Economic Growth and the HIV/AIDS Pandemic: Evidence from the Early 21st Century Copper Boom *

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Abstract

Copper mining is among the largest economic activities in Zambia, comprising close to ten percent of GDP. Between 2003 and 2008, the price of copper increased by over 400 percent. In response, copper production in Zambia grew by 70 percent and employment in copper mining increased by nearly 200 percent. This paper examines the effect of this large and sustained economic shock on sexual behavior and the spread of HIV/AIDS in Zambia. I use nationally representative survey data on sexual behavior before and during the copper boom in conjunction with detailed spatial data on the location of survey respondents and copper mines. The results indicate that the copper boom substantially reduced rates of transactional sex and multiple partnerships in the copper mining cities. These effects were partly concentrated among young adults and copper boom induced in-migration to mining areas appears to have contributed to these reductions.

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1 Introduction

Copper mining is one of the largest economic activities in Zambia, comprising close to 10 percent of GDP (USAID 2006). During the global economic expansion of the mid-2000s, demand for copper rose dramatically. As a result, the world copper price increased by over 400 percent between 2003 and 2008. In response to the large increase in the world copper price, copper production in Zambia boomed. Between 2003 and 2008, copper output in Zambia increased by 70 percent, employment in copper mining increased by 180 percent, and real GDP per capita grew by 76 percent (between 2003 and 2007).

This paper examines the effect of the copper boom on sexual behavior and the spread of HIV/AIDS in Zambia, a country in which roughly one in six adults is HIV positive. In doing so, it provides some of the first causal evidence on a growing policy debate: the effect of economic growth on the HIV/AIDS pandemic. Some in this debate (e.g., Fenton 2004) argue that poverty reduction is an important component in the fight against HIV/AIDS. Others emphasize that there is a positive gradient in the relationship between wealth and HIV prevalence, both within countries (Mishra et al 2007) and across countries in Sub-Saharan Africa (Parkhurst 2010).

Although there is little empirical evidence on the causal effect of economic growth or large economic shocks on the HIV/AIDS pandemic, several studies have examined the effect of individual and household level economic shocks on sexual behavior. Dinkelman et al (2007) find in a panel of young adults in Cape Town, South Africa that negative household-level economic shocks (e.g., death or job loss) are associated with an increased likelihood of young women in these households having multiple sexual partners. Robinson and Yeh (2010) find that among a sample of 192 commercial sex workers in Busia District, Kenya individual- and household-level negative health shocks increase willingness to supply particularly risky transactional sex. Other studies which examine compensating differentials in sex markets, such as Gertler et al (2005), find that unprotected sex is associated with a price premium in the transactional sex market, possibly suggesting that rising incomes among consumers of transactional sex may lead to increased risky sexual behavior.

As partly indicated by these studies, it is unclear whether economic growth will help alleviate the HIV/AIDS pandemic or exacerbate it. Rising wages and incomes, as well as associated socioeconomic and cultural changes, affect both the supply of sex and demand for sex. Increased employment opportunities for women outside of the transactional sex market should lead to a decrease in the supply of risky sex. Conversely, rising incomes among men may lead to an increase in demand for sex. Income and substitution effects from increased labor demand affect fertility decisions and marriage, which in turn affect sexual behavior. Other literature, such as Lurie et al (2003) and Oster (2009a), discusses the role of migration in the spread of HIV/AIDS, and development and economic growth affect migration. In addition, Oster (2009b) argues that higher incomes may increase the behavioral response to increased HIV risk. Individuals with higher incomes face a higher marginal cost of risky behavior because of the greater forgone utility in expectation from increased risk of death. Although this suggests that economic growth might reduce risky sexual behavior, the causal evidence on this issue remains scant.

I use the large increase in Zambian copper output associated with the world price shock as a quasi-experiment to estimate the effects of copper production on sexual activity and the spread of HIV/AIDS. Data on sexual behavior come from repeated nationally representative cross-sectional household surveys conducted before and during the boom. Detailed geographic information on the location of survey respondents and copper mines allow me to measure the effect of changes in copper output at a particular mine on sexual behavior among those respondents residing near that mine. This identification strategy isolates plausibly exogenous spatial and temporal variation in the intensity of the copper boom from time-invariant spatial heterogeneity and time-specific shocks.

Several key findings emerge from this analysis. First, the copper boom caused relatively large reductions in transactional sex and multiple partnerships, arguably the two riskiest activities reliably captured in sexual behavior data, as well as a reduction in pregnancy rates for younger women. Second, these effects appear to have been concentrated within the urban areas surrounding the mines. Third, the spatial pattern of changes in consumer durable ownership and migration status are consistent with the interpretation that the effects of the copper shock were very localized. Fourth, younger individuals and males, the individuals who generally report engaging in the riskiest sexual behaviors, tended to demonstrate the greatest reductions in risky behavior. Fifth, copper boom induced in-migration appears to have contributed to these effects.

These results offer new insights for understanding the effect of economic growth or large economic shocks on the HIV/AIDS pandemic in Sub-Saharan Africa. Existing studies of the relationship between economic growth and HIV/AIDS focus on the effect of HIV/AIDS on economic growth (Young 2005) or its determinants (Fortson 2009, Fortson 2010, Juhn et al 2009). I find that a large and sustained positive shock to aggregate production reduces particularly risky sexual behaviors. This suggests that the supply-side effects of rising incomes and economic opportunities for women outside of sexual activity dominate demand-side effects, if any, among men of rising incomes and increased willingness-to-pay for sex.[1] In some sense, this may not be particularly surprising. The labor supply decisions of women at risk of entering the transactional sex market are probably quite responsive to increases in outside opportunities; transactional sex likely is a last resort. In contrast,

[1] The finding in Robinson and Yeh (2010) that commercial sex workers increase their supply of particularly risky sex in response to negative individual- and household-level shocks is consistent with this interpretation. Similarly, Kohler and Thornton (2010) find that women receiving a conditional cash transfer (CCT) reduce their sexual activity in the week following the transfer. Kohler and Thornton (2010) also find that men receiving the CCT increase their sexual activity in the week following the transfer. These studies provide evidence on the effect of small shocks or small cash transfers on sexual activity among individual persons. One could also interpret these studies as providing evidence on the supply of sexual activity and the demand for sexual activity. In contrast, I provide some of the first causal evidence on the equilibrium effects of a large and sustained economic shock on sexual behavior in a long-term nationally-representative study.

many men, both low income and higher income, report engaging in transactional sex.

It is reasonable to believe that the effects of the copper boom on sexual behavior and the spread of HIV/AIDS in the copper mining region of Zambia parallel the effects of more balanced economic growth on the economy-wide spread of HIV/AIDS in other settings. The Zambian copper mines are located in relatively large cities with gender ratios close to one.[2] Moreover, the results of the empirical analysis indicate that the boom affected average behavior in the mining cities (and the behavior of women), not just the behavior of (predominately male) miners. Even if the effects I document in this analysis are specific to mining-led growth, mining booms appear to have been a substantial component of much the recent economic growth in Sub-Saharan Africa (Beny and Cook 2009), the region of the world most affected by the HIV/AIDS pandemic.

The paper proceeds as follows. Section 2 provides the institutional context for copper mining in Zambia. Section 3 describes the copper boom. Section 4 outlines a conceptual framework for interpreting the empirical results. Section 5 discusses the data on sexual behavior, consumer durable ownership, and migration. Section 6 presents the empirical strategy. Section 7 presents the results. Section 8 concludes.

