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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 shocks that directly influence health independently of economic conditions (such as flooding or grain price fluctuations). 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 are linked to changes in the opportunity cost of time. These results suggest that in rural Colombia, (1) Any adverse health consequences of incomplete consumption smoothing during bad economic times are dominated by increases in time-intensive health investments, and (2) The relative price of health is a more powerful determinant of mortality than wealth.

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1. Introduction

A growing body of evidence documents pro-cyclical mortality in wealthy countries – death rates rise during times of economic prosperity and fall during recessions (Ruhm 2000, Chay and Greenstone 2003, Neumayer 2003, Deaton and Paxson 2004, Dehejia and Lleras-Muney 2004, Neumayer 2004, 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 increase traffic fatalities. 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 could 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, dietary composition and caloric intake could deteriorate, households might switch cheaper but more harmful biomass fuels for cooking, and simple medical interventions may become unaffordable 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).

[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 influence infant and child mortality in Colombia's coffee-growing regions.[3] Panels A and B of Figure 1 show that real world coffee prices since 1970 have been remarkably volatile, varying by as much as 45-50% of the long-run mean. Our specific approach relates abrupt non-linear coffee price changes originating outside of Colombia to a cohort-based measure of mortality.[4] This measure has a number of important strengths, including freedom from chronic under-reporting in Colombia's vital registries (which presumably vary with economic conditions), coverage of fetal deaths, and the ability to capture lagged mortality.[5] Related research in developing countries has utilized variation in economic conditions linked to environmental change, fluctuations in world grain prices, and 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 directly influence health independently of their effect on economic circumstances.[6] Importantly, this is not true of world coffee price shocks.

In general, we find evidence of *procyclical* infant and child mortality in rural Colombia over the past three decades. In municipios (the Colombian equivalent of counties) with median coffee growing intensity, sudden coffee price increases (decreases) of 500 pesos/KG (about 25% of the 1970-2000 mean) were accompanied by 15% increases (decreases) in cumulative mortality. In contrast with many studies of gender bias in intrahousehold resource allocation, we

[3] Health during the first year of life is much more fragile than health in the second or subsequent years, so infants are especially vulnerable to sudden changes in health inputs <PHYSIOLOGY REFERENCES>.
[4] This approach follows Jayachandran (2006).
[5] A variety of sources document substantial under-reporting in Colombia's mortality statistics of 25% or more (Florez and Mendez 1997, Medina and Martinez 1999, PAHO 1999, Urdinola 2004, Wilmoth forthcoming).
[6] Rainfall and flooding influence sanitary conditions and the reproduction of mosquito vectors responsible for malaria transmission; grain and cereal prices are an important component of the price of calories; and financial crises often cause the collapse of public-sector programs, including health programs.

find no evidence of gender differences in these mortality changes (Rose, 1999). Consistent with an explanation based on the value of time, we also find that time-intensive child health investments (such as vaccinations and prenatal care) are *countercyclical*, increasing as coffee prices fall and vice-versa. We postulate that other important time-intensive health behaviors that we do not observe (like water boiling and hygienic practices) move with economic conditions in a similar way. Although we cannot separately identify income and substitution effects, they work in opposite directions; in this setting, the substitution effect dominates. Put differently, any adverse health consequences of incomplete consumption smoothing during economic downturns seem to be dominated by increases in time-intensive health investments.

Within our empirical framework, any confounding influence must have varied 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-growing areas in proportion to price shocks and coffee production intensity. 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.[7] 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 new mothers changed in shock years in these restricted samples. On the latter, we demonstrate that infant and child survival do not vary with price changes unrelated to coffee prices (like changes in the Colombian CPI) and coffee growing intensity during stable coffee price years. More generally, any bias due to

[7] Coffee-growing intensity cannot easily respond to price changes in less than four years (the biologically-determined amount of time between planting and first harvest for new coffee groves) (Ortiz 1999).

unobserved latent differences that become manifest in the presence of price shocks (i.e., that co-vary with coffee prices and coffee growing intensity) would alter the magnitude – not the sign – of our estimates.[8] A central contribution of this paper is the sign of its estimates.

We conclude by casting our results in the context of broader debate about the wealth-health relationship (McKeown 1976, Pritchett and Summers 1996). Beyond the congruent wealthy country studies, there is growing suggestion that the relative price of health is a much more powerful determinant of mortality than is wealth (Preston 1975 and 1980, Jamison et. al. 2001, Cutler and Miller 2005, Case and Deaton 2006, Cutler, Deaton, and Lleras-Muney forthcoming).[9] Our findings are consistent with this view, implying that the old adage "a rising tide lifts all boats" does not straightforwardly apply to health improvement in developing countries.

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

2.1. Health Production and the Value of Time

Recognition of the importance of time as an input into health production has grown from early theoretical contributions on household production of human capital and health capital (Becker 1965, Grossman 1972). Subsequent empirical studies have emphasized the role of time in medical care utilization in the United States, particularly parents' time and pediatric care (Acton 1975, Colle and Grossman 1978, Goldman and Grossman 1978, Sindelar 1982, Coffey

[8] Because we condition on municipal-level fixed effects and fail to find evidence of confounding migration, such latent differences that become manifest as price shocks occur – differences in risk aversion, for example – are the most serious concern.

[9] The same phenomenon may be true of education as well (Goldin 1999, Schady 2004).

