, precautionary saving, and the liquidation of productive assets do appear to help households to cope with sudden economic downturns. However, this protection is limited (Cochrane 1991, Paxson 1992 and 1993, Wolpin 1993, Townsend 1994 and 1995, Besley 1995, Morduch 1995, Kochar 1995 and 1999, Jacoby and Skoufias 1997, Gertler and Gruber 2002).[2] As a result, caloric intake and diet quality could deteriorate, households might switch cheaper but more harmful biomass fuels for cooking, and basic medical interventions may become less affordable during bad economic times.

[1] Research early in the twentieth century documented this phenomenon as well, but its seemingly counter-intuitive results were generally ignored (Ogburn and Thomas 1922, Thomas 1927). Some opposing evidence is provided by Brenner (1979), Gerdtham and Johannesson (2005), and van den Berg, Lindeboom, and Portrait (2006).

[2] These informal mechanisms and the portfolio-choice effects of exposure to risk can be costly, too (Wolpin 1993, Rosenzweig and Binswanger 1993, Rosenzweig and Wolpin 1993, Besley 1995, Morduch 1995, Chetty and Looney 2005).

This paper investigates how sudden, unexpected changes in world Arabica coffee prices during the first year of life are related to infant and child survival in Colombia's coffee-growing regions. Figure 1 shows that real world coffee prices since 1970 have been remarkably volatile, varying by as much as 40-45% of the long-run mean. Our specific approach relates erratic non-linear coffee price changes originating *outside of Colombia* to a cohort-based measure of mortality.[3] This measure has a number of important strengths, including freedom from notorious under-reporting in Colombia's vital registries (which presumably vary with economic conditions), coverage of fetal deaths, and the ability to capture lagged mortality.[4]

Related research in developing countries has generally utilized variation in economic circumstances linked to environmental conditions, fluctuations in world grain prices, and sudden financial crises (Lee 1981 and 1990, Galloway 1988, Livi Bacci 1991, Foster 1995, Palloni and Hill 1997, Pitt and Sigle 1998, Frankenberg, Thomas, and Beegle 1999, Rose 1999, Jensen 2000, Cameron 2002, Cutler et. al. 2002, Bengtsson 1999, Campbell, Lee et. al. 2004, Paxson and Schady 2004). However, all three sources of variation influence health independently of their effect on economic conditions.[5] Importantly, this is not true of world coffee price shocks. Because coffee also accounts for a negligible share of total household consumption, we conceptualize coffee price fluctuations as influencing health in two primary ways: (1) by decreasing (increasing) transitory income, and (2) by reducing (raising) the opportunity cost of time. Although we cannot separately identify each effect, they work in opposite directions, and we are able to estimate their combined influence.

[3] Our use of cohort size follows Jayachandran (2006).
[4] A variety of sources document substantial under-reporting in Colombia's mortality statistics, ranging from 30% to 45% or more (Florez and Mendez 1997, Medina and Martinez 1999, PAHO 1999, Urdinola 2004, Wilmoth forthcoming). See *Appendix 2* for indirect estimates of infant mortality under-reporting in Colombia between 1986 and 2000.
[5] Rainfall and flooding influence sanitary conditions and the reproduction of mosquito vectors responsible for disease transmission; grain and cereals are important inputs into health production; and financial crises often cause the collapse of public sector programs, including health programs.

In general, we find evidence of *procyclical* infant and child mortality in Colombia's coffee-growing regions over the past three decades. For the largest fluctuations on record, sudden coffee price increases (decreases) in one's county and year of birth were accompanied by 15% decreases (increases) in survival to age 5. In contrast with many studies of gender bias in intrahousehold resource allocation, there is no evidence of gender differences in these mortality changes (Rose, 1999). We also find support for an explanation based on the value of time in household health production (Grossman 1972): time-intensive child health investments (including vaccinations and prenatal care) are *countercyclical*, increasing as coffee prices fall and vice-versa. We postulate that other critical time-intensive health behaviors that we do not observe (like water boiling and basic hygienic) move with economic conditions and the opportunity cost of time in a similar way. With a one year lag, births are countercyclical as well – high (lower) prices are followed by fewer (more) births the following year – a pattern again suggesting the value of time to be an important determinant of vital events (prominently reported by Schultz (1985)). This explanation is also particularly sensible given that we find evidence of considerable consumption smoothing.

Within our empirical framework, any confounding influence must have varied in a very specific way – within counties over time (or across birth years) in the same erratic, non-linear way as world coffee prices, affecting only those born in coffee-growing areas in proportion to the size of the price shock and the importance of coffee in one's county of birth. The most natural concerns are: (1) that we mistake changes in the composition of births or women giving birth for mortality effects, and (2) that interacting plausibly exogenous price shocks with endogenous measures of coffee-growing intensity causes us to mistake selection for true behavioral responses to price shocks.[6] We present a variety of evidence suggesting that these concerns are unfounded. On the former, we restrict our analyses to cohorts already conceived at the time price shocks occurred, and we show direct evidence that that neither fertility nor the socio-economic characteristics of mothers giving birth changed in shock years. On the latter, we demonstrate that during stable coffee price years, infant and child survival do not vary with other price changes unrelated to coffee (like changes in the Colombian CPI) in a way that is systematically related to coffee-growing intensity.

We conclude by noting the implications of our findings for research on early life health injuries and later life outcomes, and we then cast our results in the context of broader debate about the wealth-health relationship (McKeown 1976, Pritchett and Summers 1996).[7] Beyond congruent wealthy country studies on the cyclicality of mortality, there is growing suggestion that the relative price of health is a more powerful determinant of mortality than income (Preston 1975 and 1980, Jamison et. al. 2001, Cutler and Miller 2005, Case and Deaton 2006, Cutler, Deaton, and Lleras-Muney 2006).[8] Our findings are consistent with this view, implying that the old adage "a rising tide lifts all boats" may not straightforwardly apply to health improvement in developing countries. In particular, policy efforts that aim to improve health may do well to target time costs as a salient part of the price of health.

2. Background: The Value of Time in Health Production and Coffee Cultivation in Colombia

2.1. Coffee Cultivation in Colombia

[6] Coffee cultivation cannot respond to price changes in less than 3-4 years (the biologically-determined amount of time between planting and first harvest for new coffee groves) (Ortiz 1999).
[7] The transitory income shocks that we examine are of course distinct from changes in permanent income.
[8] Related phenomena occur with education (Goldin 1999, Schady 2004, Kruger 2006) and fertility (Schultz 1985).

The Ecology of Coffee

Arabica *caturra* coffee (the predominant variety grown in Colombia since the early 1970s) is a tropical plant requiring very specific environmental conditions for cultivation: temperatures between 15 - 24° C, annual rainfall between 1500 and 2000 mm (depending on seasonal rainfall patterns and moisture retention of soil), slopes of certain degrees at high altitudes (over 1700m but below frost lines), and, depending on the circumstances, generous shade (Clifford and Wilson 1985). Tropical, high-altitude regions of Colombia are particularly well-suited for coffee cultivation, especially in the states of Antioquia, Quindio, and Riseralda. Most coffee-producing nations have a single annual harvest, but Colombia's unusual ecology and rainfall allows for two harvests each year in some areas – a primary harvest between October and December and a secondary one in April-May (or the reverse in a minority of areas). Figure 2 shows the geographic location of Colombia's coffee-growing regions during the 1970s and 1980s at the *municipio* (hereafter 'county') level.

Labor and Coffee Cultivation

Coffee cultivation requires considerable non-harvest maintenance, including weeding, pruning, fertilizing, pest control, and renovation (Ortiz 1999, Bacca 2002). With the introduction of green revolution coffee varieties (*caturra* in particular) and the arrival of new fungal parasites ("rusts") in Colombia during the 1970s and 1980s, non-harvest labor as a share of total labor has grown. During the harvest, coffee cherries must be picked immediately upon ripening to maximize their quality. Harvest windows for a given farm last approximately two weeks; during this period, picking cherries at their optimal stage of development can require visiting a single tree as many as eight times. After the harvest, coffee cherries must be processed (generally by the "wet" method in Colombia). This involves the use of pulping machines to soak and remove pulp from ripe cherries the day they are picked, fermenting the beans in tanks for 12-24 hours to loosen the remaining pulp and mucilage, washing to remove fermented residues, and drying either in the sun or using mechanical drying silos (CEDE 2002). This "parchment" coffee is then sold to distributors who mill and bag Colombia's "green" coffee beans for export and sale to roasters.[9]

Labor on Colombian coffee farms generally falls into one of three categories: small farm owners who supply their own non-harvest labor, day laborers who live nearby and work year-round on the same farm, and seasonal migrant farm workers.[10] Since Colombia's agrarian reforms during the 1960s, most coffee is grown on small farms of seven hectares or less (in 1997, average farm size was 1.7 hectares). This reduction in average farm size has made it possible for farm owners and their families to perform much of the non-harvest maintenance themselves. Larger farms also employ additional day-labor for in non-harvest seasons, paying piece-rates or hourly wages (depending on the season and task) to landless workers who live nearby (Ortiz 1999). Day-laborers are generally men, while many wives are hired to prepare meals for field workers and provide general support. Finally, picking ripe coffee cherries at optimal ripeness requires additional labor which is supplied by migrant harvest workers. These seasonal workers are mostly male and comprise a small but important part of the coffee workforce, moving from region to region for several months each year with the harvest (which varies according to altitude, rainfall, soil composition, etc.).

[9] "Parchment" coffee is dried coffee with a remaining hull or seed coat surrounding the bean. Once this hull is removed, the remaining "green" coffee is ready for export and roasting.

[10] Colombian coffee farms were historically larger and employed two types of labor: share-croppers or tenant farmers (*aggregados*) and seasonal migrant harvest workers (*enganchados*). The widespread rural violence from 1948 to 1964 (*La Violencia*), agrarian land reforms during the 1960s, and the adoption of green revolution technologies in the early 1970s (especially the switch from traditional to *Caturra* coffee varieties) led to the demise of tenancy farming and the rise of local day labor (Bacca 2002). *Caturra* coffee is more labor-intensive than its predecessors, especially in non-harvest maintenance.

For all three types of labor, the marginal return to working and opportunity cost of time move in the same direction as sudden world coffee price changes. Although microdata on local labor market conditions during the 1970s and 1980s is unavailable, analyses using three waves of a detailed panel survey of households conducted in 122 Colombian counties beginning in 2001 confirm this result. Parametric estimates presented in Section 5.2 imply that the largest negative coffee price shocks in the past three decades would be associated with a 5 percentage point decrease in the probability of working (nearly a 20% decline), an 11% reduction in women's wages, and 10 to 12 fewer hours of work per month.

The National Federation of Coffee Growers in Colombia

Until industrialization occurred during the 1970s, coffee was Colombia's leading export.[11] As a consequence, an unusual institutional arrangement to coordinate and manage coffee production developed in the form of the National Federation of Coffee Growers in Colombia (NFCG, or *Federacion Nacional de Cafeteros de Colombia*). The Federation was established as a cooperative organization of coffee growers in 1927, but coffee's importance in the Colombian economy has led the government to share in oversight and governance. It seeks both to promote the industrial interests of the Colombian coffee sector and to promote more broadly the welfare of coffee growers in rural regions historically neglected by government programs.[12] It also ensures that Colombia adheres to its coffee export quotas under standing International Coffee Agreements (treaties over time governing cartel-like behavior among coffee

[11] Throughout the last century, Colombia has been the world's second largest coffee producer (behind Brazil) and continues to be the largest producer of washed Arabica coffee beans (Palacios 1980, CEDE 2002). "Washed" (as opposed to "dry") coffee refers to coffee beans separated from cherries by the "wet" processing method.
[12] Coffee production is not taxed in Colombia, but in return, the National Federation of Coffee Growers invests a share of coffee sale proceeds in rural development projects (including school construction, electrification, etc.). The response of these investments to sudden coffee price changes occurs with a considerable time lag.

producing nations) and operates an internal price-support system for domestic growers. This system sets internal prices paid to growers as a function or world prices and partially shields them from international volatility, paying more than growers would otherwise during bad years and less during good years (net of export costs and other mark-ups).[13] These prices are uniform across the country – growers in all parts of Colombia are paid the same nominal price for their coffee at a given point in time. Figures 1a and 1b show how internal prices paid to Colombian coffee growers vary with world coffee prices.

2.2. Health Production and the Value of Time in Colombia

Recognition of the importance of time as an input into health production stems from early theoretical contributions on household production (Becker 1965, Grossman 1972). Subsequent empirical studies have emphasized the role of time in medical care utilization in the United States, particularly parents' time in pediatric care (Acton 1975, Colle and Grossman 1978, Goldman and Grossman 1978, Sindelar 1982, Coffey 1983, McClellan, McNeil, and Newhouse 1994, Vistnes and Hamilton 1995, Buchmueller, Jacobson, Wold 2006). The importance of time costs has also been prominent in policy efforts to improve "access" to health care services. For example, the widespread community health center movement in the United States advocated locating comprehensive health care facilities in poor neighborhoods, close to the communities they target, as a primary way to shift the supply of health care services outward (Schoor and English 1968, Levitan 1969, Geiger 1974, Starr 1982, Dievler and Giovannini 1998, GAO 2000, IOM 2000). The role of time in health production extends far beyond the use of health care service as well. In developing countries, time costs are central in household decisions about

[13] These prices are uniform across the country. FEDECAFE managed these price distortions and compliance with export quotas under International Coffee Agreements through stored reserves of coffee beans. In 2001, the price support system was partially dismantled because of sustained low world coffee prices (CEDE 2002).

drinking water sources, fuel and cooking technologies, breastfeeding, and other important health behaviors (Wolfe and Behrman 1987, Ewbank and Preston 1990, Cebu Study Team 1991, Guilkey and Stewart 1994, Smith et. al. 2000, Victora et. al. 2000, Ezzati and Kammen 2001, Black 2003, Ezzati et. al. 2004, Cutler and Miller 2005, Pokhrel et. al. 2005). These household choices are critical determinants of diarrheal disease and acute respiratory infections, the leading killers of children worldwide (Murray and Lopez 1997, WHO 2002, WHO 2005).