2 Copper Mining in Zambia

Copper mining is one of the largest economic activities in Zambia. It comprises approximately 10 percent of GDP (USAID 2006) and more than 60 percent of exports (United Nations Statistics Division 2009). The majority of copper ore mined in Zambia is smelted locally before being exported to foreign markets (Fraser and Lungu 2007). Copper and copper ore are transported by truck and rail to the south through Lusaka and on to South Africa and to the northeast through Kasama and Mpika to Tanzania.

Large-scale mining constitutes 90 to 95 percent of copper mining in Zambia.[3] During the period examined in this analysis, there were eleven large-scale mines located in nine mining cities in northern Zambia. Figure 1 shows the spatial distribution of the mines, as well as the main transportation networks in Zambia and several of the larger non-mining cities. Eight of the mining cities are clustered together in Copperbelt Province and the other mining city, Solwezi, is in an adjacent province, Northwestern Province. Without exception, each mine is located within 10 kilometers of the approximate centroid of the nearest city and in many cases the mine is located virtually in the center of the city. As shown in Table 1, eight of these cities are among the twenty largest urban areas in Zambia. The ninth mining city, Chambishi, has a population of roughly

[2]Data from the 2000 Census indicate that the ratio of males to females in the copper mining region (i.e., Copperbelt Province, whose population resides primarily in the copper mining cities) is 1.02.

[3]Personal communication with Alfred Phiri, Mining Economist, Zambia Ministry of Mines and Minerals Development.

15,000.[4]

For much of the post-colonial era, the Zambian government owned the large-scale mines. Beginning around 2000, the government privatized copper mining and all of the large-scale mines were under the control of private ownership by the end of 2004 (Fraser and Lungu 2007). The new majority owners of the mines and the associated capital inputs are British, Canadian, Chinese, Indian, South African, and Swiss companies. The government of Zambia remains a minority shareholder in two of the copper mining operations in Zambia.

Copper mining is less labor intensive than agriculture in Zambia and represents a smaller share of employment than of GDP. According to the 2005 Labor Force Survey (LFS), the "mining and quarrying" industry employed 56,227 workers, or approximately one percent of individuals aged 15 years and older. However, in Copperbelt Province, where ten of the eleven aforementioned large-scale mines are located, 8.9 percent of employment is in mining and quarrying. Not only are ten of the eleven aforementioned large-scale mines located in Copperbelt Province, but eighty-two percent of employees in mining and quarrying reside in Copperbelt Province.

The LFS indicates that workers in the mining and quarrying industry are highly skilled and highly paid relative to other workers in Zambia. Forty-five percent of workers employed in mining and quarrying have completed between grade 10 and grade 12, four percent of workers have completed A level, and seventeen percent of workers have a degree. Only two industries in Zambia are more highly skilled: "finance, insurance, and real estate" (40,666 workers) and "electricity, gas, and water" (17,122 workers). Average earnings among mining and quarrying employees are approximately 986,000 kwacha (or roughly US$200) per month, again behind only finance, insurance, and real estate (1.22 million kwacha) and electricity, gas, and water (1 million kwacha).

The LFS also shows that mining employees are predominately relatively older males who work full-time. Mining and quarrying has the greatest proportion of full-time workers of any industry and these employees work 56 hours a week on average. Ninety-three percent of mining and quarrying employees are male and the majority of females employed in mining and quarrying are part-time workers. At least at the onset of the copper boom, workers in the mining and quarrying industry were older than in any other industry. For example, 20 percent of workers were aged 40-44.

[4]The high population densities and balanced gender ratios around the Zambian copper mines make this context different from many other mining settings. For example, Stuckler et al (2010) describe a setting where most of the population near mines are mine workers who reside in all-male hostels and many of the local female residents are sex workers who locate near the mines because of the large concentration of men.

3 The Copper Boom

As shown in Figure 2, in early-to-mid-2003 the world copper price began to increase dramatically after twenty-five years of relative stability.[5] By the time it reached its peak in April of 2008, it had risen by 428 percent.[6] This increase was much larger than the two price shocks of the late-1980s and the mid-1990s, the largest of which was a 175 percent increase ending in February of 1989.

The large increase in the world copper price was an exogenous shock to Zambian copper production. Although copper is one of its largest economic activities and Zambia was the 8th largest producer of copper in the world in 2006, Zambia produces a small share of the world's copper supply. For example, Zambia produced nearly 515,000 metric tons of copper ore in 2006, which constituted 3.4 percent of the total world output of more than 15 million metric tons. In contrast, total copper output in Chile, the world's largest copper producer, equaled 5,361,000 metric tons in 2006 (International Copper Study Group 2010).[7] The most recent copper cartel, the Intergovernmental Council of Copper Exporting Countries (CIPEC), was founded in 1967 (Panayotou 1979). Indeed Zambia was a founding member, but the cartel ended in 1988, consistent with the finding (Pindyck 1978) that copper cartelization yields only minor benefits to cartel members because of the responsiveness of secondary (i.e., scrap) copper supply.

In response to the copper price shock, copper production in Zambia boomed. In 2002, the year prior to the price shock, annual copper production was approximately 335,000 metric tons. By the end of 2008 (and the end of the copper boom), annual copper production had grown by 70 percent to more than 569,000 metric tons.

Although total copper production in Zambia increased dramatically, two of the mines experienced large declines in production during this period because they began to run out of copper.[8] Figure 3 shows annual copper mining production in Zambia from 2000-2008, disaggregated by depleting and non-depleting mines. For the depleting mines, Bwana Makuba mine in Ndola and Nchanga mine in Chingola, total output actually began to decline around the onset of the world

[5] This figure reports the monthly world copper price and annual real GDP per capita in constant 2005 US$. Copper price data come from the International Monetary Fund (IMF) database. The copper price series in this database is the London Metal Exchange (LME) spot price for grade A cathode at European ports. Real GDP per capita data (in constant prices) come from, "Alan Heston, Robert Summers and Bettina Aten, Penn World Table Version 6.3, Center for International Comparisons of Production, Income, and Prices at the University of Pennsylvannia, August 2009."

[6] Although the world copper price fell dramatically at the onset of the global economic recession of the late 2000s, the sexual behavior and copper output data I use in the empirical analysis only capture the boom years and several pre-boom years.

[7] The other countries that produce more copper than does Zambia are the United States (1,220,000 metric tons), Peru (1,049,000 metric tons), Australia (859,000 metric tons), China (844,000 metric tons), Indonesia (816,000 metric tons), and the Russian Federation (675,000 metric tons).

[8] Personal communication with Alfred Phiri, Mining Economist, Zambia Ministry of Mines and Minerals Development.

copper price shock. In contrast, total production at the remaining nine mines rose sharply shortly after the world copper price shock began.

Employment in copper mining also increased substantially over this period, despite the relative capital intensity of large-scale copper mining. Figure 4 shows annual employment in copper mining from 1999-2008. Employment in copper mining grew by over 180 percent during the copper boom. By the end of the boom, roughly one in five adult males in copper mining cities was employed in copper mining. Similarly, the copper boom was associated with a large increase in aggregate output in Zambia. As shown in a previous figure (i.e., Figure 2) GDP per capita grew by 76 percent between 2003 and 2007.