1983, McClellan, McNeil, and Newhouse 1994, Vistnes and Hamilton 1995). The importance of time in the health production has also been prominent in health policy circles in efforts to improve "access" to health care services. For example, the widespread community health center movement advocated locating comprehensive health care facilities in poor neighborhoods (closer to the communities they intended to serve) as a leading means of shifting 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, too. In developing countries, time is central in household choices about drinking water sources, fuel and cooking technologies, and other health behaviors (Ewbank and Preston 1990, 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 choices are in turn 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 care 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.> As in wealthy countries, widespread efforts to increase health care service use in poor 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 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).[10]

2.2. Coffee Cultivation in Colombia

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). Figures 2a and 2b show the geographic location of Colombia's coffee-growing regions during the 1970s and 1980s at the municipio (or 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

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

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.[11]

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.[12] Since Colombia's agrarian reforms during the 1960s, most coffee is grown on small farms of seven hectares or less. This reduction in average farm size has made it possible for farm owners and their families to do 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). Most day-laborers are men, but

[11] "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.

[12] 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.

women and children are also hired. Wives of day-workers are also hired to prepare meals for field workers. Finally, picking ripe coffee cherries at the optimal point 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.).

For all three types of labor, the marginal return to working and opportunity cost of time move in the same direction as coffee price fluctuations in the short run.[13] Although local labor market data with suitable geographic identifiers is not available before 1997, analyses using the Colombian National Household Survey (Encuesta Nacional de Hogares, or ENH) from 1997-2004 confirm this result. (See the data appendix for a complete description of ENH). Simple regressions of labor market outcomes on municipal-level coffee growing intensity, prices paid to coffee growers, and their interaction show that as coffee prices fall: unemployment rises, time since last worked among unemployed individuals increases, and hours worked among the employed falls. Appendix Table 1 shows these results for the interaction between coffee growing intensity and coffee price.[14]

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[13] As shown in Figure 1, coffee price swings are sudden, erratic, and transitory. The analyses in this paper focus on immediate changes in infant and child mortality rather than the consequences of general equilibrium adjustments.

[14] The specifications estimated are similar to Equation 1 shown below under *Empirical Strategy*: $ln(o_{iym}) = \alpha + \beta g_m + \gamma p_y + \lambda(g_m \times p_y) + \delta_m + \delta_y + \delta_m \times y + \varepsilon_{iym}$, where o is a labor market outcome for individual i living in municipio m in year y, g is municipal-level coffee growing intensity (measured in hectares of coffee), p is the internal Colombian coffee price in year y, δ_m, δ_y, and $\delta_m \times y$ represent municipio and year fixed effects and municipal-specific linear time trends (respectively), and the parameter of interest is λ. The specific labor market outcomes used are whether or not an individual not working looked for a job in the last four weeks, weeks since worked conditional on unemployment, and hours worked last week conditional on employment. These results are robust to the inclusion of individual-level controls for socio-economic status, demographics, and family composition. The coffee cultivation and price data is described in greater detail in the *Data* section as well as in the data appendix. To aid in interpretation, Appendix Table 1 also shows implied changes in labor market outcomes for median coffee growing intensity (approximately 250 hectares) and price changes that correspond to the major price shocks analyzed by this paper (500 pesos). Because 1980s coffee cultivation data is matched to the 1997- 2004 ENH data (and coffee cultivation changes over time), additional measurement error is introduced.

The National Federation of Coffee Growers in Colombia

Until industrialization occurred during the 1970s, coffee was Colombia's leading export.[15] 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.[16] 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 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).[17] Panels A and B of Figure 1 shows how internal prices paid to Colombian coffee growers vary with world coffee prices.

3. Data and Empirical Strategy

[15] 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.
[16] 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.
[17] These prices are uniform within the country. FEDECAFE manages 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).

3.1 Data

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 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.[18] As shown in Figures1a 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. All three supply shocks led to dramatic changes in Colombia's internal coffee prices by as much as 50% 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 we assume that the impact of country-wide coffee price shocks varies with local coffee growing intensity, we construct municipal-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 and 1980s to measure hectares of coffee farmland ("intensity") in each Colombian municipio (or county).[19] 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 cannot easily respond to price changes in less than four years (the biologically-determined amount of

[18] 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).

[19] 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.

time required for 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). Panel A of Table 1 shows descriptive statistics for all of Colombia's municipios in 1993 population census and for municipios with and without coffee groves 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 from the complete (100%) 1993 Colombian population census universe. Specifically, because we analyze price variation at the municipio by year level, we construct municipio by birth year population counts. Cohort size can be influenced by three population processes: birth, death, and migration. Importantly, deaths are isolated from the other two by restricting the analyses to those conceived before a price shock occurred (to remove fertility effects) and by constructing cohort size counts according to municipio of birth (rather than municipio of residence).[20] 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. They show no relationship, also suggesting this concern to be unfounded. Figure 3a plots internal coffee prices and the average difference in residual birth

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

cohort size (net of year fixed effects) between municipios with above- and below- median land area dedicated to coffee cultivation (these municipios are shown in Figure 2).[21] Although this plot shows all birth cohorts and therefore does not distinguish between fertility and mortality, it nevertheless generally suggests that cohort size is countercyclical. Figure 3b shows no such relationship between coffee prices and residual cohort size in areas without coffee.