Before Colombia's massive health insurance reforms in 1993, health care services for poor Colombians were essentially "free" – no or very small fees were charged at the point-of-service by public clinics and hospitals supported by direct government subsidies. For Colombians living in rural areas, however, the time costs associated with seeking health care services were substantial. <ADD DETAILS ABOUT TRAVEL REQUIRED TO OBTAIN HEALTH CARE SERVICES IN RURAL COLOMBIA BEFORE LAW 100.> As in wealthy countries, policy efforts to increase health service use in developing countries like Colombia have emphasized the construction of health facilities in poor regions to reduce these costs (WHO 2000). However, only one study of which we are aware has explicitly investigated the link between the opportunity cost of time and the use of health care services in a developing country, documenting a negative association (Mwabu 1988).[14]

3. Data and Empirical Strategy

<u>3.1 Data</u>

We obtained average annual coffee prices for years 1970 to the present from the National Federation of Coffee Growers. Although household choices and local conditions do not

[14] One additional developing country study presents evidence on the trade-off between infant survival and the opportunity cost of time (Artadi 2005).

influence world prices (and hence the determination of internal prices), we focus our analyses on unexpected internal price shocks known to originate outside of Colombia.[15] As shown in Figures 1a and 1b, these are frosts that devastated Brazil's coffee harvest in 1975, a drought in Brazil in 1985, and the collapse of the International Coffee Agreement in 1989-1990 that led to the temporary abandonment of export quotas by 1991. All three supply shocks led to dramatic changes in Colombia's internal coffee prices by as much as 35% of the long-run mean. We do not examine price shocks in the late 1990s because our cohort-based measure of mortality is constructed using 1993 population census data.

Because prices paid to coffee growers do not vary by region, our identification strategy relies on the interaction between internal coffee prices and the intensity of local coffee production. We construct county-level intensity measures using the NFCG's decennial coffee censuses. For planning and monitoring purposes, the NFCG conducts decennial enumerations of all coffee farms in Colombia. We use this data from the early 1970s, early 1980s, and 1997 to measure hectares of coffee groves ("intensity") in each Colombian county, as shown in Figure 2.[16] (See the data appendix for a more complete description of this data.) The timing of the NFCG's coffee censuses is convenient because they were generally conducted a few years before each price shock that we analyze. Because coffee-growing intensity essentially cannot respond to price changes in less than four years (the biologically-determined amount of time required for

[15] Conducting our analyses using the entire coffee price series yields the same insights. More precisely, we focus on price changes that accompany unexpected new information about future coffee prices (the realization of climatic shocks in Brazil). In the case of the collapse of the International Coffee Agreement, we focus on the largest subsequent price reductions given initial uncertainty about how much each country would increase its coffee exports. Restricting the analyses to price shocks originating outside of Colombia is attractive because Colombia is a large exporter on world markets (accounting for 10-15% of world Arabica bean exports) (see Palacios 1980 and statistics available from the International Coffee Organization: http://www.ico.org/historical.asp).

[16] Our results are not sensitive to using alternative intensity measures including hectares of coffee as a share of all municipal farmland and hectares of coffee per capita. For each price shock, we use the immediately preceding coffee census: the 1970s census for the 1975 Brazilian frost and the 1980s census for the 1985 Brazilian drought and the 1990 ICA collapse.

new coffee groves to produce their first fruit), our hectares of coffee measures can reasonably be assumed to apply to shock years (Ortiz 1999, International Coffee Organization personal communication). Using the 1993 Colombian population census, Panel A of Table 1 shows descriptive statistics for all of Colombia's counties and for counties with and without coffee cultivation separately.

To estimate how infant and child mortality in Colombia's coffee-growing regions move with coffee prices and coffee-growing intensity, we employ a cohort-based measure of cumulative mortality using the complete (100%) 1993 Colombian population census. Specifically, because we analyze price variation at the county by birth year level, we construct county by birth year population counts. Cohort size is determined by three population processes: birth, death, and migration. We isolate deaths from the other two by restricting our analyses to those conceived before a price shock occurred (to remove fertility effects) and by constructing cohort size counts according to county of birth (rather than county of residence).[17] Because our cohort size measures can only be based on year (rather than month) of birth, however, the concern may nevertheless remain that they capture some small degree of fertility responses to price shocks (children born in the last three months of the year could have been conceived in the same year). Two types of evidence suggest that this concern is not valid. One is that the price shocks analyzed occurred mid-year, so fertility responses would only apply to those born the following year. The other is more direct: Section 5 presents analyses of how birth intervals and the socio-economic composition of women giving birth change in price shock years in our restricted sample. They demonstrate no relationship, further suggesting this concern to be unfounded.

[17] This mortality measure follows Jayachandran (2006). The 1985 population census did not collect information about county of birth, and the 1973 census was conducted before the price shocks analyzed in this paper.

Our cohort-based measure of mortality is preferable to other available measures for a variety of reasons. First, it provides information on deaths not contaminated by under-reporting. As in many developing countries, Colombia's vital statistics are plagued by substantial under-reporting (Florez and Mendez 1997, PAHO 1999, Urdinola 2004, Wilmoth et. al. forthcoming). As shown in *Appendix 2*, indirect mortality estimates suggest that under-reporting rates range from 30% to 45% or more. Importantly, these omissions are likely to be correlated with economic conditions rather than remaining fixed over time (Medina and Martinez 1999).[18] Second, they capture fetal deaths.[19] Changes in maternal health investments (like nutrition) linked to economic conditions influence fetal mortality, but vital registries do not capture them. Third, they are complete, reflecting the experiences of Colombia's entire population – this is especially important given that coffee cultivation occurs in many remote rural areas that are difficult to study using other data sources. Fourth, mortality measures based on cohort size reflect cumulative mortality, capturing potentially important lagged deaths attributable to economic shocks.

Even without formally estimating the association between cohort size and coffee prices, suggestive patterns of procyclical mortality (or countercyclical cohort size) are graphically evident. Figure 3a plots internal coffee prices and the average difference in residual birth cohort size (net of year fixed effects) between counties with above- and below- median land area dedicated to coffee cultivation (these counties are shown in Figure 2).[20] Although this plot includes all birth cohorts and therefore does not distinguish between changes in fertility and

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[18] Mortality under-reporting in developing countries is a notorious problem (PAHO 1999, Wilmoth et. al., forthcoming), especially for infants and children. In Colombia, the under-reporting of infant mortality has been shown to be related to economic circumstances (Florez and Mendez 1997, Medina and Martinez 1999, Florez 2000).
[19] Cohort size also captures abortions. Reliable data on abortions in Colombia is not available (abortion is illegal), but any bias due to unobserved abortions would take the opposite sign of the estimates we present in Section 4.
[20] Figures 3 and 4 are constructed using municipal area dedicated to coffee cultivation in the 1980s; constructing these graphs using coffee area in the 1970s yields the same pattern.

changes in mortality, it clearly shows a general pattern of countercyclical cohort size. Figure 3b shows no such relationship between coffee prices and residual cohort size in areas not cultivating coffee. Furthermore, Colombia's mortality statistics show the same pattern as well (despite their serious limitations). Appendix Figure 1 plots internal coffee prices and the average difference in residual infant deaths (net of year fixed effects) between counties with above- and below-median coffee-growing intensity. The result is again the same – a pattern of procyclical mortality.[21]

To analyze how specific health investments (not just health outcomes) and related behaviors respond to coffee price shocks, we employ Colombia's Demographic and Health Surveys (DHS). These surveys contain detailed pregnancy and child health histories for nationally-representative samples of women of reproductive age (defined as 15-49) in 1986, 1990, 1995, and 2000. We pool all four waves together to create a sample of child-level records that includes birth dates, maternal characteristics, preceding birth intervals, and detailed child health investment histories. Specific investments include maternal use of prenatal care, prenatal tetanus vaccinations, breastfeeding duration, and a variety of child vaccinations (BCG, polio, DPT, and measles).[22] Women report this information for each of their children (regardless of whether or not they are alive at the time of the survey) with the exception of child health histories, which were reported only for children born within five years of the survey in early

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[21] Digitized mortality statistics in Colombia are only available for years 1979 and later.

[22] Developed in the 1930s, *Bacille Calmette Guerin* (BCG) is reduces the likelihood and severity of tuberculosis in infants and young children. It is the most widely used vaccine in the world and the only available preventive tuberculosis vaccination. DPT stands for diphtheria, pertussis (or whooping cough), and tetanus and is a mixture of vaccines for all three infectious diseases. Polio and measles vaccines are preventive vaccines that protect against these respective diseases. The World Health Organization recommends all of these vaccines before the age of one (although the measles vaccine is recommended beginning at 12 months in the United States). The WHO's initial EPI (Expanded Programme on Immunization) initiative launched in 1974 focuses on these vaccines and has more recently expanded to encompass vaccination against yellow fever and hepatitis B. Prenatal tetanus toxoid immunization protects newborns against neonatal tetanus, a leading killer of newborns in developing countries linked to non-sterile delivery.

waves. The middle panel of Table 1 shows descriptive statistics for Colombian children and their mothers in the pooled DHS sample.

Finally, to investigate directly how local labor market conditions – and the opportunity cost of time – change with coffee price fluctuation, we use a panel survey of households conducted to evaluate Colombia's *Familias en Acción* program (a conditional cash transfer program analogous to Mexico's *Oportunidades* program). The survey was first administered to 11,502 households in 122 Colombian counties in 2002; follow-up surveys conducted in 2003 and 2005. Attrition rates for the two follow-up surveys relative to the first wave were 6.3% and 17.1%; the probability that a household is not followed through all waves is not correlated with intensity of coffee cultivation.[23] Topical modules broadly covered household demographic characteristics and composition, consumption, income, school attendance and educational attainment, labor force participation, and health. Although this data was collected after the major coffee price shocks that we study in this paper, it contains complementary information not available from other sources on employment, wages, hours worked, consumption, income, and travel time to health care facilities. The bottom panel of Table 1 shows descriptive statistics for children in the *Familias en Acción* sample (with parental, household, and county-level characteristics matched to them). All data sources are described in further detail in the data appendix.

3.2 Empirical Strategy

Our basic approach relates sudden coffee price changes in individual counties and years to cohort size among those born in that county and year. More precisely, in a cohort study framework, we estimate how birth cohort size changes from year to year in a way that is

[23] For more discussion of missing data in the *Familias en Acción* survey, see Attanasio and Vera-Hernández (2004).

proportionate both (i.) to internal coffee price changes and (ii.) to the importance of coffee in that county's local economy (captured by farmland dedicated to coffee cultivation). Our specific measure of the impact of coffee prices utilizes both sources of variation simultaneously. Constructed at the county-birth year level for counties (*municipios*) m and birth cohorts c, we implement this measure as:

(Coffee-growing intensity in first year of life)$_m$ × *(Internal coffee price in first year of life)*$_c$.

For simplicity, we write this term as: $(g_m \times p_c)$.[24] This strategy also exploits the fact that health is considerably more fragile while *in utero* and during the first year of life than during the second or subsequent years (Johnson, Moore, and Jeffries 1978, Barker 1992, Gazelian, Henry, and Olin 1992, Dietert et. al. 2000, Selevan, Kimmel, and Mendola 2000, National Center for Health Statistics 2002, Wise 2004, Jayachandran 2006).[25] Because consecutive birth cohorts experience nearly identical conditions at every age except for the first year, we associate differences in cumulative survival between them with our coffee price measure during this critical year.

We analyze each price shock shown in Figure 1 separately: the 1975 Brazilian frosts, the 1985 Brazilian drought, and the 1991 internal price collapse following the 1989/90 abandonment of International Coffee Agreement export quotas. We first restrict our analyses to samples of those in their first two years of life (age 0-1 and age 1-2) at the time that a world price shock occurred (to purge the influence of fertility from our cohort-size measure of mortality). Specifically, we estimate:

(1) $$ln(s_{cm}) = \alpha + \lambda(g_m \times p_c) + \delta_m + \delta_c + \varepsilon_{cm},$$

[24] Note that this product equals zero for counties with no coffee cultivation. Coffee prices are in real terms. Dube and Vargas (2006) independently developed a similar measure of coffee price shocks in Colombia.

[25] Death rates at ages 0-1 in the United States are at least fifteen times greater than at ages 1-2 (National Center for Health Statistics 2002), and age gradient in mortality is thought to be steeper in Colombia (Departamento Administrativo Nacional de Estadistica personal communication, World Health Organization 2005). Selective attrition is thought to play little role in explaining this difference and would only make it more difficult for us to detect statistically meaningful mortality changes.

where s is the size of birth cohort c born in county m, δ_m and δ_c represent county and birth cohort fixed effects, and the parameter of interest is λ. To test for changes in intrahousehold resource allocation that differ by a child's gender when a price shock occurs, we also estimate equation 1 separately for males and females.