4 Conceptual Framework

There are several reasons to think that the copper boom raised incomes in mining areas and affected sexual behavior in these areas as well. An exogenous increase in the price of copper should have increased demand for labor among mining firms. Thus, the immediate effects of an increase in the world copper price likely were an increase in equilibrium employment in copper mining and an increase in the equilibrium wage. If the supply of mining labor were inelastic, then much of the benefit of the increased demand for mining labor would have accrued to existing mining employees. However, Figure 4 indicates that the benefits of the copper boom were enjoyed by new mining employees as well, as employment in copper mining nearly tripled. In addition, spill-over effects from increased copper production (e.g., increased demand for auxiliary services) mean that the copper boom likely raised the standard of living among individuals not employed in mining.

These changes in income and relative prices would have affected behavior in several markets related to sexual activity. Changes in income and labor supply should have affected the dating and marriage markets. For example, if richer men are more highly valued in these markets, then we might observe an increase in dating and/or marriage among the male beneficiaries of the copper boom. A slightly different line of reasoning suggests that we might observe a substitution toward dating and away from marriage. Magruder's (2010) model of marital shopping predicts that an increase in life expectancy would increase the marital search period and reduce the rate of new marital formations.

The copper boom would have also affected the transactional sex market. Edlund and Korn (2002) argue that women in transactional sex markets earn a wage premium for the associated social stigma they incur in the marriage market. As the financial prospects associated with women's marital opportunities improve with the copper boom, one would expect a decreased willingness to supply transactional sex. Similarly, Robinson and Yeh (2010) show that negative economic shocks among commercial sex workers increase their willingness to supply particularly risky sex because of the desire to smooth consumption. Thus, rising incomes may have reduced willingness to supply risky sex on the extensive margin as well as the intensive margin. On the other hand, rising incomes may increase demand for transactional sex if transactional sex is a normal good.

There are several other possible effects of the copper boom. First, in Oster's (2009b) model of demand for risky behavior, rising incomes increase the continuation value of life, increasing the expected marginal cost of risky sex and reducing the equilibrium quantity of risky sex. Second, in a labor supply model where individuals choose effort to allocate to various tasks, an increase in copper mining employment and wages may be associated with increased effort exerted in the formal labor market and decreased effort exerted in marital search and sexual activity. Third, the increase in economic opportunities in mining areas may have induced labor migration to the mining areas. Increased in-migration likely affects the supply of sexual activity and demand for sexual activity.

5 Data and Descriptive Statistics

The individual- and household-level data for this analysis come from two sets of repeated cross-sectional nationally representative household surveys: the Demographic Health Surveys (DHS) and the Zambia Sexual Behavior Surveys (ZSBS). I use the 2001 and 2007 survey rounds of the DHS and the 2003 and 2005 survey rounds of the ZSBS. These data include information on sexual behavior, consumer durable ownership, and migration status. In addition, I use administrative records on the location of the primary sampling units in these surveys to calculate relatively precise measures of the location of each survey household.[9] This process yields 3,670 individuals in the 2001 DHS, 4,150 individuals in the 2003 ZSBS, 3,746 individuals in the 2005 ZBS, and 13,646 individuals in the 2007 DHS.[10]

These surveys capture several dimensions of sexual behavior. In addition to standard demo-

[9]The nature of the spatial information in these surveys likely introduces bias toward zero in the estimates of the effect of the boom on material standard of living and sexual behavior in mining areas. For the ZSBS and the 2001 DHS, I use information on the respondent's Standard Enumeration Area (SEA) of residence to define the precise location of the respondent as the centroid of this SEA. Because these administrative units were designed to capture approximately 1,000 individuals, they tend to be quite small in urban areas. Hence, this method should produce location calculations indicating with a relatively high degree of accuracy which ZSBS and 2001 DHS respondents reside in mining areas. However, the 2007 DHS contains slightly different spatial information. Instead of revealing the respondent's SEA of residence, the 2007 DHS provides GPS data points that are intentionally measured with error for each respondent to address privacy concerns associated with the HIV testing module in this DHS. In the Zambia 2007 DHS, these data points were generated by adding a randomly drawn vector with length between zero and ten kilometers to the latitude and longitude of the centroid of the SEA of residence.

[10]The DHS and ZSBS survey females age 15-49 and males age 15-59. The 2001 DHS oversamples females by sampling only females in some households. I exclude these female-only oversampled households from the analysis to avoid complications associated with creating ad hoc sample weights. In addition, the digitized census map provided by the Zambia Central Statistical Office, which I use to identify the location of the primary sampling units for the respondents in the 2001-2005 survey rounds, is missing approximately seven percent of the Statistical Enumeration Areas (SEAs) in Zambia. Thus, I am unable to identify the precise location of 6.58 percent of the 2001-2005 survey respondents and exclude these respondents from the empirical analysis.

graphic questions about marital status and pregnancy, the surveys ask respondents to enumerate up to their last three sexual partners in the twelve months prior to the survey date. I use these partner histories to construct indicator variables for whether the respondent had any sexual partner in the past twelve months and whether the respondent had multiple partners in the past twelve months. All of the surveys ask the respondent whether they used a condom the last time they had sex with a given partner in the past twelve months and I use this information to construct a measure of the proportion of sex acts that were unprotected conditional on reporting a sexual encounter in the past twelve months. The ZSBS asks all respondents whether they exchanged sex for money (or money for sex) in the past twelve months and the DHS asks male respondents this same question. I use this information to construct an indicator variable for transactional sex. The surveys ask respondents when was the last time they had sex and I construct an indicator variable for whether they had sex in the past month. Finally, as an additional measure of risky sexual behavior the surveys ask respondents whether they consumed alcohol before they had sex.

Table 2 shows the gender-specific age profiles for each of these measures of sexual behavior. For the moment, I focus on describing some basic facts about gender and age differences in sexual behavior so I pool all four of the survey rounds to calculate sample means. Three key facts emerge from this analysis and will aid in the interpretation of the subsequent regression results. First, premarital sex is an important part of sexual activity. For example, only 20 percent of females age 15-19 are married yet 42 percent report having a sexual partner in the past twelve months.[11] Second, the likelihood of engaging in the riskiest sexual behaviors (i.e., multiple partnerships and transactional sex) is greatest among younger age groups (i.e., females age 15-19 and males age 20-29). Third, most females are married by their early twenties and most males are married by their late twenties, potentially constraining their ability to adjust their behaviors in response to the copper boom.[12]

Because my main empirical strategy relies on comparing the change in sexual behavior in mining cities to the change in sexual behavior elsewhere, it is useful to examine possible differences between these areas. Table 3 displays basic development indicators, demographic characteristics, and measures of sexual behavior in the copper mining cities, in the rest of Zambia, and in districts on

[11] Although these data are not presented in Table 2, forty-six percent of unmarried males and thirty-seven percent of unmarried females report having a sexual partner in the past twelve months. Over 98 percent of married males and over 97 percent of married females report having a sexual partner in the past twelve months.