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). Moreover, these omissions are likely to be correlated with economic conditions rather than remaining fixed over time (Medina and Martinez 1999).[22] Second, they capture fetal deaths.[23] 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. Fourth, mortality measures based on cohort size reflect cumulative mortality, capturing potentially important lagged deaths attributable to economic shocks. Despite their much more serious limitations, analyses not shown using both Colombia's mortality statistics and the Demographic and Health Surveys are consistent with our

[21] 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 general patterns.
[22] Mortality under-reporting in developing countries is a notorious problem (PAHO 1999, Wilmoth et. al., forthcoming), especially for infants and children. Similar problems arise with mother's self-reports of infant and child mortality in Colombia's Demographic and Health Surveys. 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). The 1993 population census was surely not completely free of undercounting, but it was it presumably far less than 25% or more, and it is unlikely that these errors vary systematically by year of birth and coffee-growing intensity in that year.
[23] 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.

major finding of procyclical infant and child mortality. Figure 4a plots internal coffee prices and the average difference in residual infant deaths (net of year fixed effects) between municipios with above- and below-median coffee growing intensity. Despite the presence of systematic time-varying measurement error, it also generally suggests that infant mortality is procyclical.[24] Figure 4b shows no such relationship between coffee prices and infant deaths in regions not growing coffee.

To analyze how behavior and specific health investments 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).[25] 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 waves. The bottom panel of Table 1 shows

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

[25] 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.

descriptive statistics for Colombian children and their mothers in the pooled DHS sample. All data sources are described in greater detail in the *Data Appendix*.

3.2 Empirical Strategy

Our basic approach relates cohort size at the municipio by birth year level to abrupt non-linear changes in prevailing internal coffee prices and coffee growing intensity in the first year of life. Specifically, in a cohort study framework, we compare the survival of infants and children (i.) born at the same time in areas with varying coffee-growing intensity, (ii.) born in adjacent years within the same coffee-growing area, and (iii.) born in different years but experiencing price shocks at the same age and in the same area. This strategy exploits the fact that health is considerably more fragile while *in utero* and during the first year of life than during the second (National Center for Health Statistics 2002, Wise 2004, Jayachandran 2006 <ADD PHYSIOLOGY CITATIONS>).[26] Because consecutive birth cohorts experience nearly identical conditions at every age except for the first year, we associate survival differences between them with experiences during this critical year.

We first analyze each price shock shown in Figure 1 separately: the 1975 Brazilian frosts, the 1985 Brazilian drought, and the 1991 price collapse following the 1989/90 abandonment of International Coffee Agreement export quotas. We begin by 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 shock occurred. Specifically, for consecutive annual birth cohorts c and municipios m, we estimate:

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

[26] 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 the birth cohort c born in municipio m, g is coffee growing intensity in municipio m (measured in hectares of coffee in the preceding NFCG coffee census), p is the internal coffee price in cohort c's year of birth, δ_m represent municipio fixed effects, and the parameter estimate of interest is the estimate of λ. To test for changes in intrahousehold resource allocation that differ by children's gender when price shocks occur, we also estimate equation 1 for males and females separately.

Next, using samples of those in their first three (rather than first two) years of life when a shock occurred (age 0-1, 1-2, and 2-3), we re-estimate a variant of equation 1 that includes a birth year dummy variable and its interaction with the municipio fixed effects (which capture municipal-specific linear time trends).[27] 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 municipio.[28]

To investigate cyclical changes in health behaviors and investments that underlie our results, we also estimate variants of equation 1 using child-level DHS records. Most health investment measures are dichotomous, so we generally employ probit models of the following general form for children i, birth cohorts c, and municipios m:

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

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

[28] Pooling together samples used to analyze each price shock separately, we then estimate: $ln(s_{cm}) = \alpha + \pi k_c + \beta g_m + \gamma p_c + \mu(k_c \times g_m) + \eta(k_c \times p_c) + \lambda(g_m \times p_c) + \rho(k_c \times g_m \times p_c) + \delta_m + \delta_m \times y + \varepsilon_{cm}$, where k is a dummy variable indicating whether or not a price shock occurred in cohort c's year of birth, $\delta_m \times y$ represents municipal-specific linear trends, and all other variables are defined as before.

where $\Phi[\cdot]$ is the standard normal cumulative density function, *b* is a dichotomous outcome of interest (prenatal tetanus toxoid, prenatal care, medical birth assistance, BCG vaccine, DPT vaccine, polio vaccine, and measles vaccine), w is a vector of maternal characteristics (mother's age, education, number of household members, number of preceding births, age at first birth, and age at first marriage), and all other variables are defined as in equation 1.[29]

4. Results

4.1 Mortality Results

Table 2 shows estimates of λ (the coefficient on the interaction between 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 (approximately 250 hectares) and a 500 peso price change.[30]

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

[30] The distribution of coffee hectares is heavily right-skewed. These calculations emphasize a sample that excludes the uppermost 5% of the distribution. The estimates shown in Table 2 are robust to the inclusion/exclusion of outliers. Re-estimating equation 1 with a squared term for coffee hectares and its interaction with price yields the same pattern of results for the median coffee growing municipio. Quantile (median) regression estimates are also statistically identical.

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).[31] 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%. Pooled analyses (not shown) that exploit all three price shocks simultaneously imply comparable cohort size changes.[32] 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 five, our estimates imply that the largest price fluctuations are associated with changes in child survival of up to 16%.[33]

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.

4.2 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

[31] 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.

[32] For median coffee growing intensity and a 1,000 peso price change, the pooled analyses imply a -2.2% change in cohort size (available upon request).

[33] For a mean birth year by municipio 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 excess mortality occurs after age 5, so this is an overstatement of the true change in survival.

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 are an important part of the explanation for the results in Table 2.

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 4 reports marginal probabilities corresponding to estimates of λ (evaluated at the mean of the independent variables) obtained from equation 2.[34] In general, the estimates are negative, implying that children are more likely to receive health investments when coffee prices are low (and in areas

[34] Sample sizes for childhood vaccines in 1985 are smaller because early DHS waves only reported these health investments for children born within five years of the survey date. For this reason, the 1975 price shock cannot be analyzed.

with greater coffee growing intensity). For a municipio with approximately 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. Presumably there are many time-intensive hygienic behaviors that 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. Assuming that substitution effects dominate income effects when the price of children changes, 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). 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 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 5 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 municipios with median coffee growing intensity, a 500 peso price decrease was associated with birth intervals that were 2.6 and 6.0 months shorter, respectively.[35]

[35] These results are also not sensitive to controlling for parity.