Next, using samples of those in their first three (rather than first two) years of life when a shock occurred (ages 0-1, 1-2, and 2-3), we re-estimate variants of equation 1 that include county-specific linear time trends.[26] In addition, we conduct pooled analyses that utilize all three price shocks simultaneously. This allows us to compare the survival of children who experienced different price shocks of different signs and magnitudes but at the same age and in the same county.

After establishing how cohort size and cumulative mortality co-vary with birth year coffee prices, we then explore a value of time explanation for these results by estimating variants of equation 1 using child-level DHS records (again restricted to two consecutive cohorts of children already conceived or older when a price shock occurred). Most health investment measures are dichotomous, so we generally employ probit models of the following general form for children i, birth cohorts c, and counties (*municipios*) m:

$$(2) \qquad \Pr(b_{icm} = 1) = \Phi\left[\alpha + \lambda(g_m \times p_c) + \sum_k \phi_k w_{ik} + \delta_m + \delta_c + \varepsilon_{icm}\right],$$

where $\Phi[\cdot]$ is the standard normal cumulative density function, b is a dichotomous outcome of interest (receipt of a prenatal tetanus toxoid vaccine, prenatal care, medical birth assistance, BCG vaccine, DPT vaccine, polio vaccine, or measles vaccine), w is a vector of maternal characteristics (mother's age, education, number of household members, number of preceding

[26] Using samples of those in their first three years of life in price shock years, we estimate: $ln(s_{cm}) = \alpha + \lambda(g_m \times p_c) + \delta_m + \delta_c + \delta_m \times c + \varepsilon_{cm}$, where $\delta_m \times c$ represents municipal-specific linear trends and all other variables are defined as in equation 1.

births, age at first birth, and age at first marriage), and all other variables are defined as in equation 1.[27]

Finally, although collected after the major coffee price shocks that this paper examines, we use the *Familias en Acción* data to directly investigate the relationship between coffee prices and labor market outcomes underlying time-intensive child health investment decisions. Specifically, for adult individuals i in years y and counties m, we estimate:

(3) $$o_{iym} = \alpha + \beta g_m + \pi p_y + \lambda(g_m \times p_y) + \delta_m + \delta_y + \delta_m \times y + \varepsilon_{iym},$$

where o is a labor market outcome, g is county-level coffee-growing intensity (hectares of coffee cultivation in 1997), p is the real internal Colombian coffee price in year y, and δ_m, δ_y, and $\delta_m \times y$ represent county and year fixed effects and county-specific linear time trends (respectively). Specific labor market outcomes examined separately for mothers and household heads include ln(wage), whether or not one worked for pay the week prior to the survey, and hours of paid work in the past month (both unconditionally and conditional on working for pay in the past week).

4. Results

4.1 Mortality Results

We first present graphical evidence on the relationship between coffee price shocks and cohort size. For each price shock that we examine, Figures 4a, 4b, and 4c show how each county's change in cohort size (in percent terms from the preceding year) varies with intensity of coffee cultivation. In all instances, the correlation between percent change in cohort size and coffee cultivation is visibly negative. Sudden price increases in 1975 and 1985 were

[27] The results are not sensitive to conditioning on maternal characteristics; Section 5 presents evidence that the composition of mothers did not change with coffee price shocks in this sample.

accompanied by cohort size changes that fall with intensity of cultivation. Similarly, the sudden price decrease in 1991 was accompanied by cohort size changes that grow with cultivation intensity.

Table 2 then shows estimates of λ (the coefficient on the interaction between county-level coffee-growing intensity and coffee price in the first year of life) obtained by estimating equation 1. The panels report results for different price shocks (1975, 1985, and 1991), and the columns correspond to different samples and specifications (those ages 0-2 at the time of a price shock, those ages 0-3 at the time of a shock, and those ages 0-3 while also conditioning on municipal-specific linear time trends, respectively). Because the dependent variable is in logarithmic form, coefficient estimates can roughly be interpreted as percent changes in cohort size associated with marginal changes in coffee prices and coffee-growing intensity. To aid in interpretation, implied changes in cohort size are also shown for median coffee-growing intensity (roughly 250 hectares) and a 500 peso price change.[28]

In general, Table 2 presents evidence that infant and child mortality move in the same direction as coffee prices for both price increases (1975 and 1985) and decreases (1991).[29] In other words, mortality increases as prices rise and decrease as prices fall (or cohort size falls as prices rise and vice-versa). Implied changes in cohort size range from about -0.4% to more than -2.0%. Although cohort size in 1993 is a measure of cumulative mortality, Table 2 suggests that deaths linked to coffee price fluctuations generally occur at young ages (the 1985 shock estimates are not smaller than the 1975 shock estimates, but the 1991 ones are smaller than the 1985 ones). Under the assumption that all excess mortality related to price shocks occurs by age

[28] The distribution of county-level coffee hectares is heavily right-skewed; the estimates shown in Table 2 are robust to the inclusion/exclusion of outliers.
[29] The single exception is the 1991 price shock estimate in the sample of those ages 0-3 at the time of the shock conditional on municipal-specific time trends.

five, our estimates imply that the largest price fluctuations are associated with changes in child survival of up to 16%.[30]

Table 3 shows estimates of λ obtained by estimating equation 1 separately for males and females. In contrast with other studies of consumption smoothing, intrahousehold resource allocation, and child mortality (Rose 1999), we find no evidence of statistically meaningful differences in survival between boys and girls. This equivalence of results by children's gender is generally consistent with other suggestions of little gender bias in intrahousehold resource allocation in Colombia (PROFAMILIA 2005).

Changes in infant and child survival correlated with coffee price fluctuations are also surprisingly linear across the distribution of coffee cultivation. Figures 4a, 4b, and 4c show that nonparametric and linear regression lines for each price shock are virtually indistinguishable. The only visibly noticeable exception occurs in the right tail of the coffee cultivation distribution with the 1991 price shock. However, results not shown indicate that estimates of λ in equation 1 are not statistically different from each other across quartiles or deciles of the coffee cultivation distribution.

4.2 Validity Tests

Before investigating why infant and child mortality in rural Colombia is procyclical, we first attempt to better establish that this relationship is not spurious. Any confounding influence in our analyses would have to vary in a very specific way – over time (across birth cohorts) in the same erratic, non-linear way as world coffee prices, affecting only those born in coffee-

[30] For a mean birth year by county cell size of 617, a 1% reduction implies 6.17 fewer people or 10 fewer people per 1,000. Mortality under age 5 in Colombia was about 60 per 1,000 in 1980 (Hill, Pande, Mahy, and Jones 1999); 10/60≈16%. Presumably some excess mortality occurs after age 5, so this is a slight overstatement of the true change in survival.

growing areas in a manner proportionate both to coffee price shocks and coffee-growing intensity. The most natural concerns are: (1) that we mistake changes in the composition of births or the composition of women giving birth for true mortality effects, or (2) that selection into areas with varying coffee-growing intensity biases the estimates shown in Tables 2 and 3. This section presents a variety of validity tests that investigate – but fail to corroborate – such concerns.

We first consider how coffee price shocks may alter the composition of births or the types of women giving birth. Models of fertility predict that changes in economic conditions should differentially influence the fertility of women with varying opportunity costs of time (as measured by socioeconomic status, for example) (Becker and Lewis 1973, Ben-Porath 1973, Becker 1981, Butz and Ward 1979, Perry 2003, Dehejia and Lleras-Muney 2004). We address potential changes in the composition of women giving birth by restricting our analyses to children already conceived at the time a price shock occurred (children in their first or second year of life in shock years). However, because we only know children's year of birth, we also investigate the possibility of confounding compositional changes directly. Exploiting detailed information on maternal characteristics available in the Demographic and Health Surveys, we use samples of children ages 0-2 in shock years to regress measures of maternal socio-economic status on coffee price in the first year of life, coffee-growing intensity, and their interaction as in equation 1.

Table 4 shows coefficient estimates for the interaction between price and intensity. There is no evidence of any change in the composition of mothers' age, education, age at first birth, age at first marriage, preceding number of births, or number of household members. Similarly, estimates for preceding birth intervals are statistically indistinguishable from zero, suggesting no within-mother selection of births. Other confounding compositional changes should also be evident in these analyses. These include differential migration induced by price shocks and selective mortality among mothers or fertile women. Table 4 provides no evidence of any of these changes.

We then explore how selection into counties with varying coffee-growing intensity that preceded price shocks might bias our main results. Although coffee price shocks originating outside of Colombia are plausibly exogenous, their impact is also assumed to vary with municipal-level coffee-growing intensity. A natural concern is that Colombians sort themselves into counties with varying coffee-growing intensity according to unobserved characteristics related to price responsiveness and child survival. We condition on both fixed and time varying differences across counties, and time-varying changes in the composition of women giving birth (through migration or selective mortality, for example) would be evident in Table 4. However, unobserved differences that influence the type or magnitude of behavioral responses to price shocks (such as the degree of risk aversion) may still be problematic. A testable implication of this concern is that if people in counties with varying coffee-growing intensity were subjected to the same price shock (i.e., one whose impact should not vary with coffee-growing intensity), they would respond differently in ways that influence infant/child survival.

To test this concern, we replace internal coffee prices with the Colombian CPI and re-estimate equation 1 using stable coffee price years (1968-69, 1982-83, and 1988-89). During these years, Colombian consumer prices changed by 7%, 20%, and 26% (respectively).[31] Table 5 presents coefficient estimates for the interaction between CPI in the first year of life and coffee-growing intensity. None are statistically distinguishable from zero.

[31] See: http://www.banrep.gov.co/econome/dsbb/i_srea_012.xls

5. Why Is Infant/Child Mortality Procyclical?

Three major explanations for procyclical mortality in developed countries have been proposed: changes in the opportunity cost of time, changes in the consumption of harmful normal goods (like alcohol and tobacco), and changes in the emission of pollutants linked to economic activity (Ruhm 2000 and 2003, Chay and Greenstone 2003, Neumayer 2003, Deaton and Paxson 2004, Dehejia and Lleras-Muney 2004). There is little industrial pollution in Colombia's rural coffee-growing regions, and alcohol and tobacco consumption are unlikely to be important causes of infant and child death (although maternal drinking and second-hand smoke can influence survival). This section explores the hypothesis that procyclical changes in the value of time play an important role in explaining the results in Tables 2 and 3.

5.1 Evidence from Colombia's Demographic and Health Surveys

If time is an important input into the production of health (Grossman 1972), then time-intensive health investments should be countercyclical (as the opportunity cost of time falls during bad economic times, health investments should increase). The use of preventive health services is an important form of health investment in developing countries, especially for children (UNICEF 2003). In particular, many important preventive services are administered to children at very young ages – ages that are the specific focus of this paper. Moreover, health care services in rural Colombia were almost exclusively provided by heavily subsidized public facilities until the mid-1990s. This means that the financial costs of services were trivial, while the time costs of seeking services from distant clinics accounted for a large share of the price of health care.

Capitalizing on the fact that Colombia's Demographic and Health Surveys report detailed information about preventive health care use in infancy and childhood, we are able to directly estimate how time-intensive health investments vary with coffee prices. Table 6 reports marginal probabilities corresponding to estimates of λ (evaluated at the mean of the independent variables) obtained from equation 2.[32] Although our sample sizes are small, all estimates that are distinguishable from zero are negative, implying that children are more likely to receive health investments when coffee prices are low (and disproportionately more in areas with more coffee). For a county with median coffee-growing intensity experiencing a 500 peso price change, the implied changes in the probability of receiving specific health investments are 13.5 percentage points for prenatal tetanus vaccinations in 1985, 0.2 percentage points for polio vaccines in 1985, and 8.4 percentage points for prenatal care in 1991. Using means in our pooled DHS sample, these correspond to percent changes of 16%, 0.2%, and 10%, respectively. There are many other time-intensive hygienic behaviors that presumably also respond to changes in the opportunity cost of time.

If cyclical changes in the value of time are an important explanation for our major findings, it should also be possible to detect congruent fertility changes. Specifically, women should be more likely to become pregnant in low price years and less likely to become pregnant in high price years (Becker and Lewis 1973, Becker 1981, Schultz 1985). In Colombia's Demographic and Health Survey data, this should be evident as decreases (increases) in preceding birth intervals among children born the year after price declines (increases). To

[32] Sample sizes for the 1985 price shock analyses are smaller because early DHS waves only report health investments for children born within five years of the survey date. For this reason, the 1975 price shock cannot be analyzed. In addition, as later waves that reported health investment information for all children – not just those born within five years of the survey date – did so for some investments (primarily prenatal and neonatal) but not others. Although some child vaccination campaigns linked to UNICEF's GOBI initiative during the 1980s were conducted independently of health care infrastructure, most vaccination still occurred in rural health care facilities.

explore how birth intervals varied with coffee prices, we estimate equations closely akin to equation 2 using samples of children who were *conceived* either in the year that a price shock occurred or the preceding year. Specifically, we regress preceding birth intervals on internal coffee prices at age -1 (the year of conception), municipal-level coffee-growing intensity, their interaction, and the same set of other covariates. Table 7 reports marginal probabilities for estimates of the interaction term evaluated at the mean of the independent variables. Estimates for the 1985 and 1991 price shocks are positive, implying that in counties with median coffee-growing intensity, a 500 peso price decline was associated with birth intervals that were 2.7 and 6.0 months shorter, respectively.[33]

5.2 Evidence from the *Familias en Acción* Surveys

Direct evidence on how local labor market conditions respond to coffee prices should also be consistent with the value of time hypothesis. Although microdata on labor market outcomes during the 1970s and 1980s is unavailable, Table 8 reports estimates of λ obtained by estimating equation 3 with *Familias en Acción* survey data collected between 2002 and 2005.[34] Although coffee prices fluctuations between 2002 and 2005 are considerably smaller than the major price shocks analyzed throughout the paper, labor market conditions move as expected. Specifically, for women in a median coffee cultivation county, the first row shows that the dollar equivalent of a 500 peso price decline is associated with an 11% decline in wages (shown under "Implied Change"). For men, the estimates in the second row are somewhat larger but are statistically indistinguishable from zero. Calculated using estimates from a probit model, the

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[33] These results are also in sensitive to controlling for parity.