[12] At least two other points are worth noting. First, for the riskiest sexual activities, there are large differences by gender in average self-reported sexual activity. Gersovitz et al (1998) show that females under-reporting sexual activity and/or males over-reporting sexual activity is more likely to explain these gender differences in sexual behavior than is the existence of a small group of high sexual frequency women not captured by the survey. Second, thirty-two percent of females report being pregnant in the twelve months prior to the survey date, a figure that seems slightly high compared to the estimate total fertility rate in Zambia, 5.91 (Fortson 2009). This suggests that respondents may interpret the "twelve months" prior to the survey as a period longer than twelve months.

the copper transportation routes.[13] I define a mining city as the area encompassed by a circle with a 10 kilometer radius located at the approximate centroid of the urbanized area. This implementation captures all of the urban area (i.e., area contiguously populated with structures) visible in satellite imagery for each of the nine copper mining cities in Zambia.

As shown in the first two columns in Table 3, residents of mining cities enjoy a higher standard of living than does the rest of Zambia. For most of the measures of material standard of living, households in mining cities are approximately twice as likely to report ownership than are households in the rest of Zambia.[14] For measures such as motorcycle ownership, these differences disappear, partly because motorcycles are extremely rare in Zambia.

Rural-to-urban migration in Zambia means that residents of mining cities are more likely to be migrants (22 percent) than are residents of the rest of Zambia (17 percent). Interpreting the level of these figures requires caution because the measure of migration is based on whether the individual has lived in the same household location for at least a year or not. Thus, this measure defines anyone who has relocated within a given city or village as a migrant even if they lived in that community for their entire life.

Individuals in mining areas appear to engage in less sexual activity than individuals in the rest of Zambia. The likelihood of having any partner in the past twelve months, having multiple partners, having sex in the past month, and pregnancy rates are lower in mining areas than in the rest of Zambia, as are marital rates. Rates of transactional sex and unprotected sex are approximately the same in mining cities and in the rest of Zambia. The single exception to this general pattern is alcohol use before sex.

HIV prevalence is higher in mining areas (16.3 percent) than in the rest of Zambia (14.5 percent). Although lack of data on changes in HIV prevalence at the sub-province level means I cannot directly examine the effect of the copper boom on HIV prevalence, there exist data on HIV status in the 2007 DHS at the individual level so I am able to calculate HIV prevalence in mining areas and in the rest of Zambia. Higher HIV prevalence in mining areas might seem surprising given that the level and riskiness of sexual activity is not higher in mining areas than in the rest of Zambia. However, as we shall see momentarily, sexual activity is similarly lower, and HIV prevalence is similarly higher, in the other urban areas in Zambia (i.e., districts along the main transportation routes), as compared to the non-mining regions of Zambia as a whole. This suggests that the level of urbanization (or population density) is an important determinant of HIV prevalence, an observation that is consistent with epidemiological models of HIV transmission.

Districts on the copper transportation routes are more similar to the mining cities than is the

[13] There are 72 districts in Zambia and the copper transportation routes pass through 19 of these districts. The districts on the copper transportation routes are: Chibombo, Chinsola, Choma, Isoka, Kabwe, Kafue, Kalomo, Kapiri Mposhi, Kasama, Kazungula, Livingstone, Lusaka, Masaiti, Mazabuka, Mkushi, Monze, Mpika, Nakonde, and Sernje.

[14] "Floor" is an indicator variable for improved (i.e., brick, concrete, tile, or wood) floor.

rest of Zambia as a whole. Column (3) in Table 3 shows the average characteristics of districts on copper transportation routes. Although the mining cities are still richer than these districts, the divide is smaller for all consumer durable ownership rates except motorcycle ownership. Likewise, residents of these districts have similar average demographic characteristics as mining cities. Sexual behavior in districts on copper transportation routes is also closer to that in mining cities than sexual behavior in the rest of Zambia as whole. HIV prevalence in these districts is virtually the same as in mining cities.

Monthly data on mine-level copper output come from the Ministry of Mines and Minerals Development. These data are available for the period January 2000 through December 2008.[15] Although I would like to complement the analysis of the effect of copper output with an analysis of the effects of employment in mining and of wages in mining, these data are not available at the mine level. Monthly data on the world copper price comes from the International Monetary Fund (IMF) database. The copper price series in the IMF database is the London Metal Exchange (LME) spot price for grade A cathode at CIF European ports.

6 Empirical Strategy

The main empirical strategy of this paper is to compare changes in sexual behavior associated with changes in copper output for individuals residing in mining areas to synchronous changes for individuals residing in non-mining areas. The basic premise of this approach is that the intensity of the copper shock was greater in copper mining areas than in other areas, both directly because of the increase in copper production and indirectly because of spill-over effects into other local markets. The identifying assumption underlying this strategy is that in the absence of the copper boom these changes in sexual behavior (or material standard of living) in mining areas would have been the same as those in non-mining areas. Toward the end of this section, I provide evidence on pre-boom trends that supports this assumption.

There remain two primary concerns about the ability of this strategy to identify the causal effect of the copper boom on sexual activity (or material standard of living) in mining areas. First, the copper boom may have affected sexual activity in non-mining areas as well, meaning that this strategy may yield a biased estimate of the effect of the copper boom on sexual activity in mining areas. I explore this possibility by examining the effect of excluding the non-mining areas most likely to be affected by the copper boom (i.e., the main transportation routes used for copper output) on

[15] Mine-level output data are missing for various months for various mines. When these missing data are not known to be due to a mine closing (or a delayed opening), mine-level output is re-constructed using a simple linear interpolation between the two bounding data points. Because I examine the effect of total local copper output in the twelve months prior to the survey date on sexual behavior during that period, failing to interpolate these data (or, alternatively and more unreasonably, failing to treat the missing values as zeros) would drastically reduce the number of "treatment" observations.

the coefficient estimates. Second, there may have been unobservable shocks to sexual activity that were correlated spatially or temporally with changes in copper output. To address these concerns, I include district fixed effects, year fixed effects, and month fixed effects.[16] Month fixed effects also capture any seasonal variation in sexual activity. In addition, the baseline empirical specification also includes a linear time trend and, in the (individual-level) sexual behavior regressions, gender and five-year age group fixed effects. Thus, the primary regression equation is

$$y_{ijkt} = \gamma output_{kt} + \alpha localmine_{ij} + \beta localoutput_{ijkt} + X'_{ijkt}\Gamma + \eta_t + \mu_k + \delta_j + \xi t + \epsilon_{ijkt} \qquad (1)$$

where y_{ijkt} denotes the outcome (i.e., measure of sexual activity in the past twelve months, measure of contemporaneous material standard of living, or migration status) for individual i (or household i) residing in district j in month k in year t, $output_{kt}$ is total copper production in Zambia in the twelve months leading up to the interview date, $localmine_{ij}$ is an indicator variable equal to one if the respondent resides in a mining area, $localoutput_{ijkt}$ measures total copper output in the area around the respondent in the twelve months leading up to the interview date, X'_{ijkt} is a vector of individual-level controls, η_t are year fixed effects, μ_k are month fixed effects, δ_j are district fixed effects, and ξt is a linear trend. In alternative specifications, I examine the effect of lagged local copper output on consumer durables ownership, sexual behavior, and migration status.

The baseline specification treats the respondent as residing in a mining area if they reside within 10 kilometers of the center of a mining city. As discussed in Section 2, for each of the large-scale copper mines in Zambia there is a relatively large urban area located at (or very close to) to the mine. The effect of copper mining on behavior operates through markets and the urban area near each mine is a spatial approximation of the relevant market. To capture this dynamic, I assign the location of each mine to be the approximate centroid of the nearest urban area. Thus, in practice the 10 kilometer radius means that the regressions compare individuals living in these urban areas at the mines to individuals living elsewhere in Zambia.