Taken together, Tables 4 and 5 suggest that changes in the value of time are an important part of the explanation for why infant and child mortality are procyclical in rural Colombia. Although we cannot separately identify the income and substitution effects induced by these price changes, they work in opposite directions. The pattern of results that we find implies that the substitution effect dominates.

5. Validity Tests

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-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 6 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 6 provides no evidence of any of these changes.

We then explore how selection into municipios 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 municipios with varying coffee growing intensity according to unobserved characteristics related to price responsiveness and child survival.[36] We do condition on both fixed and time varying differences across municipios, and time-varying changes in the composition of women giving birth (through migration or selective mortality, for example) would be evident in Table 6. However, unobserved *latent* differences that influence the type or magnitude of behavioral

[36] Table 1 shows characteristics of municipios with and without coffee in the 1993 population census. Municipios with more coffee tend to have more educated residents who are more likely to be employed, but many similarities are also evident.

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 municipios 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 an average of 7%, 20%, and 26% (respectively).[37] Table 7 presents coefficient estimates for the interaction between CPI in the first year of life and coffee growing intensity. None are statistically distinguishable from zero.[38] Importantly, any bias due to unobserved latent differences that become manifest in the presence of price shocks would alter the magnitude – but not the sign – of our estimates.

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 (due to incomplete credit, saving, and insurance markets) 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

[37] See: http://www.banrep.gov.co/econome/dsbb/i_srea_012.xls
[38] We also find estimates that are indistinguishable from zero when we re-estimate equation 2 using the Colombian CPI and these same birth cohorts using Demographic and Health Survey data.

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, invoking the opportunity cost of time (Goldin 1999, Schady 2004).

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 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 selection process could be systematically related to the outcomes examined. The literature generally addresses this concern by proposing that the direction of any bias due to selective attrition should be downward. The reason is that those in the left tail of underlying health and socio-economic distributions are disproportionately likely to die, dropping out of the sample of survivors (and most studies report that early life health injuries are associated with worse later life outcomes, hence the downward bias). This paper's 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 marginal survivors are relatively weak, then the average health and socio-economic status of the surviving population later in life would mechanically be worse. The point is not that these studies necessarily draw misleading conclusions, but rather the sign of any bias due to selective mortality can be ambiguous.

Finally, 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 measures of 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 much 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 forthcoming). Our results are consistent with this view, illustrating how reductions in the price of health can reduce mortality even as income falls. By implication, the old adage "a rising tide lifts all boats" may not apply to health improvement in developing countries.

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Figure 1a: Real World Coffee Prices and Internal Prices Paid
to Colombian Coffee Growers, 1970 - 2000

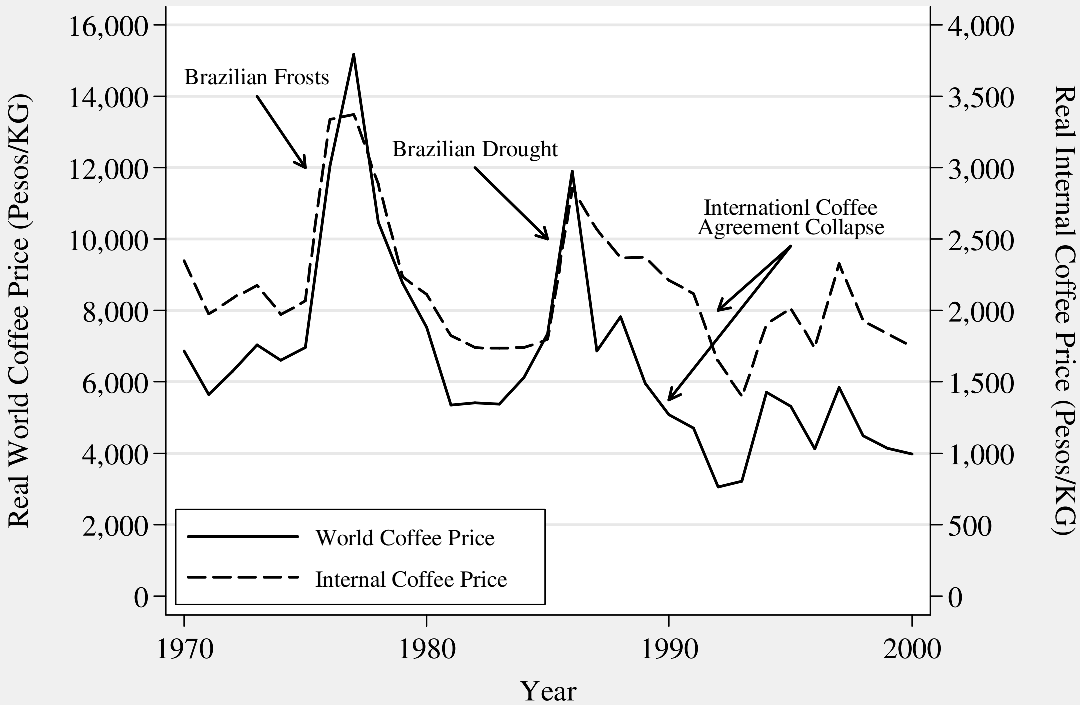

Figure 1b: Real World Coffee Prices and Internal Prices Paid
to Colombian Coffee Growers, 1970 - 2000