[34] Because 2005 price data is available from the International Coffee Organization (ICO) but not the NFCG, we use ICO price data in real US dollars for the *Familias en Acción* analyses. The results shown are robust to the inclusion of individual-level controls for socio-economic status, demographics, and family composition.

third and fourth rows show that the same price decline is associated with a 5 percentage point decrease (or 18% decline) in the probability that either a mother or a household head worked for pay during the preceding week. The fifth and sixth rows shows that for mothers and household heads in median coffee cultivation counties, large negative price shocks are associated with working 10 and 12 fewer hours per month, respectively.[35] Conditional on working the week prior to the survey, the reduction in hours worked are statistically indistinguishable from the unconditional estimates but are not themselves statistically different from zero at conventional significance levels (sample sizes are smaller). Taken together, these results indicate that falling coffee prices reduce the opportunity cost of time considerably as employment, wages, and hours of work fall.

We also examine the *Familias en Acción* surveys' explicit measure of travel time (in minutes) to health facilities. These analyses should be interpreted cautiously: we do not have plausibly exogenous variation in travel time, our measure is reported by respondents but not verified, and our only reasonably health service measure is infant and child growth monitoring (i.e., "check-ups").[36] Nevertheless, Appendix Table 1 shows that the correlation between travel time to health facilities and health service use is negative, statistically significant, and remarkably robust to the inclusion of an unusually rich set of covariates described in the table. (For a detailed discussion of the validity of assuming orthogonality between travel time to facilities in rural Colombia and other determinants of service use, see Attanasio and Vera-

[35] About 10% of household heads and 18% of mothers are missing data for hours worked. Missing data is not correlated with intensity of coffee cultivation – for more discussion of missing data in the *Familias en Acción* survey, see Attanasio and Vera-Hernández (2004). The estimates presented in Table 8 are insensitive to restricting the analyses to women with complete data for all variables examined.

[36] The only other health service measure available in the *Familias en Acción* data DPT immunization rates, but because childhood immunization delivery was removed from the regular responsibilities of health facilities in 1993 – and therefore should be unrelated to travel time – we do not examine it.

Hernández 2004.) Given that rural travel to health facilities during the 1970s and 1980s often involved a daylong investment of time, the magnitude of these estimates is reasonable.

Finally, regressions (not shown) of log household consumption on log household income, conditional on household fixed effects, yield estimated elasticities of about 0.10. These estimates imply considerable – but certainly not complete – consumption smoothing in rural Colombia.

6. Conclusion

This paper presents new evidence of procyclical infant and child mortality in developing countries. Unlike previous research, it exploits economic variation not directly related to health except through economic circumstances. It suggests that during sudden economic downturns, any adverse health consequences of incomplete consumption smoothing are dominated by increases in time-intensive health investments. These findings are consistent with a more general explanation for procyclical mortality based on the value of time. We postulate that other important but unobserved health behaviors also move with economic conditions in a similar way. For example, simple hygienic health behaviors like water boiling and food washing are time-intensive activities thought to have a large impact on infant and child survival (Ewbank and Preston 1990, Preston and Haines 1991, Glewwe 1999, Miller 2006). Other studies focusing on education report similar patterns of countercyclical investments in children and similarly invoke the opportunity cost of time (Goldin 1999, Schady 2004, Kruger 2006).

Our results also have important implications for research on early life health injuries and later life health and socio-economic outcomes (Stein, Susser, Saenger, and Marolla 1975, Barker 1992 and 1998, Doblhammer and Vaupel 2001, Akresh and Verwimp 2006, Alderman, Hoddinott, and Kinsey 2005, Almond 2006, Maccini and Yang 2006). This literature consists primarily of cohort studies that face common difficulties of selective attrition operating through mortality. As a result, the composition of observed survivors may differ considerably from the early life population of interest, and this attrition process could be systematically related to the outcomes examined. Many studies address this concern by suggesting that the direction of any bias due to selective mortality should be downward. The reason is that those in the left tail of underlying health and socio-economic distributions are the ones most likely to drop out of the sample of survivors (and most studies report that early life health injuries are associated with worse rather than better later life outcomes, hence the downward bias). Our findings suggest that if early life health injuries are related to poor economic conditions (injuries linked to rainfall and flooding, for example), the resulting bias due to selective mortality could instead be upward. If infant and child survival actually improve (at least in some settings) during economic downturns and the marginal survivors are relatively weak, then average health and socio-economic status in the surviving population would be mechanically worse. The point is not that these studies draw misleading conclusions, but rather the sign of any bias due to selective mortality can in fact be ambiguous.

Our findings are directly related to broader debate about the wealth-health relationship. Although wealth has prominently been proposed as an important determinant of mortality (McKeown 1976, Pritchett and Summers 1996), both cross-sectional and longitudinal relationships between wealth and health presumably mask important but unobserved determinants of both (Case and Deaton 2006). In particular, there is growing suggestion that reductions in the relative price of health (due to technological progress in public health, for example) explain the majority of the mortality decline observed throughout history, and more recently, in developing countries (Preston 1975 and 1980, Jamison et. al. 2001, Cutler and Miller 2005, Cutler, Deaton, and Lleras-Muney 2006). Although we examine shocks to transitory rather than permanent income, our results are consistent with this view, illustrating how reductions in the price of health can reduce mortality even as transitory income falls. By implication, the old adage "a rising tide lifts all boats" may not apply to health improvement in developing countries. Our results agree with renewed efforts in global health to improve access to efficacious health technologies and to target time costs as an important component of the price of health.

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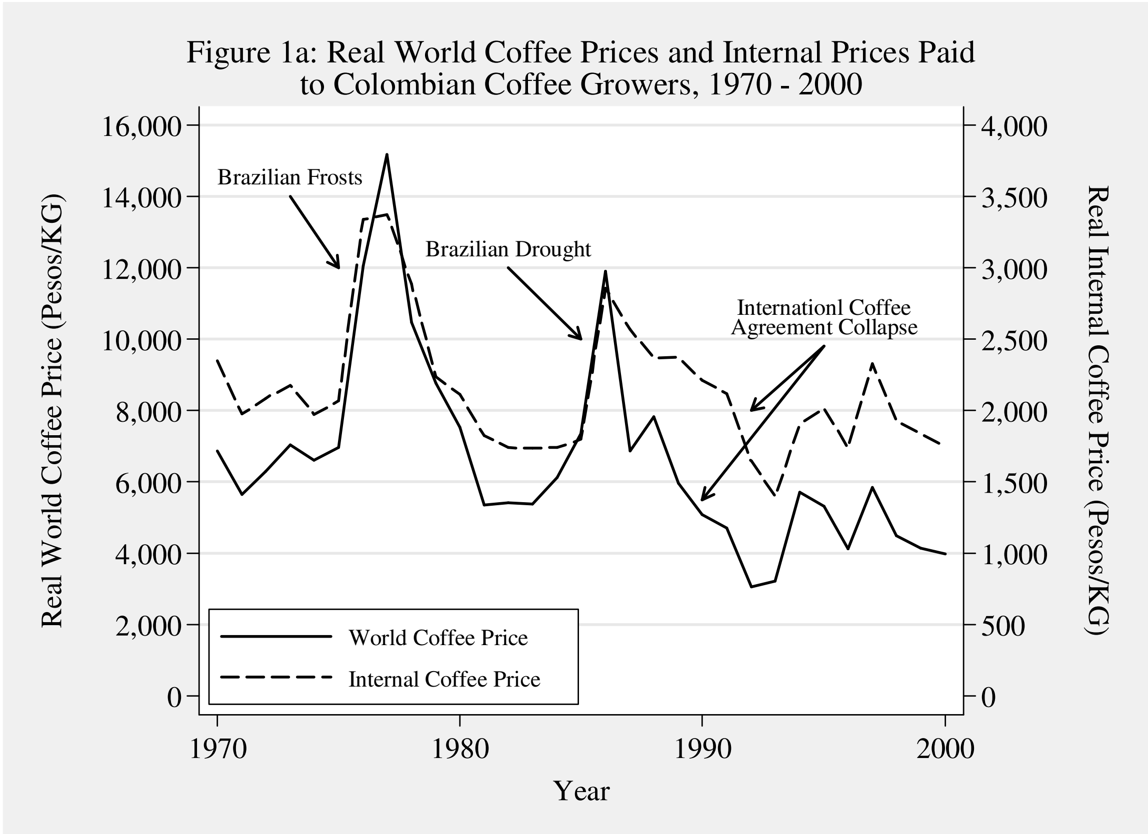


Figure 1a: Real World Coffee Prices and Internal Prices Paid to Colombian Coffee Growers, 1970 - 2000
Brazilian Frosts
Brazilian Drought
Internationl Coffee Agreement Collapse
World Coffee Price
Internal Coffee Price
Real World Coffee Price (Pesos/KG)
Real Internal Coffee Price (Pesos/KG)
Year
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1970
1980
1990
2000

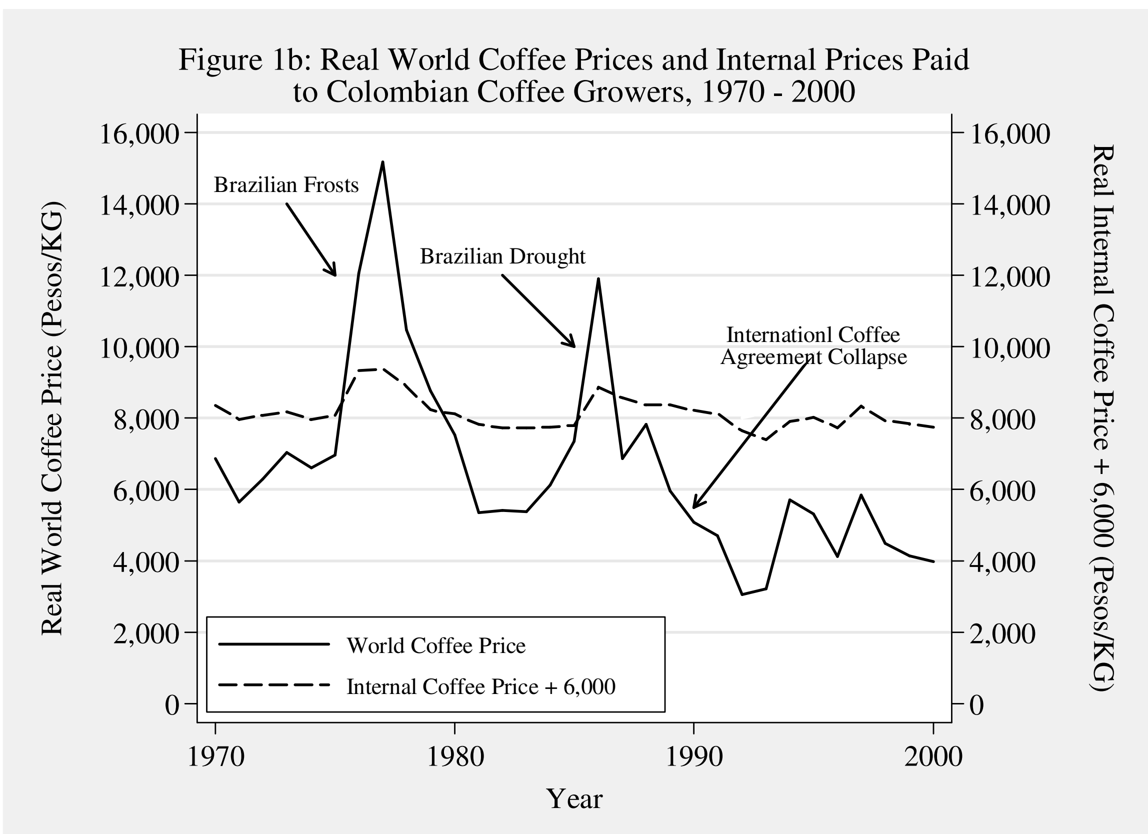


Figure 1b: Real World Coffee Prices and Internal Prices Paid to Colombian Coffee Growers, 1970 - 2000
Brazilian Frosts
Brazilian Drought
Internationl Coffee Agreement Collapse
World Coffee Price
Internal Coffee Price + 6,000
Real World Coffee Price (Pesos/KG)
Real Internal Coffee Price + 6,000 (Pesos/KG)
Year
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1970
1980
1990
2000