This specification imposes a couple of simple restrictions that facilitate the exposition of the empirical results. First, in the absence of district fixed effects, equation (1) imposes the restriction that living within 10 kilometers of the center of a mining city has the same relationship with the outcome of interest (e.g., transactional sex) regardless of the identity of the mine. Including district fixed effects relaxes this restriction somewhat under the assumption that any heterogeneity across mines in this relationship is time invariant. Second, equation (1) imposes the restriction that changes in copper output within 10 kilometers of an individual have the same effect on the outcome of interest regardless of the identity of the mining city. Alternatively, I am estimating the

[16] I am able to include both year and month fixed effects because the repeated cross-sections include numerous observations from the same month in different years, as well as numerous observations from the same year in different months.

average effect of changes in copper output across the eleven mines.

There are two other points concerning identification worth mentioning here, as well as revisiting in the following section. The baseline specification does not immediately distinguish between the effects of copper output produced during the copper boom and prior to the boom. However, including an indicator variable for living in a mining area (as well as district fixed effects) means that the identifying variation comes from changes in output in each mining region, changes that are driven by the copper boom. Nonetheless, in the following section I examine the robustness of the baseline estimate to allowing the effect of local copper output to vary by whether it was produced during the boom era (i.e., the 2005 and 2007 survey rounds). The second point concerning identification is that the baseline specification does not provide special treatment to the depleting mines. It is reasonable to believe that in the absence of the dramatic increase in the world copper price output would have declined even more rapidly than as displayed in Figure 3 because the copper ore in these depleting mines was becoming more costly to extract. Thus, the boom likely increased output in these depleting mines relative to the counterfactual case of no increase in the world copper price. In any case, as reported in footnotes 18 and 21, the effect of output at the non-depleting mines is very similar to that estimated using the full sample.

Before proceeding to the main empirical analysis, it is useful to investigate pre-boom trends in material standard of living, sexual behavior, and migration in mining areas and non-mining areas. I use the subset of data that are from the pre-boom period (i.e., prior to 2003) to estimate a version of equation (1) which omits the two measures of copper output (i.e., $output_{kt}$ and $localoutput_{ijkt}$) and allows for a separate linear time trend for respondents residing in copper mining areas (i.e., respondents residing within 10 kilometers of the center of a mining city). Table 4 presents evidence on pre-boom trends in consumer durables ownership. Although there is some support for the existence of secular pre-boom trends in floor quality and television ownership, there is virtually no support for the hypothesis that consumer durables ownership rates were increasing in mining areas prior to the boom. In fact, aside from radio and bicycle ownership, the estimates suggest a slight downward pre-boom trend in consumer durables ownership rates in mining areas, although the majority of these estimates are not statistically significant. Table 5 repeats this analysis for sexual behavior and migration. Again, the results fail to provide broad support to the hypothesis that sexual behavior (and migration) in mining areas and non-mining areas were on different pre-boom trends. Although there is some evidence that the probability of having any partner (and of having a partner in the past month) was decreasing in mining areas relative to non-mining areas, condom use appears to have been falling in mining areas relative to non-mining areas and pregnancy rates appear to have been rising in mining areas relative to non-mining areas.[17] Overall, these results

[17] An important caveat is that these data only include a single survey year (i.e., the 2001 DHS, conducted in 2001 and 2002). Thus, the results of the pre-boom analysis may confound a hypothetical pattern in the 2001 DHS of surveying riskier individuals latter in the survey round with a downward pre-boom in risky sexual behavior. However,

support the identifying assumption underlying my main empirical strategy.

7 Results

I begin the empirical analysis by examining the effect of the copper boom on consumer durable ownership. This analysis illustrates the magnitude and spatial extent of the copper boom. Then I examine the effect of the copper boom on migration and sexual behavior. As part of this analysis, I conduct a variety of robustness checks and explore heterogeneity by gender and age in the effects of the copper boom. Finally, I examine the role of selective in-migration in explaining these results.

7.1 The Copper Boom and Household Consumer Durable Ownership

The regression results indicate that the copper boom increased the standard of living of households in mining areas. Estimates of the effects of copper output on consumer durable ownership appear in Table 6. All specifications include district fixed effects, year fixed effects, month fixed effects, and a linear time trend, as well as controls for total copper production in Zambia and for whether the respondent resides in a mining area. Standard errors are clustered by Standard Enumeration Area (SEA) of residence.

Panel A presents the results from the baseline specification. These estimates indicate that the copper boom increased household ownership rates for many consumer durables, including improved flooring, refrigerators, and televisions. The effects are statistically significant (p-values = 0.076, 0.021, and 0.014, respectively) and are relatively large.[18] The estimates indicate that a one standard deviation increase in copper output in the past year within 10 kilometers of a household (i.e., 21,000 metric tons) increased ownership rates for these consumer durables by between 2 and 5 percentage points. In relative terms, these are fairly large effects. For example, a one standard deviation in copper output increased the probability of having a high quality floor by 10 percent relative to the average for Zambia as a whole. The copper boom had little-to-no effect on vehicle ownership rates. However, vehicles are substantively different from the other consumer durables measured in the DHS and ZSBS. Cars are much more expensive than the other consumer durables, bicycles may not be normal goods in this income range, and very few Zambians own motorcycles.[19]

for this to be a true threat to the pre-boom analysis, the hypothetical pattern in the 2001 DHS of surveying riskier individuals would have had to have been stronger in mining areas than in non-minings. Although I cannot refute this hypothesis, it seems quite unlikely.

[18] Allowing the effect of local copper output to vary by whether it was produced at a non-depleting mine generates similar results. The coefficient estimate on local copper output produced at non-depleting mines in the floor, refrigerator, and television regressions are 0.213, 0.195, and 0.253, respectively (p-values = 0.112, 0.027, 0.021, respectively).

[19] Average vehicle ownership rates are consistent with this interpretation. As shown in Table 3, fewer than five percent of households own a car, close to zero percent of households own a motorcycle, and bicycles are the only consumer durable for which ownership rates are lower in copper mining cities than elsewhere in Zambia.

In Panel B, I allow the effect of local copper output to vary by whether it was produced during the copper boom (i.e., the 2005 and 2007 survey rounds) or prior to the boom (i.e., the 2001 and 2003 survey rounds). As discussed in the previous section, the inclusion of the mining area indicator variable (as well as district fixed effects) means that the baseline specification identifies the effect of local copper output on consumer durables ownership from changes in local copper output within a particular mining area. Because aggregate copper output was relatively flat prior to the boom, most of the identification in the baseline specification comes from the rise in output during the boom period. Thus, it is not surprising that the estimated effect of local copper output produced during the boom era (i.e., the coefficient estimate reported in Panel B) is very similar to that presented in Panel A, as are the associated standard errors.

Panel C examines the possibility that the baseline results simply reflect a secular trend in material standard of living in mining areas. These regressions allow the linear time trend to vary by whether the respondent resides in a mining area (i.e., within 10 kilometers of the center of a mining city). The estimated effect of copper output within 10 kilometers of the respondent on material standard of living is slightly smaller than that in Panel A for most of the consumer durables and as a whole become only marginally significant (for floor, refrigerator, television, and radio, p-values = 0.187, 0.102, 0.093, and 0.107, respectively), but the effects remain large. These results are consistent with two facts discussed previously. The analysis of pre-boom trends in Table 4 indicated that the material standard of living in mining areas prior to the boom appeared to be on the same time trend as that in non-mining areas. Likewise, the existence of depleting mines with declining output during the period of overall rising output means that the estimated effect of copper output is partly identified off of decreasing copper output for some respondents.