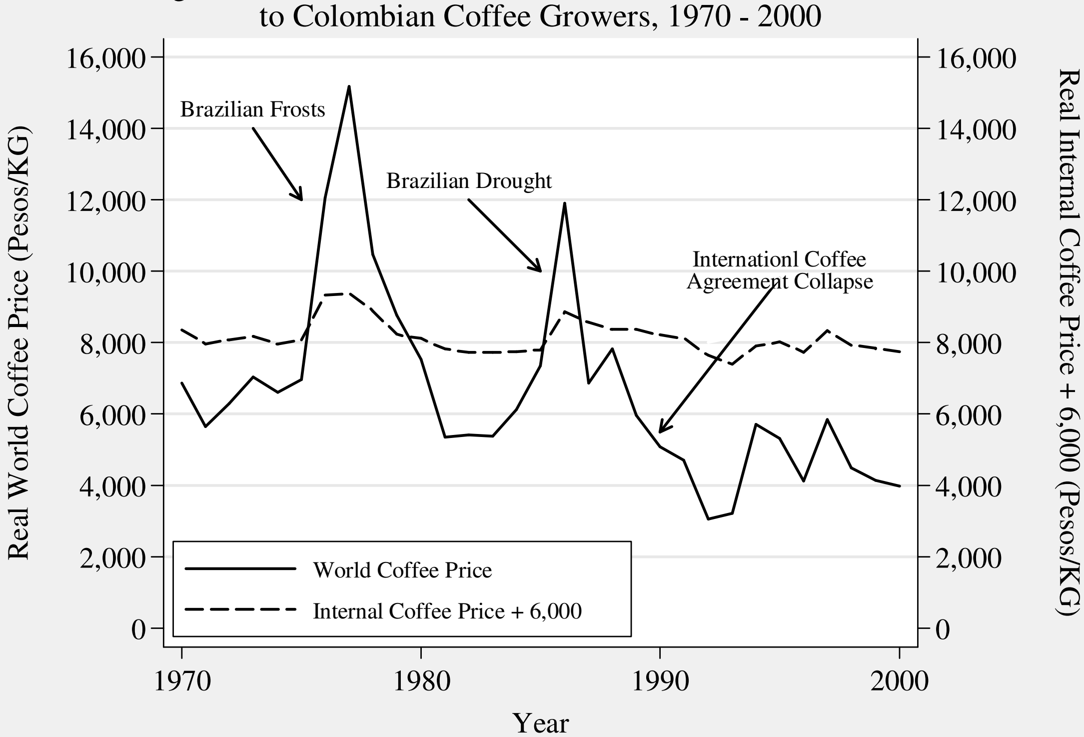

Figure 2: The Geography of Coffee Cultivation in Colombia's Municipalities

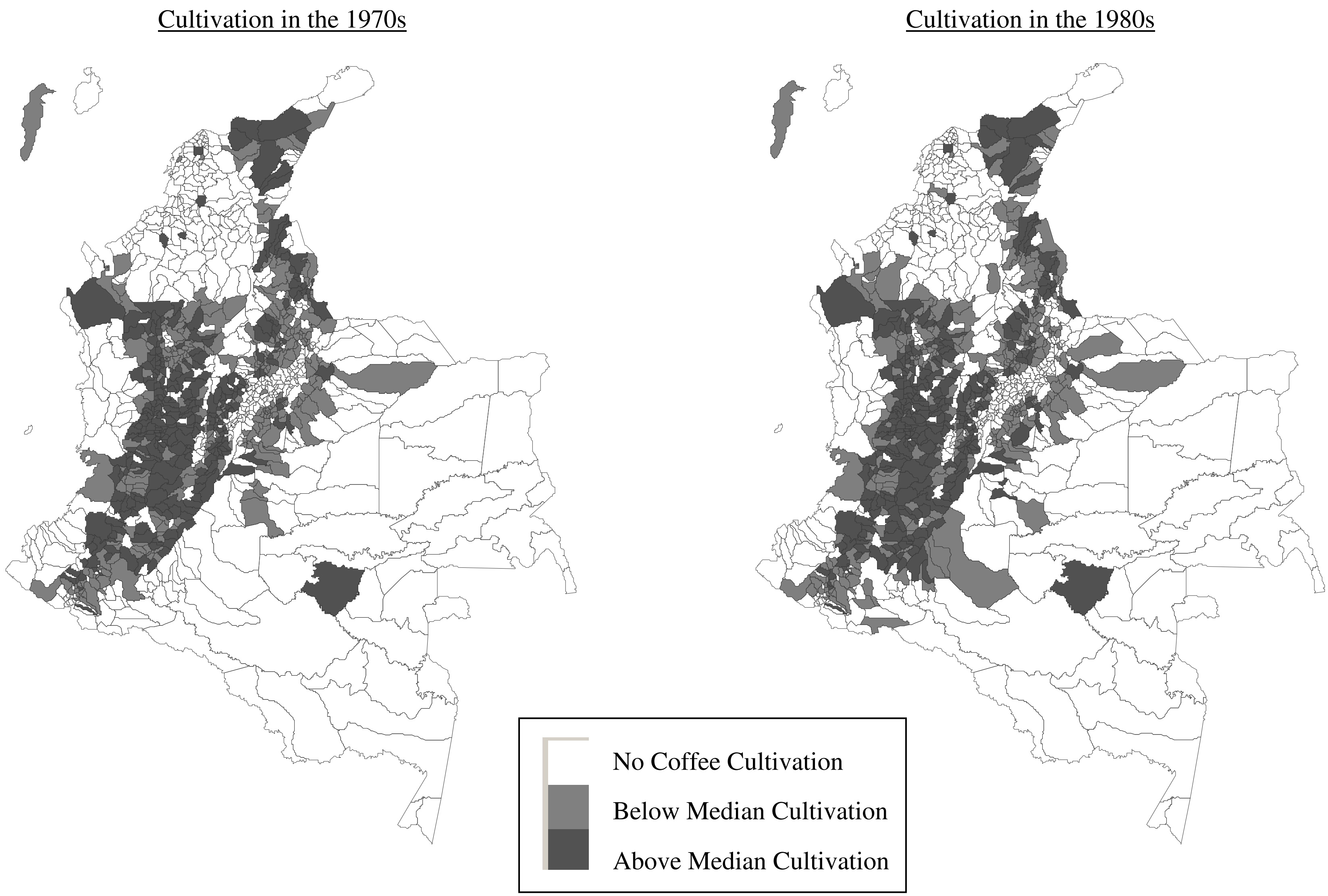

Figure 3a: Coffee Prices Paid to Colombian Growers and Difference in Birth Cohort Size