Figure 2: The Geography of Coffee Cultivation in Colombia’s Counties

Cultivation in the 1970s

Cultivation in the 1980s

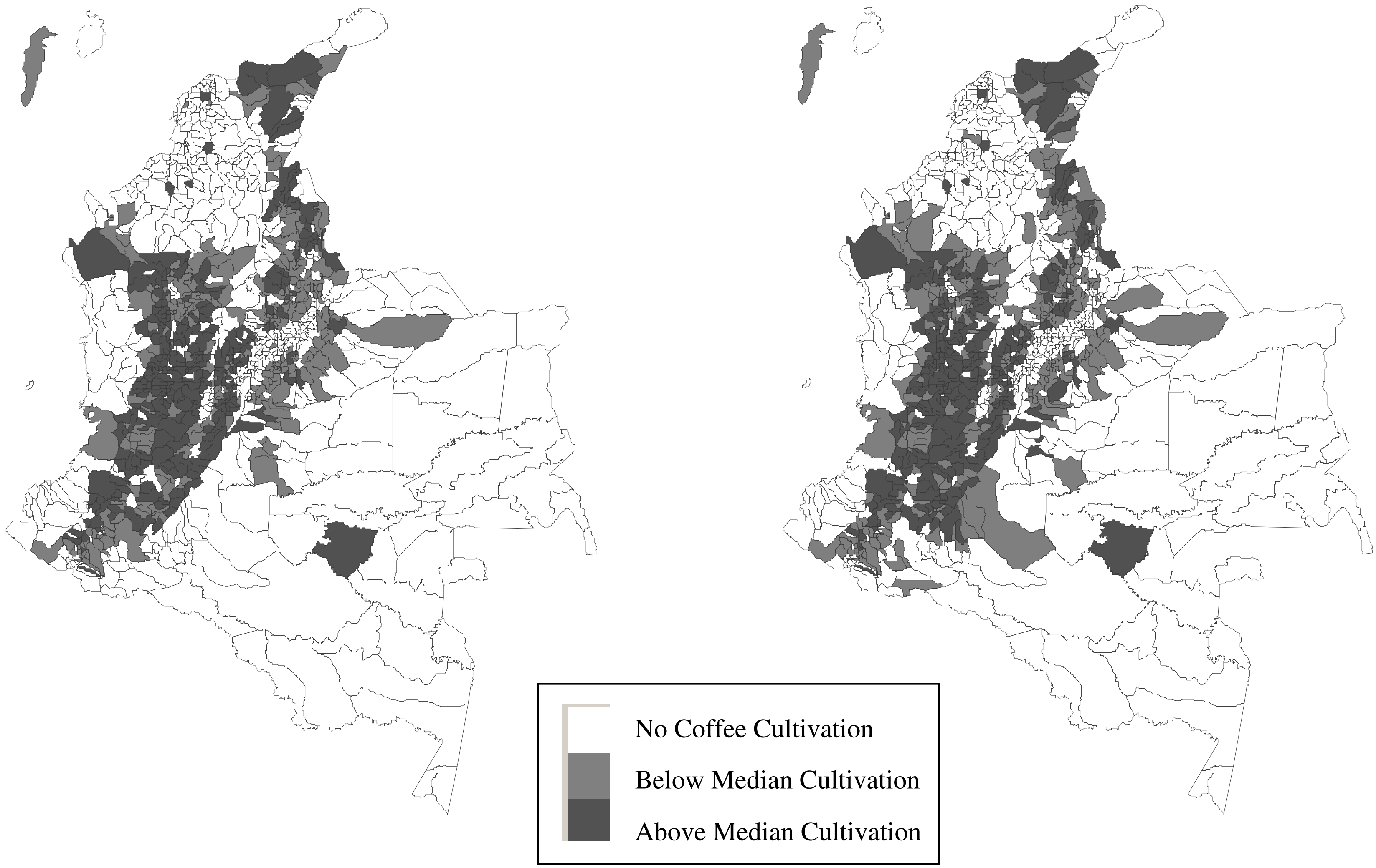


Figure 3a: Coffee Prices Paid to Colombian Growers and Difference in Birth Cohort Size between Municipalities with Above/Below Median Coffee Cultivation, 1970-1991

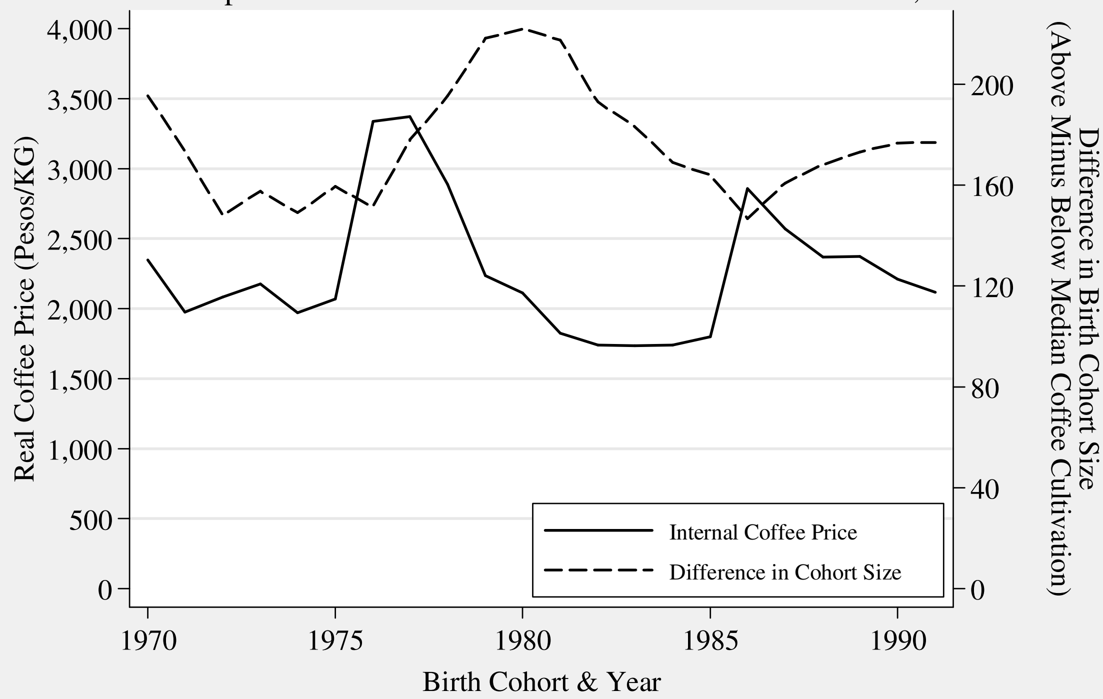
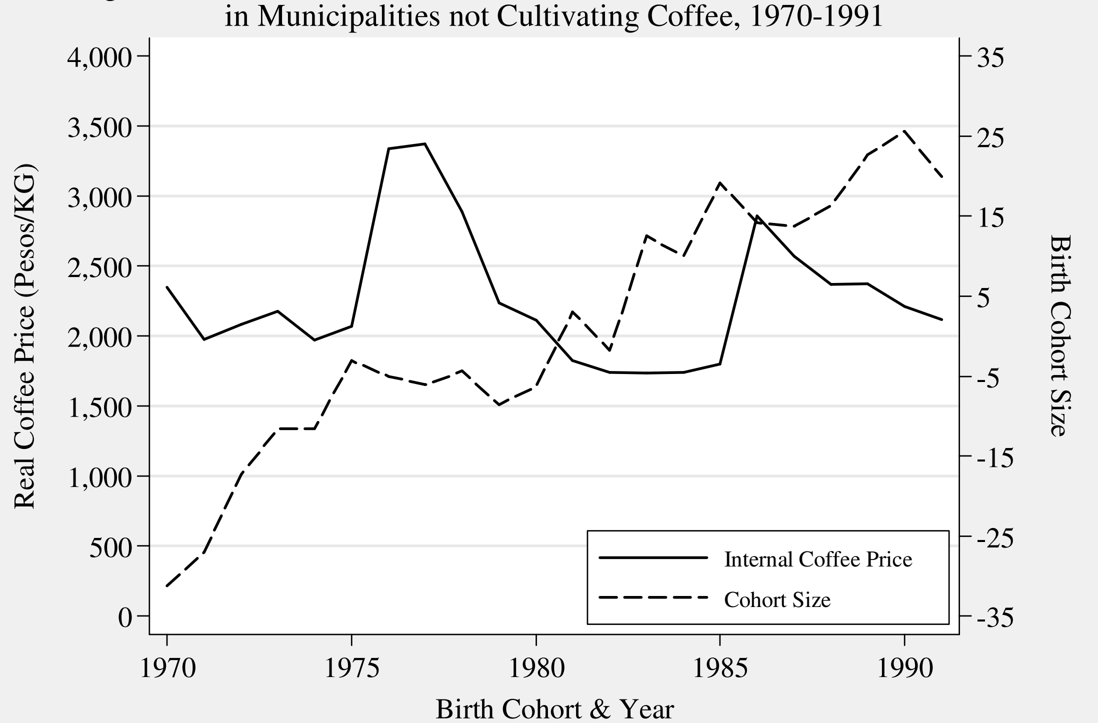


Figure 3b: Coffee Prices Paid to Colombian Growers and Birth Cohort Size in Municipalities not Cultivating Coffee, 1970-1991



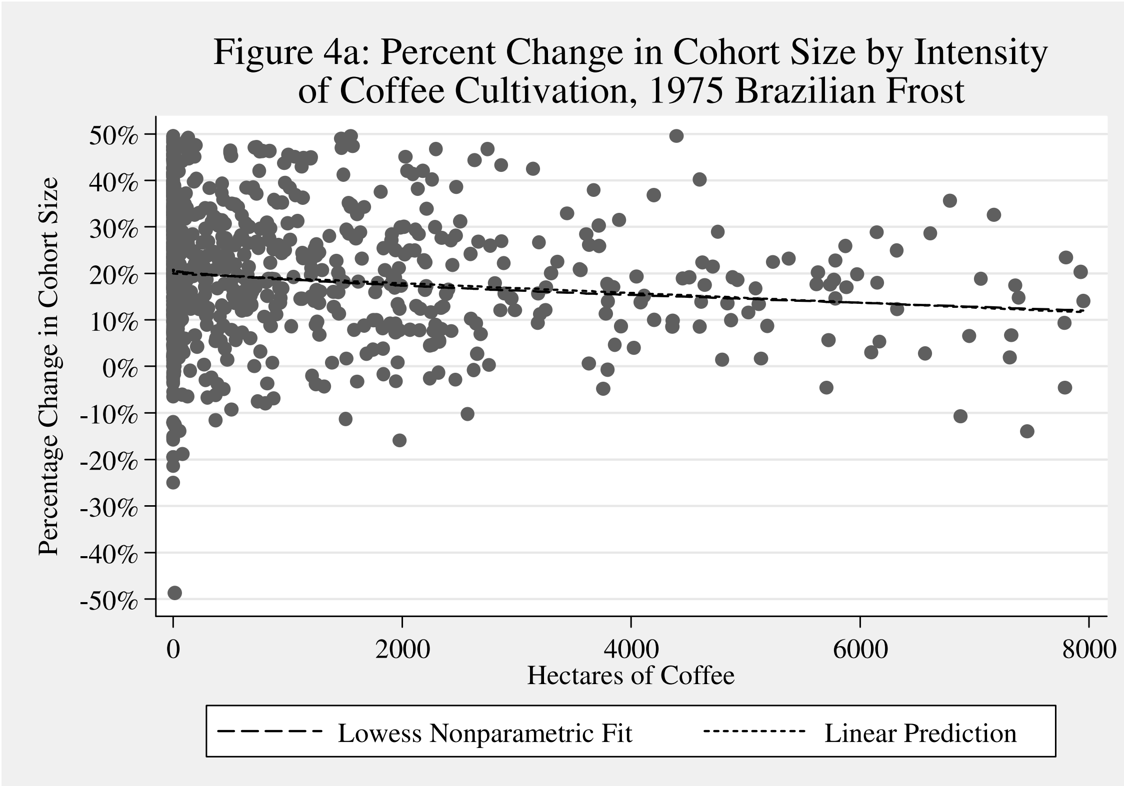


Figure 4a: Percent Change in Cohort Size by Intensity of Coffee Cultivation, 1975 Brazilian Frost
Percentage Change in Cohort Size
50%
40%
30%
20%
10%
0%
-10%
-20%
-30%
-40%
-50%
0
2000
4000
6000
8000
Hectares of Coffee
Lowess Nonparametric Fit
Linear Prediction