The coefficient estimates presented thus far may be underestimates of the effect of the copper boom on the material standard of living in mining areas. If the copper boom raised the material standard of living in non-mining areas as well, then the estimates in Panels A through C may be biased downwards. To explore this possibility, Panel D excludes respondents who live along the copper transportation corridors. These corridors are: (i) the route south from the copper mining region to Lusaka and on to Livingstone, and (ii) the route from the copper mining region to the east and on past Kasama. Households in these areas would appear to be those households outside of the copper mining region most likely to have benefited from increased copper production.[20]

The estimated effects of the copper boom on the material standard of living in mining areas are robust to excluding districts along the copper transportation corridor. All of the effects identified in the baseline specification (i.e., Panel A) are present in Panel D (for floor, refrigerator, television, p-values = 0.059, 0.014, and 0.006, respectively). In addition, the effect of local copper output on

[20] I exclude the following districts from the regressions in Panel D: Chibombo, Chinsola, Choma, Isoka, Kabwe, Kafue, Kalomo, Kapiri Mposhi, Kasama, Kazungula, Livingstone, Lusaka, Masaiti, Mazabuka, Mkushi, Monze, Mpika, Nakonde, and Sernje.

radio ownership becomes statistically significant at the 10 percent level (p-value = 0.072). For some consumer durables measures (e.g., improved floor) the estimated effects are slightly larger in Panel D than in Panel A, suggesting that districts along transportation corridors may have benefited from the copper boom. However, these differences are not large.

Panel E investigates the sensitivity of the estimated effect of local copper output in the past twelve months to including a measure of local copper output prior to the past twelve months and the joint significance of the contemporaneous and lagged effects. Specifically, I include as an additional regressor a measure of local copper output in the 13 to 24 months prior to the survey date (i.e., the one-year lagged analogue to $CUoutput, 0-10km$; or, $localoutput_{ikt-1}$). This lagged specification also includes a control for total copper output in all of Zambia in the 13 to 24 months prior to the survey date (i.e., $output_{ikt-1}$ in addition to $output_{ikt}$). I report the coefficient estimates for local copper output and $(t-1)$ lagged local copper output in Panel E.

As a whole, the point estimates for the effect of contemporaneous local copper output (i.e., $CUoutput, 0-10km$) in Panel E are roughly similar to those in the previous panels. However, the correlation between contemporaneous local copper output and lagged local copper output is 0.97 (and 0.92 in mining areas), suggesting it is difficult to identify the separate effects of contemporaneous and lagged output. The point estimate on contemporaneous local copper output is not quite statistically significant at the 10 percent level in Panel E for floor (p-value = 0.109), and the contemporaneous effects for refrigerator and television ownership become statistically insignificant. Nonetheless, the joint effect of contemporaneous output and lagged output is statistically significant for refrigerator and television ownership (p-values = 0.027 and 0.016) and only somewhat less precise for floor (p-value = 0.155). In addition, the effect of contemporaneous local output for radio ownership becomes statistically significant (p-value = 0.040), although the joint effect is not statistically significant (p-value = 0.401).

As a final robustness check, I examine the effect of the value of copper produced on material standard of living, rather than the quantity of copper produced. Panel F presents the results of this exercise. The independent variable of interest, "CU value, 0-10km", is simply the LME spot price for a metric ton of grade A cathode at CIF European ports (measured in (2005) US$ '0,000s) multiplied by the independent variable of interest in the previous panels (i.e., metric tons of output produced within 10 kilometers of the respondent in the twelve months prior to the survey date). Again, the large and positive coefficient estimates are consistent with the claim that the copper boom raised material standard of living in mining areas. However, aside from the television regression (p-value = 0.044), the estimated effects are no longer statistically significant. The attenuated and generally insignificant effect of the value of local copper output suggests that most residents of mining areas benefited from increased quantity of production rather than increased value of production.

7.2 The Copper Boom and Individual Behavior: Sexual Activity and Migration

7.2.1 Baseline Results

The baseline regression results indicate that the copper boom reduced transactional sex and multiple partnerships in mining areas. Estimates of the effects of copper output on sexual activity appear in Table 7. All specifications include district fixed effects, year fixed effects, month fixed effects, a linear time trend, and controls for gender and five-year age groups, as well as controls for total copper production in Zambia and for whether the respondent resides in a mining area. Standard errors are clustered by Standard Enumeration Area (SEA) of residence.

Panel A presents the results from the baseline specification. These estimates indicate that the copper boom reduced transactional sex and multiple partnerships in mining cities. A one standard deviation increase in copper output in the past year within 10 kilometers of a household (i.e., 21,000 metric tons) reduced rates of transactional sex and multiple partnerships by approximately one percentage point each. Although the magnitude of these effects is not particularly large in absolute terms, they are statistically significant (p-values = 0.037 and 0.078, respectively) and large in relative terms.[21] An increase of one standard deviation in copper output in the past year within 10 kilometers of a household reduced rates of transactional sex by 23 percent and of multiple partnerships by 20 percent.[22] For none of the other measures of sexual behavior (aside from married, which is not a sexual behavior per se, p-value = 0.084) is the coefficient on local copper output statistically significant. However, the coefficient estimate is always negative, suggesting the boom did not increase risky behavior as captured by these (less risky and somewhat less reliable) auxiliary measures.

Panel B allows the effect of local copper output to vary by whether it was produced during the copper boom or prior to the boom. Consistent with the discussion of the empirical strategy and the consumer durables regression results, the estimated effect of local copper output produced during the boom (i.e., the coefficient estimate reported in Panel B) is virtually identical to that in Panel

[21] Allowing the effect of local copper output to vary by whether it was produced at a non-depleting mine generates similar results. The coefficient estimates on local copper output produced at non-depleting mines in the transactional sex and multiple partners regressions are -0.060 and -0.045, respectively (p-values = 0.035 and 0.077, respectively).

[22] In principle, HIV prevention and treatment efforts on the part of mining companies is one channel through which the copper boom may have affected sexual activity. However, there is little anecdotal or statistical evidence to support the hypothesis that the scale, scope, and/or intensity of HIV prevention and treatment efforts on the part of mining companies was correlated with copper output. Fraser and Lungu (2007) note that: (i) the mining companies that currently have the most comprehensive HIV/AIDS policies implemented these prior to the boom (i.e., 2002) rather than during the boom, and (ii) the mining companies' main HIV/AIDS policy is treatment (not prevention), partly because of a failed mandatory (i.e., involuntary) HIV testing program at one of the large mines in 2001. To provide statistical evidence on this question, I estimated equation (1) using an indicator variable for having been required to take a HIV test in the past twelve months as the outcome of interest. The regression results indicate neither a large nor statistically significant effect of copper output on HIV testing behavior, the main measure in the DHS and ZSBS of possible exposure to mining company HIV/AIDS interventions.

A, as are the associated standard errors.