between Municipalities with Above/Below Median Coffee Cultivation, 1970-1991

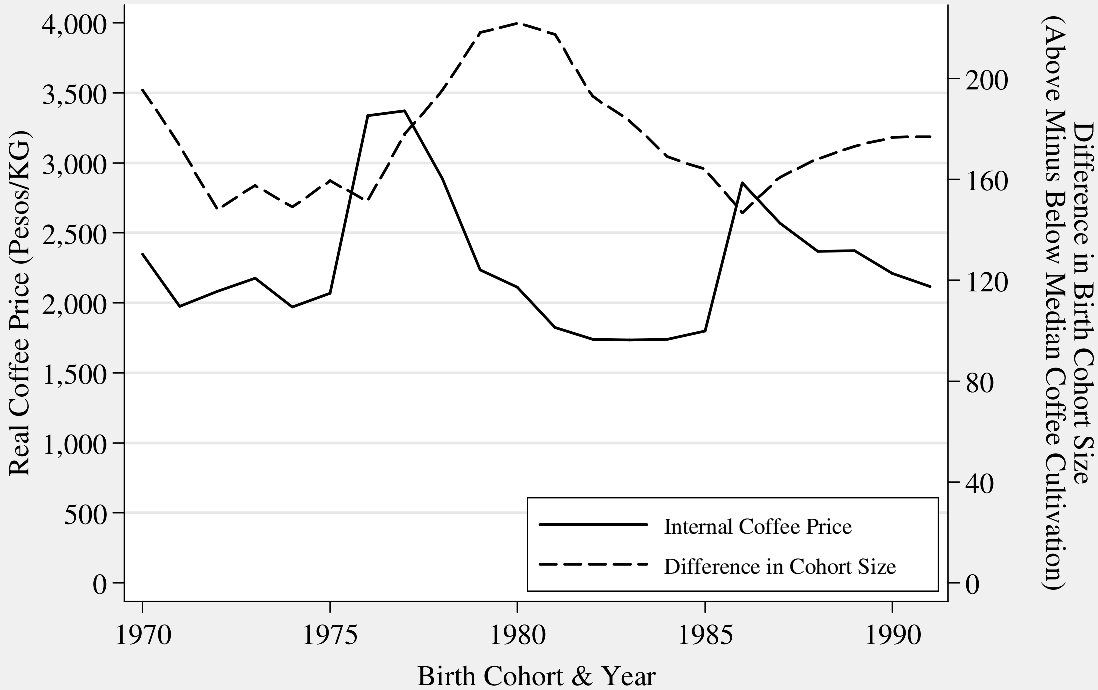

Figure 3b: Coffee Prices Paid to Colombian Growers and Birth Cohort Size in Municipalities not Cultivating Coffee, 1970-1991