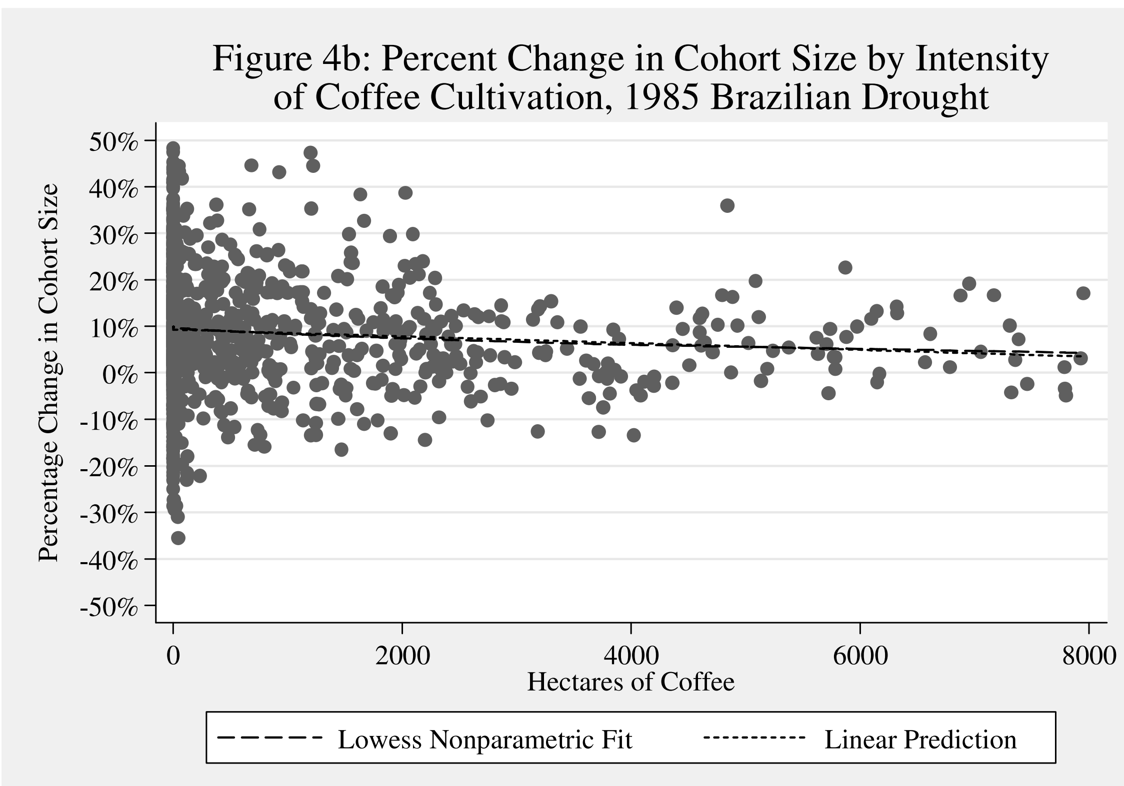


Figure 4b: Percent Change in Cohort Size by Intensity of Coffee Cultivation, 1985 Brazilian Drought
Percentage Change in Cohort Size
50%
40%
30%
20%
10%
0%
-10%
-20%
-30%
-40%
-50%
0
2000
4000
6000
8000
Hectares of Coffee
Lowess Nonparametric Fit
Linear Prediction

Figure 4c: Percent Change in Cohort Size by Intensity of Coffee Cultivation, 1990 ICA Collapse

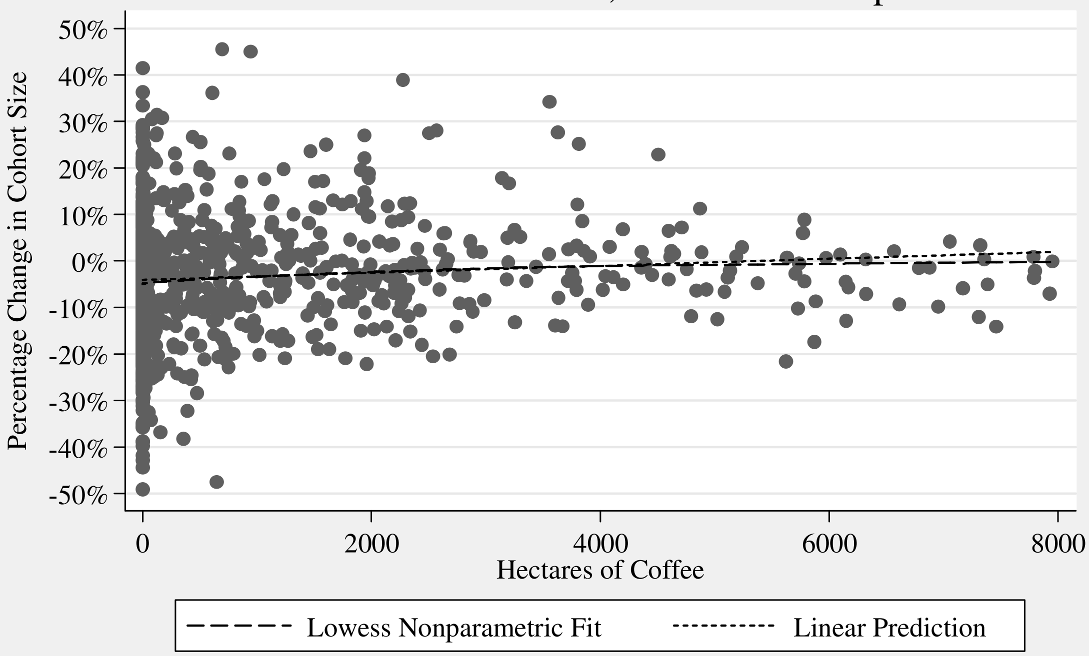


TABLE 1:
Descriptive Statistics

Panel A: Counties in the 1993 Population Census

	All Counties (N=1,060)		Counties with Coffee (N=589)		Counties without Coffee (N=471)	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Number of Households	6,532	(34,598)	6,675	(23,535)	6,354	(44,767)
Number of Individuals	30,942	(174,651)	30,200	(106,237)	31,869	(233,683)
Share Female	0.49	(0.02)	0.49	(0.02)	0.49	(0.02)
Age	25.31	(2.48)	25.93	(2.30)	24.53	(2.48)
Share Under Age 5	0.13	(0.02)	0.12	(0.02)	0.13	(0.02)
Share Married or in Free Union (over Age 14)	0.53	(0.12)	0.54	(0.07)	0.52	(0.16)
Share Born in Current Municipality	0.66	(0.17)	0.65	(0.16)	0.67	(0.19)
Share Literate (over Age 4)	0.76	(0.18)	0.79	(0.11)	0.71	(0.23)
Share in School (over Age 4)	0.26	(0.05)	0.25	(0.04)	0.27	(0.05)
Years of Education (over Age 4)	3.62	(0.90)	3.65	(0.84)	3.59	(0.97)
Share Employed (over Age 9)	0.41	(0.10)	0.43	(0.06)	0.38	(0.12)
Children Ever Born (Females over Age 14)	3.66	(0.52)	3.65	(0.50)	3.67	(0.55)
Children Alive (Females over Age 14)	4.11	(0.49)	4.07	(0.48)	4.15	(0.49)
Age at Last Birth (Females over Age 14)	29.85	(1.40)	29.91	(1.29)	29.76	(1.53)
Share with Brick or Prefabricated Walls	0.47	(0.24)	0.47	(0.22)	0.48	(0.25)
Share with Adobe or Pressed Dirt Walls	0.20	(0.24)	0.21	(0.24)	0.18	(0.24)
Share with Dirt Floors	0.28	(0.22)	0.23	(0.18)	0.34	(0.24)
Share with Water Access	0.55	(0.26)	0.61	(0.23)	0.48	(0.28)
Share with Sewage Access	0.32	(0.25)	0.40	(0.24)	0.22	(0.23)
Share with Electricity	0.67	(0.27)	0.73	(0.22)	0.60	(0.30)
Number of Household Rooms	3.14	(0.43)	3.22	(0.45)	3.05	(0.39)
Share Owning Home	0.70	(0.17)	0.70	(0.12)	0.69	(0.22)
Share Renting or Leasing Home	0.17	(0.11)	0.18	(0.10)	0.16	(0.11)
Hectares of Coffee (Early 1980s)	979	(1,871)	1,726	(2,209)	0	(0.00)

Panel B: Children in the Pooled Demographic and Health Survey Sample (1986, 1990, 1995, and 2000 Waves)

	All Counties (N=70,695)		Counties with Coffee (N=22,313)		Counties without Coffee (N=48,382)	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Mother's Age	36.01	(8.16)	36.24	(8.17)	35.91	(8.16)
Mother's Years of Education	5.28	(3.83)	4.77	(3.55)	5.52	(3.93)
Number of Household Members	6.16	(2.61)	6.38	(2.61)	6.06	(2.60)
Mother's Total Number of Births	4.40	(2.73)	4.76	(3.00)	4.24	(2.58)
Mother's Age at First Birth	19.84	(3.92)	19.83	(3.90)	19.84	(3.93)
Mother's Age at First Marriage	18.97	(4.14)	19.03	(4.20)	18.94	(4.11)
Preceding Birth Interval (Months)	35.89	(27.13)	34.44	(26.45)	36.57	(27.42)
Share Receiving Prenatal Tetanus Toxoid	0.68	(0.46)	0.65	(0.48)	0.70	(0.46)
Share of Mothers Receiving Prenatal Care	0.84	(0.37)	0.81	(0.39)	0.85	(0.36)
Share of Medically-Supervised Births	0.82	(0.39)	0.80	(0.40)	0.83	(0.38)
Months Breastfed	9.66	(8.69)	9.11	(8.69)	9.91	(8.68)
Share Receiving BCG Vaccine	0.92	(0.27)	0.93	(0.25)	0.91	(0.28)
Share Receiving DPT Vaccine	0.92	(0.28)	0.93	(0.26)	0.91	(0.28)
Share Receiving Polio Vaccine	0.93	(0.25)	0.94	(0.24)	0.93	(0.26)
Share Receiving Measles Vaccine	0.64	(0.48)	0.68	(0.46)	0.62	(0.49)
Hectares of Coffee in Municipality (Early 1980s)	1,899	(3,136)	2,974	(3,493)	0	(0.00)

Panel C: Children in the *Familias en Acción* Survey Sample

	All Counties (N=13,732)		Counties with Coffee (N=5,176)		Counties without Coffee (N=8,556)	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Age	3.50	(1.92)	3.49	(1.91)	3.50	(1.93)
Share Compliant with DPT Vaccination Schedule	0.77	(0.42)	0.79	(0.41)	0.76	(0.43)
Share Compliant with Growth and Development Monitoring	0.32	(0.47)	0.37	(0.48)	0.29	(0.45)
Mother's Age	31.15	(7.01)	31.05	(6.82)	31.21	(7.13)
Mothers: Share with No Education	0.15	(0.35)	0.12	(0.32)	0.16	(0.37)
Mothers: Share with Primary Education	0.21	(0.41)	0.20	(0.40)	0.21	(0.41)
Mothers: Share with Secondary Education or More	0.06	(0.24)	0.06	(0.23)	0.06	(0.24)
Mothers: Share Worked for Money in Preceding Week	0.35	(0.48)	0.34	(0.47)	0.35	(0.48)
Mothers: Monthly Hours of Paid Work	36.69	(77.19)	38.30	(78.55)	35.66	(76.30)
Household Head's Age	40.57	(12.33)	39.97	(12.00)	40.95	(12.53)
Household Head: Share with No Education	0.23	(0.42)	0.19	(0.39)	0.26	(0.44)
Household Head: Share with Primary Education	0.11	(0.31)	0.09	(0.29)	0.11	(0.32)
Household Head: Share with Secondary Education or More	0.04	(0.20)	0.04	(0.19)	0.04	(0.21)
Household Head: Share Worked for Money in Preceding Week	0.91	(0.29)	0.91	(0.29)	0.91	(0.28)
Household Head: Monthly Hours of Paid Work	173.93	(91.92)	175.20	(88.99)	173.17	(93.64)
Number of People in Household	6.60	(2.53)	6.53	(2.51)	6.64	(2.54)
Number of Children in Household (Ages 0-6)	2.09	(1.13)	2.08	(1.12)	2.09	(1.14)
Travel Time in Minutes to Town Center	56.29	(101.12)	55.04	(64.39)	57.08	(118.54)
Travel Time in Minutes to Nearest Health Care Facility	41.74	(61.31)	44.30	(53.75)	40.13	(65.58)

Notes: Data summarized in Panel A obtained from the complete 1993 Colombian population census and the National Federation of Coffee Grower's early 1980s coffee census; Data summarized in Panel B obtained from the pooled child records from the 1986, 1990, 1995, and 2000 Colombian Demographic and Health Surveys and the National Federation of Coffee Grower's early 1980s coffee census; Data summarized in Panel C obtained from the Familias en Acción Survey (2002 first wave characteristics only shown). Standard deviations shown in parentheses.

TABLE 2:
Coffee Price Shocks and ln(Cohort Size)

	Sample/Specification		
	Ages 0-2	Ages 0-3	Ages 0-3 with Trends
Panel A: 1975 Brazilian Frost	-1.73E-07***	-3.16E-08***	-7.94E-08***
	(2.61E-08)	(1.21E-08)	(1.50E-08)
Municipal Fixed Effects	Yes	Yes	Yes
Municipal-Specific Linear Trends	No	No	Yes
Implied Change	**-2.16%**	**-0.40%**	**-0.99%**
N	2215	3319	3319
R^2	0.99	0.99	0.99
Panel B: 1985 Brazilian Drought	-1.63E-07***	-1.35E-07***	-2.31E-07***
	(4.44E-08)	(3.59E-08)	(8.73E-08)
Municipal Fixed Effects	Yes	Yes	Yes
Municipal-Specific Linear Trends	No	No	Yes
Implied Change	**-2.04%**	**-1.69%**	**-2.89%**
N	2208	3310	3310
R^2	0.99	0.99	0.99
Panel C: 1990 ICA Collapse	-9.73E-08***	-4.66E-08***	7.55E-08
	(2.60E-08)	(9.23E-09)	(5.56E-08)
Municipal Fixed Effects	Yes	Yes	Yes
Municipal-Specific Linear Trends	No	No	Yes
Implied Change	**-1.22%**	**-0.58%**	**---**
N	2203	3305	3305
R^2	0.99	0.99	0.99

Notes: Estimates shown for the interaction between coffee growing intensity and coffee price in the first year of life in equation 1; standard errors clustered at the county level shown in parentheses. Implied changes are calculated for 250 hectares of coffee and a 500 peso price change. *p<0.1, **p<0.05, ***p<0.01.