In Panel C, I examine the sensitivity of the estimates to the inclusion of a mining area-specific time trend. As in the consumer durables regressions, these regressions allow the linear time trend to vary by whether the respondent resides in a mining area. For most of the measures of risky sexual behavior, the estimated effect of copper output within 10 kilometers of the respondent on material standard of living is slightly smaller than that in Panel A. However, the effects for the two particularly risky behaviors, transactional sex and multiple partnerships, are relatively robust to the inclusion of the mining area-specific trend. Although the coefficient in the transactional sex regression falls from 0.059 in the baseline specification to 0.048 in Panel C, the coefficient in the multiple partners regression remains virtually unchanged and each coefficient remains significant at the 10 percent level (p-values = 0.081 and 0.094, respectively).

The coefficient estimates in Panels A through C might reflect an increase in sexual activity in non-mining areas rather than a decrease in sexual activity in mining areas. Oster (2009a) provides evidence from Sub-Saharan Africa that increases in exports and associated trucking activity are linked to increases in HIV incidence. If the copper boom induced an increase in sexual activity along copper transportation routes, the regressions in Panels A through C might show a negative effect of copper output on sexual activity in mining areas even if there was actually no effect on sexual activity in mining areas. To explore this hypothesis, Panel D excludes respondents who live along the copper transportation corridors.

The estimated effects of the copper boom on transactional sex and multiple partnerships in mining areas are robust to excluding districts along the copper transportation corridor. All of the effects identified in the baseline specification (i.e., Panel A) are present in Panel D. In particular, a one standard deviation in local copper output continues to reduce rates of transactional sex and multiple partnerships by between approximately 20 and 25 percent (p-values = 0.043 and 0.06, respectively). Moreover, the estimated effect on the likelihood of being pregnant (i.e., -0.064, or a reduction of 6.4 percentage points) becomes statistically significant at the 10 percent level (i.e., p-value = 0.065).

In Panel E, I examine the sensitivity of the estimated effect of contemporaneous local copper output to including lagged local copper output and the joint significance of the estimates. The specification in Panel E is the individual-level analogue to Panel E in the consumer durables regressions. Similar to the results of the consumer durables regressions that include lagged output, the effect of contemporaneous copper output in Panel E is not statistically significant. However, the joint effect of contemporaneous and lagged local output in the transactional sex and multiple partnerships regressions is large in relative terms and statistically significant (p-values = 0.024 and 0.082, respectively). In addition, the effect of lagged local output on pregnancy is statistically significant (p-value = 0.058), as is the joint effect on pregnancy (p-value = 0.039).

Panel F presents results from sexual behavior regressions that use the value of copper produced within 10 kilometers of the respondent instead of the quantity of copper produced. The results from the consumer durables regressions indicate that the value of copper produced had a large and significant effect on the material standard of living, similar to the effect of the quantity of copper produced. Thus, given the other results presented in this analysis, it is not surprising that the results of the transactional sex and multiple partnerships regressions (p-values = 0.012 and 0.015, respectively) are robust to this substitution. Moreover, the effects on the likelihood of having any sexual partner becomes statistically significant at the 10 percent level (i.e., p-value = 0.092).

As part of the analysis of the individual-level behavioral response to the copper boom, I examine the effect of the copper boom on in-migration. Column (9) of Table 7 presents the in-migration results. As shown in Panel A, the copper boom induced in-migration to the copper mining cities. A one standard deviation increase in copper output in a given mining city increased the probability a resident was a recent in-migrant by 2.7 percentage points (p-value = 0.017), or by roughly 10 percent as compared to the baseline proportion of in-migrants. The migration results in Panels B, C, D, and F show similarly strong and statistically significant effects (p-values = 0.074, 0.021, and 0.002, respectively), as does the joint effect in Panel E (p-value = 0.016). Because of the large and statistically significant increase in in-migration generated by the copper boom, I examine the role of in-migration in explaining the sexual behavior results after I finish examining heterogeneity by gender and age in the effect of the copper boom.

7.2.2 Gender

Although the copper boom reduced average risky sexual behavior in mining cities, males and females may not have responded to the copper boom in the same way. Table 8 allows the effect of copper output on sexual activity to vary by gender of the respondent. The estimates suggest that the copper boom decreased sexual activity more for males than for females, although the gender difference rarely is statistically significant and never indicates that the boom increased sexual activity.

The estimated effect of local copper output on the sexual activity of males is larger than that estimated in the baseline specification. For example, the estimated effect is eight percent larger for transactional sex and thirty-two percent larger for multiple partnerships. For all measures aside from any partner (10 percent level) and proportion unprotected (statistically insignificant), the effect of local copper output is statistically significant at (at least) the 5 percent level (and often the 1 percent level). For most measures of sexual activity, the estimated effects for females are roughly between one-quarter to three-quarters the magnitude of the effects for males. Although the differences by gender are statistically significant for alcohol consumption at sex and sex in the past month (p-values = 0.018 and 0.014, respectively), none of the differences by gender suggest an increase in sexual activity among females as a result of the boom.

Although the presumption is that the vast majority of reported sexual activity in Zambia is heterosexual, this does not rule out differential effects by gender. There are at least three reasons why the estimated effects of the boom may vary by gender. First, the survey data may under-sample high frequency females. It may be the case that under-sampled high frequency women are reducing their sexual activity by more than the women in the sample. Second, the available measures of sexual activity mostly capture the extensive margin of sexual behavior decision-making and do not capture the intensive margin. It may be the case that the intensive margin decreases more for women than for men. Third, as mentioned in a footnote in Section 5, Gersovitz et al (1998) demonstrate that the large gender difference in average levels of sexual activity that characterizes nationally representative sexual behavior surveys like the DHS and ZSBS suggests that females may under-report their levels of risky sexual behavior. The extremely low rates of transactional sex and multiple partnerships among women in the Zambia data (i.e., 2.8 percent and 1.7 percent, respectively) are consistent with this claim and also mechanically limit the scope for reductions among women in these behaviors.

As I demonstrate in the following section, the available evidence on this issue appears to point toward the reporting bias explanation. Pregnancy is the sexual behavior least susceptible to reporting bias because largely it is observable. The estimates presented in the following section indicate that increases in local copper output generated a large and statistically significant reduction in pregnancy rates among women age 15-19 and age 20-29. Furthermore, consistent with the reporting bias explanation, aside from pregnancy rates, women in these age groups largely fail to demonstrate sexual behavior changes in response to local copper output that are statistically different from women in other age groups.

Disaggregating the in-migration response by gender has little impact on the estimated effect of the copper boom. Although the effect is somewhat larger for males, the difference by gender is not statistically significant. This suggests that the copper boom attracted female and male in-migrants in roughly equal proportions.

7.2.3 Age

The large differences by age in sexual behavior displayed in Table 2 suggest that the effect of the copper boom on sexual activity may have varied across age groups. For example, rates of transactional sex are highest at younger age groups and decline precipitously with age. Table 9 examines this possibility by reporting the coefficient estimates on a female indicator variable, age-group indicator variables, and the interactions of these two sets of variables.

These estimates indicate that the effect of copper output on transactional sex was concentrated among younger males (i.e., age 20-29, p-value = 0.03). One explanation for this finding is that males age 20-29 have the highest rates of transactional sex and hence the greatest scope for reduction. The lack of heterogeneity in the effect of local copper output on multiple partnerships, an outcome with a much flatter age profile, is consistent with this interpretation.