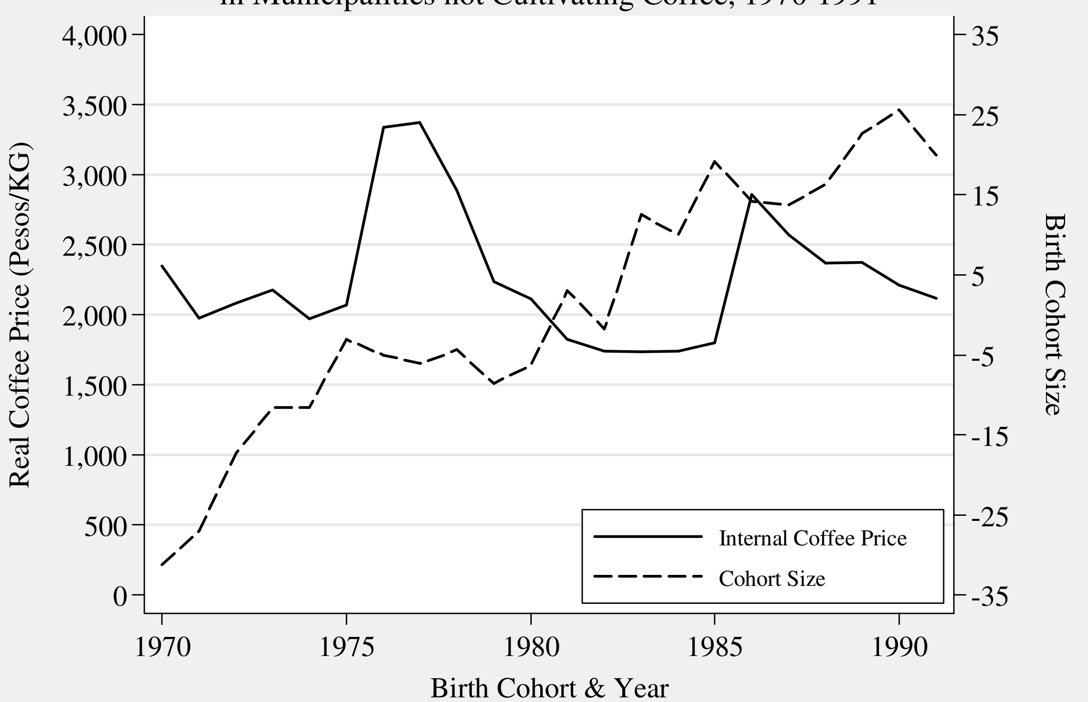

Figure 4a: Coffee Prices Paid to Colombian Growers and Difference in Infant Mortality between Municipalities with Above/Below Median Coffee Cultivation, 1979-2000

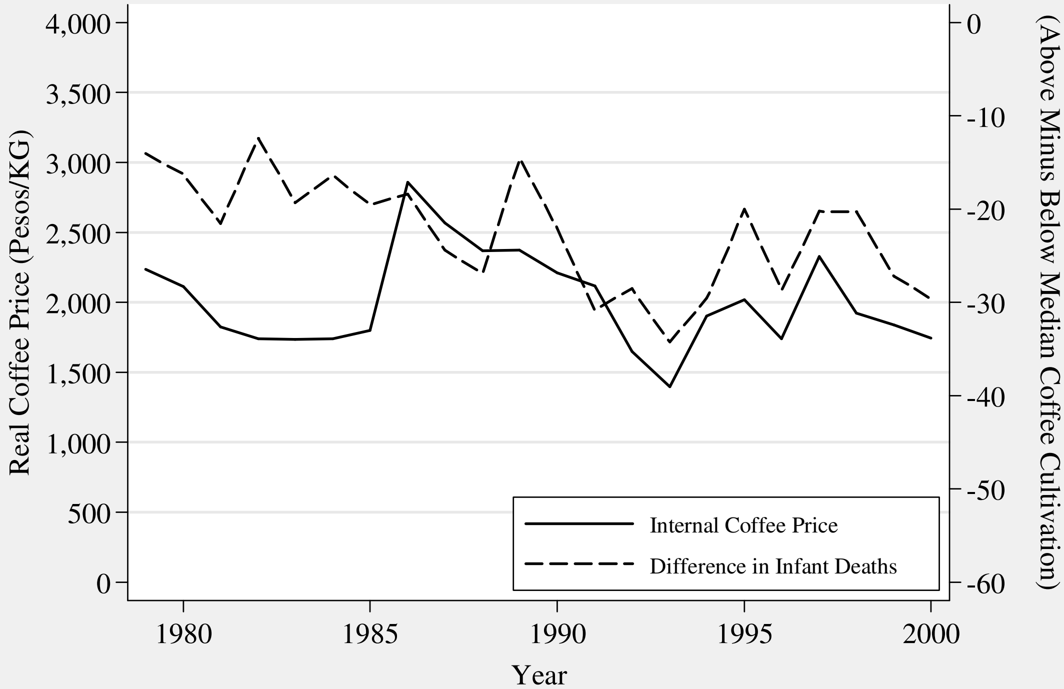

Figure 4b: Coffee Prices Paid to Colombian Growers and Infant Mortality in Municipalities not Cultivating Coffee, 1979-2000

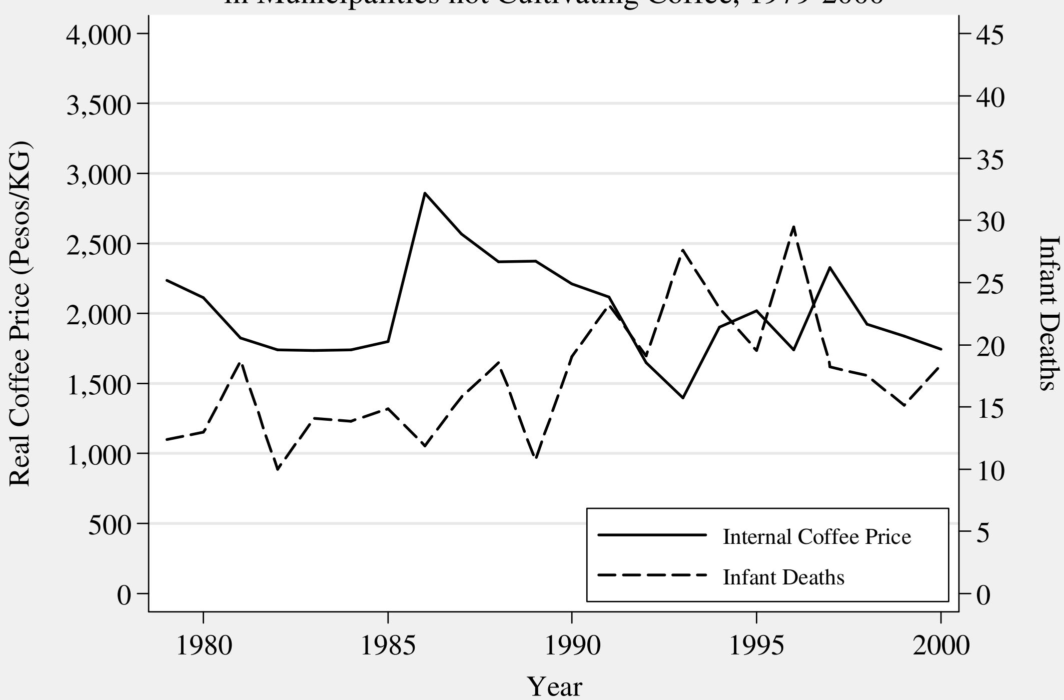

Table 1: Descriptive Statistics

Panel A: Municipalities in the 1993 Population Census

	All Municipalities (N=1,060)		Municipalities with Coffee (N=589)		Municipalities 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 Preabricated 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 Municipalities (N=70,695)		Municipalities with Coffee (N=22,313)		Municipalities 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)

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 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.