TABLE 3:
Coffee Price Shocks and ln(Cohort Size) by Gender

Male-Only Sample

	Sample/Specification		
	Ages 0-2	Ages 0-3	Ages 0-3 with Trends
Panel A: 1975 Brazilian Frost	-1.67E-07***	-3.84E-08**	-8.09E-08***
	(3.57E-08)	(1.59E-08)	(2.05E-08)
Municipal Fixed Effects	Yes	Yes	Yes
Municipal-Specific Linear Trends	No	No	Yes
Implied Change	**-2.09%**	**-0.48%**	**-1.01%**
N	2207	3305	3305
R^2	0.99	0.99	0.99
Panel B: 1985 Brazilian Drought	-1.63E-07***	-1.45E-07***	-1.99E-07*
	(5.32E-08)	(4.57E-08)	(1.05E-07)
Municipal Fixed Effects	Yes	Yes	Yes
Municipal-Specific Linear Trends	No	No	Yes
Implied Change	**-2.04%**	**-1.81%**	**-2.49%**
N	2199	3299	3299
R^2	0.99	0.99	1.00
Panel C: 1990 ICA Collapse	-9.06E-08**	-5.37E-08***	3.39E-08
	(3.64E-08)	(1.31E-08)	(8.26E-08)
Municipal Fixed Effects	Yes	Yes	Yes
Municipal-Specific Linear Trends	No	No	Yes
Implied Change	**-1.13%**	**-0.67%**	**---**
N	2199	3300	3300
R^2	0.99	0.99	0.99

Female-Only Sample

	Sample/Specification		
	Ages 0-2	Ages 0-3	Ages 0-3 with Trends
Panel D: 1975 Brazilian Frost	-1.72E-07***	-3.00E-08**	-7.75E-08***
	(3.08E-08)	(1.46E-08)	(1.77E-08)
Municipal Fixed Effects	Yes	Yes	Yes
Municipal-Specific Linear Trends	No	No	Yes
Implied Change	**-2.15%**	**-0.38%**	**-0.97%**
N	2205	3307	3307
R^2	0.99	0.99	0.99
Panel E: 1985 Brazilian Drought	-1.70E-07***	-1.30E-07***	-2.50E-07**
	(5.71E-08)	(4.65E-08)	(1.11E-07)
Municipal Fixed Effects	Yes	Yes	Yes
Municipal-Specific Linear Trends	No	No	Yes
Implied Change	**-2.13%**	**-1.63%**	**-3.13%**
N	2205	3305	3305
R^2	0.99	0.99	0.99
Panel F: 1990 ICA Collapse	-9.84E-08***	-3.68E-08***	1.10E-07
	(3.79E-08)	(1.28E-08)	(7.75E-08)
Municipal Fixed Effects	Yes	Yes	Yes
Municipal-Specific Linear Trends	No	No	Yes
Implied Change	**-1.23%**	**-0.46%**	**---**
N	2198	3298	3298
R^2	0.99	0.99	0.99

Notes: Estimates shown for the interaction between coffee growing intensity and coffee price in the first year of life in equation 1; standard errors clustered at the county level shown in parentheses. Implied changes are calculated for 250 hectares of coffee and a 500 peso price change. *p<0.1, **p<0.05, ***p<0.01.

TABLE 4:
Coffee Price Shocks, Maternal Characteristics, and Birth Timing

	1975 Brazilian Frost	1985 Brazilian Drought	1990 ICA Collapse
Mother's Age	1.95E-06	5.62E-04	-4.22E-07
	(1.59E-06)	(1.76E-03)	(1.07E-06)
Maternal Education	-8.61E-07	1.05E-07	3.65E-07
	(7.87E-07)	(9.38E-07)	(8.87E-07)
Number of Household Members	-4.61E-07	-2.73E-07	-8.80E-07
	(6.24E-07)	(1.02E-06)	(9.19E-07)
Mother's Preceeding Number of Births	2.56E-07	-1.07E-06*	1.46E-07
	(7.76E-07)	(6.30E-07)	(5.56E-07)
Mother's Age at First Birth	8.92E-07	-8.50E-07	-1.34E-06
	(7.28E-07)	(9.91E-07)	(1.55E-06)
Mother's Age at First Marriage	7.04E-07	-5.18E-07	-3.73E-07
	(9.54E-07)	(1.14E-06)	(3.43E-06)
Preceding Birth Interval	-2.63E-06	9.66E-06	-2.30E-05
	(7.42E-06)	(1.80E-05)	(2.04E-05)

Notes: Estimates shown for the interaction between coffee growing intensity and coffee price in the first year of life; standard errors clustered at the county level shown in parentheses. All specifications also include mother's age, education, number of household members, number of preceding births, age at first birth, and age at first marriage. *p<0.1, **p<0.05, ***p<0.01.

TABLE 5:
CPI Changes and ln(Cohort Size) in Stable Coffee Price Years

	Sample/Specification		
	Ages 0-2	Ages 0-3	Ages 0-3 with Trends
Panel A: 1969 CPI Change	-1.91E-04	-4.25E-06	7.79E-04
	(1.21E-04)	(6.58E-05)	(5.95E-04)
Municipal Fixed Effects	Yes	Yes	Yes
Municipal-Specific Linear Trends	No	No	Yes
N	2207	3314	3314
R^2	0.99	0.99	0.99
Panel B: 1983 CPI Change	-1.10E-04	-8.29E-05	7.39E-06
	(6.97E-05)	(5.26E-05)	(4.82E-06)
Municipal Fixed Effects	Yes	Yes	Yes
Municipal-Specific Linear Trends	No	No	Yes
N	2207	3310	3310
R^2	0.99	0.99	0.99
Panel C: 1989 CPI Change	-9.11E-07	-3.44E-07	-8.03E-06
	(7.32E-07)	(4.16E-07)	(8.51E-06)
Municipal Fixed Effects	Yes	Yes	Yes
Municipal-Specific Linear Trends	No	No	Yes
N	2204	3305	3305
R^2	0.99	0.99	0.99

Notes: Estimates shown for the interaction between coffee growing intensity and the Colombian Consumer Price Index (CPI) in the first year of life; standard errors clustered at the county level shown in parentheses. *p<0.1, **p<0.05, ***p<0.01.

TABLE 6:
Coffee Price Shocks and Child Health Investments

	Estimate	Standard Error	Implied Change	N	R^2/Pseudo R^2
1985 Brazilian Drought					
Prenatal Tetanus Toxoid	-1.08E-06***	(3.70E-07)	-0.135	1082	0.19
Prenatal Care	-3.61E-07	(3.08E-07)	---	1055	0.17
Birth Assistance	-1.66E-07	(3.22E-07)	---	1034	0.25
Months Breastfed	-5.27E-07	(4.93E-06)	---	1218	0.20
BCG Vaccine	2.86E-07	(3.67E-07)	---	490	0.15
DPT Vaccine	-5.11E-13	(5.94E-10)	---	531	0.13
Polio Vaccine	-1.19E-08***	(7.75E-09)	-0.002	540	0.12
Measles Vaccine	3.26E-07	(4.78E-07)	---	574	0.12
1990 ICA Collapse					
Prenatal Tetanus Toxoid	2.49E-07	(5.12E-07)	---	1790	0.17
Prenatal Care	-6.73E-07*	(4.18E-07)	-0.084	1815	0.13
Birth Assistance	8.67E-07	(4.20E-07)	---	1668	0.18
Months Breastfed	1.26E-05	(1.00E-05)	---	1939	0.17
BCG Vaccine	-3.71E-08	(2.82E-07)	---	1397	0.15
DPT Vaccine	-4.46E-08	(2.51E-07)	---	1631	0.25
Polio Vaccine	1.86E-08	(1.56E-07)	---	1743	0.25
Measles Vaccine	-5.82E-08	(1.73E-07)	---	1096	0.25

Notes: Marginal probabilities shown for the interaction between coffee growing intensity and coffee price in the first year of life in equation 2 (OLS estimates reported for "Months Breastfed"); standard errors clustered at the county level shown in parentheses. All specifications also include mother's age, education, number of household members, number of preceding births, age at first birth, and age at first marriage. Implied changes are calculated for 250 hectares of coffee and a 500 peso price change. Breastfeeding results are invariant to methods of addressing censoring in the distribution of months breastfed. *p<0.1, **p<0.05, ***p<0.01.

TABLE 7:
Coffee Price Shocks Lagged by One Year and Birth Intervals

	Estimate	Standard Error	Implied Change	N	R^2
1975 Brazilian Frost	-4.13E-06	(6.02E-06)	---	2419	0.12
1985 Brazilian Drought	2.12E-05*	(1.25E-05)	2.65	3676	0.12
1990 ICA Collapse	4.79E-05**	(2.18E-05)	5.99	2567	0.07

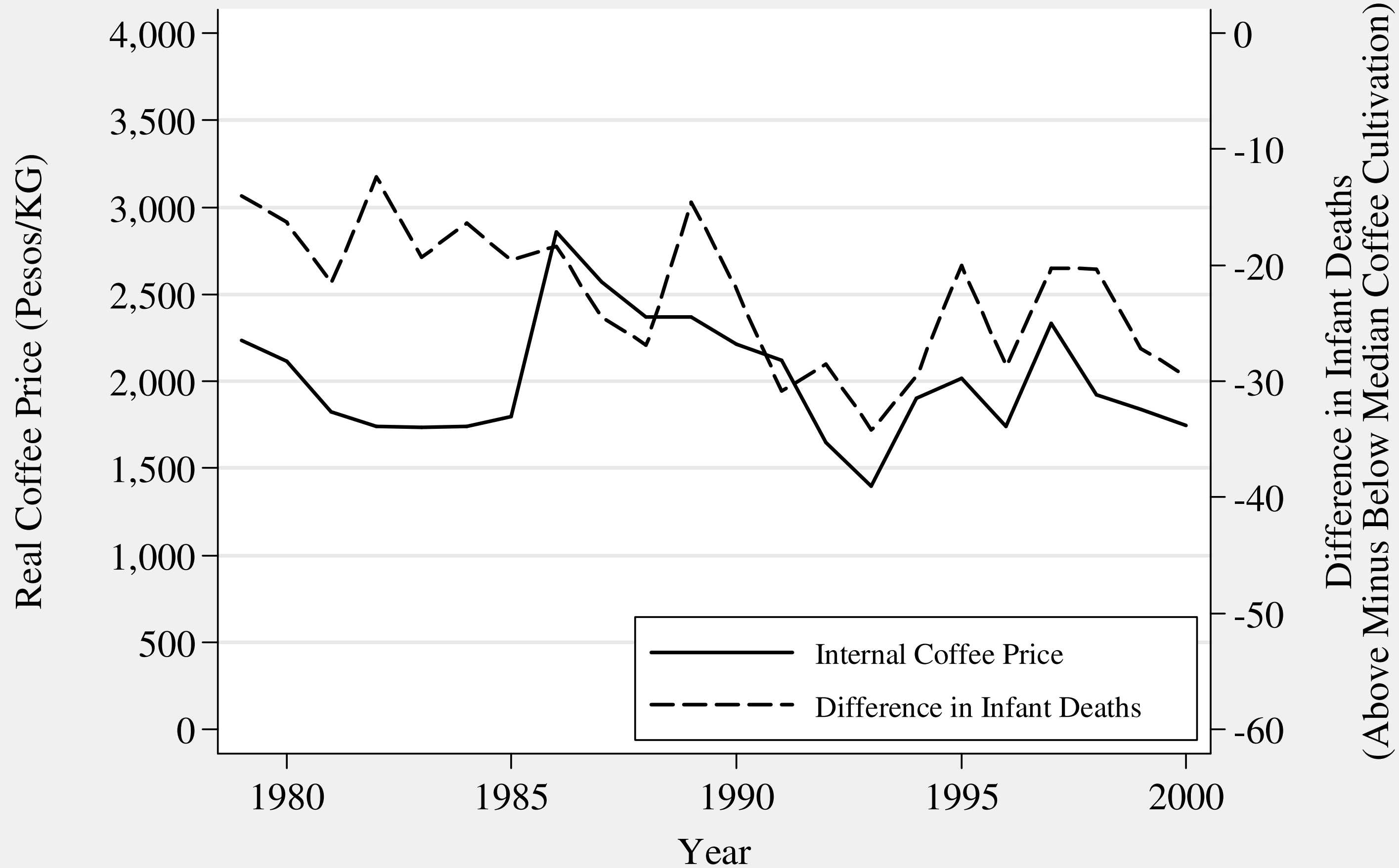
Notes: Estimates shown for the interaction between coffee growing intensity and coffee price in the year of conception; standard errors clustered at the county level shown in parentheses. All specifications also include mother's age, education, number of household members, number of preceding births, age at first birth, and age at first marriage. Implied changes are calculated for 250 hectares of coffee and a 500 peso price change. *p<0.1, **p<0.05, ***p<0.01.

TABLE 8:
Coffee Price Shocks and Local Labor Markets

	Estimate	Standard Error	Implied Change	N	R^2/Pseudo R^2
ln(Female Wage), Rural Areas	5.40E-06***	7.02E-07	11.01%	12,071	0.60
ln(Male Wage), Rural Areas	1.17E-07	7.41E-07	---	12,129	0.69
Mother - Employed last Week?	2.21E-06*	1.29E-06	0.05	11,110	0.04
Household head - Employed Last Week?	2.38E-06***	6.95E-07	0.05	18,093	0.05
Mother - Hours of Monthly Paid Work	4.81E-04*	2.77E-04	9.81	8,757	0.10
Household Head - Hours of Monthly Paid Work	5.85E-04***	1.96E-04	11.93	16,737	0.05
Mother - Hours of Monthly Paid Work (Conditional on Employed Last Week)	6.84E-04	4.88E-04	---	3,369	0.08
Household Head - Hours of Monthly Paid Work (Conditional on Employed Last Week)	2.06E-04	1.72E-04	---	15,236	0.04

Notes: Estimates shown for the interaction between coffee growing intensity and coffee price; standard errors are clustered at the county level. For the wage regressions, the natural logarithm of wages are used; for employment in the preceding week, marginal probabilities calculated from probit estimates at the mean of the independent variables are reported. Implied changes are calculated for 250 hectares of coffee and a 500 peso price change. *p<0.1, **p<0.05, ***p<0.01.

Appendix Figure 1: Coffee Prices Paid to Colombian Growers and Difference in Infant Mortality between Municipalities with Above/Below Median Coffee Cultivation, 1979 - 2000



APPENDIX TABLE 1:
Travel Time to Health Facilities and Health Care Service Use (Growth and Development Monitoring)

	Without County Fixed Effects						With County Fixed Effects					
Travel Time to Nearest Health Facility	-0.00025	-0.00018	-0.00014	-0.00011	-0.00080	-0.00076	-0.00013	-0.00008	-0.00008	-0.00010	-0.00045	-0.00047
	(0.00005)	(0.00005)	(0.00005)	(0.00004)	(0.00019)	(0.00023)	(0.00005)	(0.00005)	(0.00005)	(0.00005)	(0.00024)	(0.00028)
	***	***	***	**	***	***	***	*	*	**	**	*
Child Age and Sex; *Familias en Acción Program* Participation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Maternal Characteristics[1]	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Household Composition and Characteristics[2]	No	No	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Household Head and Maternal Labor Force Participation[3]	No	No	No	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes
Houshold Income and Consumption	No	No	No	No	Yes	Yes	No	No	No	No	Yes	Yes
Travel Time to Town Center	No	No	No	No	No	Yes	No	No	No	No	No	Yes
N	22,463	19,884	13,987	9,491	2,456	2,456	22,326	19,754	13,837	9,382	2,228	2,228
Pseudo R^2	0.01	0.02	0.09	0.12	0.06	0.06	0.09	0.10	0.16	0.19	0.16	0.16

Notes: All results are marginal probabilities obtained from probit specifications, evaluated at the mean of the independent variables. [1]Maternal Characteristics: mother's educational attainment dummy variables, mother's age, and mother's anthropometrics; [2]Household Composition and Characteristics:number of children ages 0-6, number of children ages 7-17, number of adults, age of household head, number of births, number of newborn deaths, number of child deaths under age 5; [3]Household Head and Maternal Labor Force Participation: household head ever worked for money, household head worked for pay in the past week, household head hours of monthly paid work, mother ever worked for money, mother worked for pay in the past week, mother hours of monthly paid work. Standard errors shown in parentheses clustered at the household level.
*p<0.1, **p<0.05, ***p<0.01.

Appendix 1: Data

Coffee Prices

We initially obtained average annual internal coffee prices paid to Colombian coffee growers for years 1970 to 2002 from two sources: the London-based International Coffee Organization (ICO) and the National Federation of Coffee Growers (NFCG). Internal prices paid to Colombian coffee growers at a given point in time do not vary within the country. The ICO's price data is obtained directly from the NFCG, so we generally use the latter. (The single exception is our analyses of *Familias en Acción* survey data. Because the last wave of the survey was conducted in 2005/2006 – but the NFCG only provided price data through 2004 – we use real ICO price data in US dollars). We then converted the NFCG time series price data (obtained in Colombian pesos per kilogram of "green" coffee) to real 1998 terms using the official consumer price index constructed and published by the Colombian Central Bank (Banco de la República). This price index is available on-line at: http://www.banrep.gov.co/estad/dsbb/srea_012.xls.

Coffee Cultivation

Approximately once per decade, the National Federation of Coffee Growers conducts a complete enumeration of all coffee growers in Colombia for planning and monitoring purposes. The 1970 coffee census combined information collected directly from coffee growers with land use data gathered through aerial photography. Drawing on the experiences of the 1970 census, the 1980-81 coffee census was conducted primarily using aerial photography with field verification for purposes of quality control. The 1997 coffee census, which we use only in conjunction with the *Familias en Acción* survey data, was based on a complete enumeration (by ground) of all coffee growers between 1993 and 1997. In all of our analyses, we use the immediately preceding coffee census conducted prior to a given price shock. (Because new coffee plants require four years to produce their first mature harvest, area dedicated to coffee cultivation cannot respond quickly to changes in world coffee markets.)

The 1970 and 1980 coffee censuses are available only in hard-copy format from the NFCG. With special permission from the NFCG, we digitized municipal-level indicators of coffee cultivation from each census using these printed volumes. Specific measures include hectares dedicated to coffee cultivation, number of coffee plants, and kilograms of coffee harvested. The 1997 coffee census is available in electronic format.

Birth Cohort Size

We constructed birth cohort size counts at the county-birth year level using the complete (100%) 1993 Colombian population census obtained from the Colombian National Statistical Agency (Departamento Administrativo Nacional de Estadística, or DANE). These birth cohort counts were generated using detailed geographic identifiers that allow all counties to be recognized according to each individual's county of birth, not county of residence in 1993. There were 32,451,229 non-institutionalized individuals in 1060 counties recorded in the 1993 population census. These counties account for all of Colombia in a mutually exclusive and collectively exhaustive manner. Birth cohort counts were then matched to (i.) prevailing real internal coffee prices in each cohort's year of birth and (ii.) the most recent municipal-level coffee cultivation measures prior to that year in each cohort's county of birth.

Health Investments and Maternal Socio-Economic Status

Our primary measures of health investments and mothers' socio-economic status are obtained from four waves of Colombia's Demographic and Health Surveys (DHS). These are nationally-representative surveys of fertile age women (defined as 15-49) in the year a survey is conducted. We pool the four DHS waves together using variables reported in a comparable manner over time. (The first wave in 1986 was conducted by the Corporación Centro Regional de Población; the 1990, 1995, and 2000 waves were conducted by the Asociación Pro-Bienestar de la Familia Colombiana, or PROFAMILIA.) Public-use DHS data is available for download by registering at: http://www.measuredhs.com/. Using the child recode files matched to maternal characteristics (a pooled sample of 70,695 children), we then match each child to (i.) the prevailing real internal coffee price in his/her year of birth and (ii.) the most recent municipal-level coffee cultivation measures prior to the child's birth year according to county of residence at the time of the survey (county of birth is not recorded in the DHS data). Individual counties are not identified in the publicly-available Colombian DHS data, but PROFAMILIA and Macro International (the US-based DHS partner) provided keys that match sampling clusters to individual counties.

Available measures of health investments reported consistently across the four waves include: maternal use of prenatal care, prenatal tetanus vaccinations, birth assistance, breastfeeding duration, and a variety of child vaccinations (BCG, polio, DPT, and measles). This mother-reported information can be divided into two categories: birth histories and child health histories. The birth histories are reported for every live birth (regardless of child survival to the survey date) and include prenatal care, prenatal tetanus vaccinations, birth assistance, and breastfeeding duration. The child health histories are reported for all children born within sixty months of the survey date (regardless of child survival to the survey date) up to a maximum of six children per woman and include BCG, polio, DPT, and measles vaccinations. Maternal socio-economic characteristics for each child that are available in all four waves include: age, educational attainment in years, number of preceding births, preceding birth interval, age at first birth, age at first marriage, and number of household members.

Rural Labor Markets and Travel Time to Health Care Facilities

Our data on rural labor markets and travel time to health care facilities is drawn from three waves of a household panel survey conducted to evaluate the *Familias en Acción* program in Colombia. *Familias en Acción* is a non-randomized conditional cash transfer program similar to Mexico's *Oportunidades* program (formerly known as Progressa). The survey was first conducted in 2002 with follow-up surveys repeated in 2003 and 2005/2006. In 2002, the baseline survey was administered to 11,502 households in 122 Colombian counties. Attrition rates for the two follow-up surveys relative to the first wave were 6.3% and 17.1%. Topical survey modules broadly covered household demographic characteristics and composition, consumption, income, school attendance and educational attainment, and labor force participation. In addition, detailed health questions – including preventive health care service use – were asked for all children 6 years of age and younger. Although the *Familias en Acción* survey data does not extend back to the three major world coffee price shocks studied by this paper, it collected complementary data relevant to our analyses but not available in any other data source on employment, wages, hours worked, and travel time to health care facilities.

Mortality

Electronic death records at the individual level are available for years 1979-2002 from the Colombian National Statistical Agency (Departamento Administrativo Nacional de Estadística, or DANE). These records include deaths by age, sex, cause (ICD classification), place of occurrence, place of residence, month and year, marital status, and certification by a medical professional. We provide graphical evidence of infant mortality over time by degree of coffee cultivation but do not otherwise make use of Colombia's mortality statistics because of concerns about data quality and under-reporting (particulary given that the degree of under-reporting thought to be correlated with economic conditions) (Florez and Mendez 1997, Medina and Martinez 1999, Wilmoth et. al. forthcoming). *Appendix 2* provides indirect estimates of under-reporting in Colombia's vital registry data that range between 30% and 45%.

Appendix 2: Indirect Mortality Estimation

To assess the extent of under-reporting in Colombia's mortality statistics, Appendix Table 2 below shows indirect estimates of Colombia's infant mortality rate (deaths under age 1 per 1,000 live births) over time. These calculations, taken from Urdinola (2004), are conducted using Colombia's Demographic and Health Surveys (DHS) and the Brass-Trussell method (United Nations 1990). Specifically, these estimates suggest that under-reporting rates were 31% in 1986, 46% in 1990, 47% in 1995, and 44% in 2000. Similar calculations (not shown) using the Palloni-Helligman (1985) variant of the Brass method yields infant mortality estimates that are roughly equivalent. Perhaps counter-intuitively, the table below suggests that the quality of Colombia's vital registration system may have been deteriorating over time. This is consistent with observations made by others assessing the quality of Colombia's vital registration system (Medina and Martinez 1999).

Estimated Infant Mortality Rates in Colombia Using the Brass-Trussell Method (per Thousand Live Births)

Source	Year	Estimated IMR	Vital Registry IMR
DHS 1986	1986	40.6	27.9
DHS 1990	1990	37.5	20.0
DHS 1995	1995	33.7	18.0
DHS 2000	2000	30.6	17.1

<u>Indirect Estimation of Infant Mortality Rates: the Brass-Trussell Method</u>[1]

The Brass method of indirect mortality estimation is a standard tool used by demographers to calculate the probability that a child has died (*q(x)*) by age *x* in cross-sectional data (Brass, 1974). These probabilities *q(x)* can therefore be interpreted as age-specific mortality rates commonly found in standard life tables. At minimum, this method requires information on the proportion of infants and children who have died as a share of children ever born to women at each age. Widespread reliance on the Brass Method in producing indirect estimates of age-specific mortality rates has led the United Nations to place the number of children ever born and the number of surviving children on its list of recommended items for national population censuses (United Nations 1990).

The Brass method essentially utilizes differences in child survival rates across age cohorts of mothers to recover information about age-specific child mortality. It exploits the fact that all else equal, children (both alive and dead) born to older women are observed at older ages. Women at varying ages are therefore assumed to provide information about the experiences of all women in the population at each age. An important limitation of this approach is therefore its assumption that cumulative mortality rates depend on age alone. Nevertheless, a large literature in demography demonstrates its usefulness as an approximation in assessing the extent of under-reporting in vital registries.

Following standard notation used in demography, the number of children dead as a share of children ever born (denoted as D_i) among women in reproductive age groups *i* (*i*=1 for women

[1] For more details on indirect mortality estimation, see United Nations (1983), United Nations (1990), or Preston, Heuveline, and Guillot (2001).

15-19, i=2 for women 20-24, …, i = 7 for women 45-49) are transformed into probabilities of dying ($q(x)$) between birth and exact age x. For the infant mortality calculations shown above in Appendix Table 2, the age x of interest is one. The Brass method's basic equation is:

(3) $q(x)=k_i D_i$,

where k_i is a vector of multipliers derived from fertility measures among women in the population of interest. Through simulations, Brass generated the proportions of children dead, the probabilities of dying, and parity ratios (P_1/P_2, P_2/P_3, etc) linking them. Thus, an estimate of the probability of dying by age 1, $q(1)$, can be derived from the proportion of children dead reported by women aged 15-19, $D(1)$; the probability of dying by age 2, $q(2)$, can be obtained from the proportion of children dead for women aged 20-24, $D(2)$, and so on.

The original Brass method also assumes that mortality rates are constant over time, making cohort and period mortality probabilities identical. This assumption has subsequently been relaxed – if the rate of change over time as assumed to be constant, the reference date of each $q(x)$ can be estimated by making allowances for the age pattern of fertility by means of the parity ratios.

More flexible variants of the Brass method have also been developed. One of the best known is the Trussell (1975) variant, which estimates the multipliers k_i differently. Specifically, the fertility schedule used to produce the ratios P_1/P_2, etc. is taken from the Coale-Demeny (1966) model life tables.[2] The Trussell variant also differs in assuming that both infant mortality and fertility patterns remained constant in preceding periods (specifically, the preceding 15 years). Finally, the Palloni-Heligman variation includes a correction using more precise information on birth timing and employs United Nations model life tables for developing countries.[3] The Coale-Demeny model life table that best fits Colombian vital patterns is the West life table, and the Palloni-Heligman table that best fits Colombian vital patterns is the Latin American variant.

[2] Coale-Demeny model life tables were developed using data from a variety of countries and have for basic regional: North, South, East and West.

[3] United Nations model life tables are also constructed for different regions of the world, with several distinct variants: Chilean, Latin America, South Asia, Far Eastern and General.