Table 2: The Effect of Coffee Price Shocks on ln(Cohort Size) in Coffee Growing Regions

	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 municipality 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: The Effect of Coffee Price Shocks on ln(Cohort Size) in Coffee Growing Regions 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: 1991 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 municipality 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: The Effect of Coffee Price Shocks on Child Health Investments in Coffee Growing Regions

	Estimate	Standard Error	N	R^2/Pseudo R^2
1985 Brazilian Drought				
Prenatal Tetanus Toxoid	-1.08E-06***	(3.70E-07)	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)	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)	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 municipality 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. Addressing censoring in the distribution of months breastfed does not change its statistical insignificance at conventional levels. *p<0.1, **p<0.05, ***p<0.01.

Table 5: The Effect of Lagged Coffee Price Shocks on Preceding Birth Intervals in Coffee Growing Regions

	Estimate	Standard Error	N	R^2
1975 Brazilian Frost	-4.13E-06	(6.02E-06)	2419	0.12
1985 Brazilian Drought	2.12E-05*	(1.25E-05)	3676	0.12
1990 ICA Collapse	4.79E-05**	(2.18E-05)	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 municipality 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 6: The Effect of Coffee Price Shocks on Maternal Characteristics and Birth Timing in Coffee Growing Regions

	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 municipality 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 7: The Effect of CPI Changes on ln(Cohort Size) in Coffee Growing Regions

	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 municipality level shown in parentheses. *p<0.1, **p<0.05, ***p<0.01.

Data Appendix

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 worked exclusively with the latter. We then converted the 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. <DESCRIBE HOW THESE WERE CONDUCTED IN THE 1970S AND 1980S> In our analyses, we use the most recent coffee census conducted before a particular price shock of interest. (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.

Birth Cohort Size

We constructed birth cohort size counts at the municipio-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 municipios to be recognized according to each individual's municipio of birth, not municipio of residence in 1993. There were 32,451,229 non-institutionalized individuals in 1060 municipios recorded in the 1993 population census. These municipios 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 municipio 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 Bogotá-based Asociacion 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 municipio of residence at the time of the survey (municipio of birth is not recorded in the DHS data). Individual municipios 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 municipios.

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

The Colombian National Household Survey ("Encuesta Nacional de Hogares," or ENH) is a household survey originally designed to measure national-level unemployment. Prior to 1992, the ENH only sampled households in Colombia's thirteen largest cities (the "traditional" sample). Beginning in 1992, the ENH began surveying separate "rural" and "urban" household samples as well as continuing the traditional sample. The rural/urban distinction corresponds to technicalities of local administrative jurisdictions. Households surveyed between 1992 and 1995 were drawn from the 1985 population census, while subsequent samples have been drawn from the 1993 population census.

Prior to 2001, the ENH was conducted quarterly as a repeated, cross-sectional survey. The third quarter survey is the largest and is representative at the national and departmental (or state) level as well as being representative of "rural" and "urban" Colombia. The other quarters are representative of Colombia's seven and thirteen largest cities (the "traditional" sample), depending on the year. Beginning in 2001, the ENH was transformed into a monthly rotating-panel survey, but survey data continues to be released quarterly as before.

Because no "rural" data was collected before 1992 and the municipio-level identifiers for survey years before 1996 are fraught with errors, we restrict our supplementary analyses using the ENH to third-quarter survey data from 1997-2004. Pooling these third-quarter waves together yields a sample size of XXX. Specific measures relevant for this study include: whether or not a respondent's primary activity in the last week was work, how many hours were worked in the last week, whether or not one looked for work in the last four weeks, and weeks since a respondent last worked. Questions about source-specific income are asked, but responses are very often missing.

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 <LIST VARIABLES THAT CAN BE CONSISTENTLY FOLLOWED OVER TIME – deaths by age, sex, cause, place of occurrence, etc.>. 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 (that is presumably correlated with economic conditions) (Florez and Mendez 1997, Medina and Martinez 1999, Wilmoth et. al. forthcoming). For example, the crude death rates in Colombia calculated for 1985 and 1993 using the vital statistics and the population censuses were 5.2 and 5.1. The crude death rate in the United States in both years was 8.7. This mortality rate difference is not explained by differences in population age structure alone.

Appendix Table 1: The Effect of Coffee Price Shocks on Local Labor Markets

	Estimate	Standard Error	Implied Change	N	R^2/Pseudo R^2
If not working, probability that looked for work in last 4 weeks	-4.28E-09**	(1.80E-09)	-0.054%	58,916	0.02
If unemployed, weeks since last worked	-1.12E-08***	(1.05E-09)	-0.140%	59,563	-----
If worked last week, hours worked last week	2.25E-07***	(5.85E-09)	0.028	81,175	0.01

Notes: Estimates shown for the interaction between coffee growing intensity and coffee price (the first row shows marginal probabilities calculated at the mea of the dependent variables obtained from probit estimates; the second row shows negative binomial estimates, and third row reports OLS estimates); standard errors clustered at the municipality level are shown in parentheses. Implied changes are calculate for 250 hectares of coffee and a 500 peso price change. *p<0.1, **p<0.05, ***p<0.01.