The overall body of evidence presented thus far indicates that the copper boom reduced particularly risky sexual behaviors and did not increase sexual activity on other margins. Thus, it is somewhat surprising that the propensity to engage in unprotected sex conditional on having a sexual partner in the past twelve months actually increased for males age 15-19 (p-value = 0.015). However, coital frequency (i.e., sex in the past month) appears to have fallen among this age group (p-value = 0.103), suggesting a compositional change in who is having sex the most may explain this single discrepancy.

Consistent with the concentrated effect of the boom on transactional sex for males age 20-29, this demographic group also demonstrated the largest reductions in alcohol consumption at sex. Similarly, males age 20-29 demonstrated the largest reduction in the likelihood of having any partner in the past twelve months. Although the effect on having had sex in the past month for this demographic group is not statistically indistinguishable from that for males age 15-19, males age 20-29 also reduced coital frequency in response to the boom (p-value = 0.103).

The large reduction in pregnancy rates among females age 15-19 and age 20-29 corroborates the argument that the large (although not statistically significant) differences by gender in Table 8 are explained by attenuation toward zero due to females under-reporting sexual activity. Because it is an observable characteristic (at least in the later stages and often to the surveyor) and possibly a less stigmatized outcome, women are seemingly much less likely to prevaricate when reporting pregnancy within the past twelve months than when reporting other (often stigmatized) sexual behaviors. The coefficient estimate for local copper output for females age 15-19 (p-value = 0.010) and shared by females age 20-29 indicates that a one standard deviation increase in local copper output reduces pregnancy rates in this demographic group by nearly 2.5 percentage points (i.e., more than a ten percent reduction).

Disaggregating the in-migration response by the interaction of age and gender suggests that younger individuals may have been more likely to migrate to copper mining cities in response to the boom. Older males (e.g., ages 30-39 and 40-49) were slightly less likely to demonstrate a change in the probability of being an in-migrant. Females in the middle of the age distribution (i.e., ages 20-29) were also less likely to demonstrate a change in the probability of being an in-migrant. However, none of these differences are statistically significant at conventional levels.

7.3 Selection and Effects on Non-Migrants

Substantial in-migration in mining areas induced by the copper boom raises two important points about the results presented thus far. First, selective in-migration may have contributed to the overall reduction in particularly risky sexual behavior due to the copper boom. Second, if self-reported sexual activity among in-migrants partly reflects the respondent's behavior in the previous (i.e., non-mining) location, then this may be driving the estimated effects of local copper output on sexual activity. This section addresses these issues in detail by comparing the behavior of in-migrants and non-migrants in mining areas, as well as by allowing the effect of the boom to vary by whether the respondent is a recent in-migrant to a mining area.

A comparison of means indicates that migrants in mining areas are less risky than non-migrants in mining areas. As shown in Table 10, migrants in mining cities are less likely to engage in transactional sex, engage in unprotected sex, consume alcohol at sex, have had sex in the past month, or be married. Differences between migrants and non-migrants in the likelihood of having had any partner or multiple sexual partners in the past twelve months are small or non-existent. The one measure of sexual activity by which migrants appear to be riskier than non-migrants is in the likelihood of being pregnant in the past twelve months. Consistent with their generally lower levels of sexual activity, migrants are less likely to be HIV positive.

Although copper boom induced in-migration is consistent with a compositional effect on sexual activity, the copper boom still may have affected the behavior of non-migrants residing in mining areas. To examine this hypothesis, I interact the measure of local copper output (i.e., CU output, 0-10km) with the measure of whether the respondent is a recent in-migrant (i.e., an indicator variable equal to one if the respondent has resided in the same household for less than one year). The coefficient on local copper output yields the estimated effect of the boom on non-migrants in mining areas.

Table 11 presents the consumer durables results for this unrestricted specification. These regressions include the same set of controls as the baseline specification, as well as controls for in-migrant and in-migrant interacted with the indicator variable for mining city. The estimates are similar to those found in the baseline sample (i.e., the results presented in Table 6). Among non-migrants, the copper boom had large effects on floor quality, television ownership, and refrigerator ownership (p-values = 0.077, 0.049, and 0.020, respectively). The coefficient on the recent in-migrant interaction tends to be small, statistically insignificant, and sometimes negative. The single exception is in the radio regression where the in-migrant interaction is significant at the 5 percent level. In general, these results (unsurprisingly) confirm that non-migrants in mining areas did receive a positive economic shock and that the effect for recent in-migrants largely is statistically indistinguishable from that for non-migrants.

Table 12 presents the sexual behavior results for this unrestricted specification. Again, these regressions include the same set of controls as the baseline specification, as well as controls for in-migrant and in-migrant interacted with the indicator variable for mining city. Although the estimated effect of the copper boom on transactional sex for non-migrants in mining cities is slightly smaller than in the baseline specification, the estimates for transactional sex and multiple partners for non-migrants are still statistically significant (p-values = 0.095 and 0.075, respectively). Again, the effect for recent in-migrants is statistically indistinguishable from that for non-migrants.

Overall, the analysis of recent in-migrants in mining areas provides little support for the notion that in-migration induced by the copper boom increased the propensity to engage in risky sexual activity in mining areas. In fact, copper boom induced in-migration in mining areas appears to have contributed to the reduction in rates of transactional sex and multiple partnerships. This finding may seem puzzling given the existing literature on the relationship between migration and risky sexual behavior. However, these in-migrants in Zambian copper mining areas may differ from the migrants examined in the existing literature on migration and HIV/AIDS. As shown in the consumer durables ownership rates in Table 10, the copper boom in-migrants appear to be as wealthy or wealthier than the (relatively rich, by Zambian standards) non-migrants in mining areas.

8 Conclusion

This paper provides evidence on the effect of a large and sustained economic shock on sexual behavior and the spread of HIV/AIDS. I exploit the dramatic increase in the world copper price in the early 21st century, a change that was exogenous to the process determining sexual behavior in Zambia, to credibly identify the effects of increased production in a major sector of the Zambian economy on sexual behavior. I use newly assembled repeated cross-sectional sexual behavior survey data with a detailed geographic component collected before and during the copper boom and employ a host of spatial and temporal controls to address remaining concerns about identification.

In the setting I examine, Zambia during the early 21st century copper boom, a large positive economic shock to production in mining areas reduced transactional sex and multiple partnerships, two sexual behaviors that are particularly risky. Similarly, this large and sustained economic shock reduced pregnancy rates among young women, the women most likely in general to report engaging in transactional sex and having multiple sexual partners. This suggests that the supply-side effects of rising incomes and economic opportunities for women outside of sexual activity dominate demand-side effects, if any, among men of rising incomes and increased willingness-to-pay for sex.

These results appear to be broadly generalizable to predict the effects of economy-wide on risky sexual behavior in other very poor countries. Unlike stereotypical mining settings in many other parts of the world, the Zambian copper mines are located in relatively large urban areas with gender ratios very close to one. Thus, the effects of the quasi-experiment provided by the Zambian copper boom may resemble the effects of economy-wide growth on risky sexual behavior in very poor countries. This suggests that balanced economic growth in Sub-Saharan Africa may be an important factor in the fight against the HIV/AIDS pandemic. However, the effect of long-run economic growth on sexual behavior and the spread of HIV/AIDS may differ from that of a long and sustained positive economic shock, so additional research on this question is required.

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Figure 1: Spatial Distribution of Copper Mining in Zambia

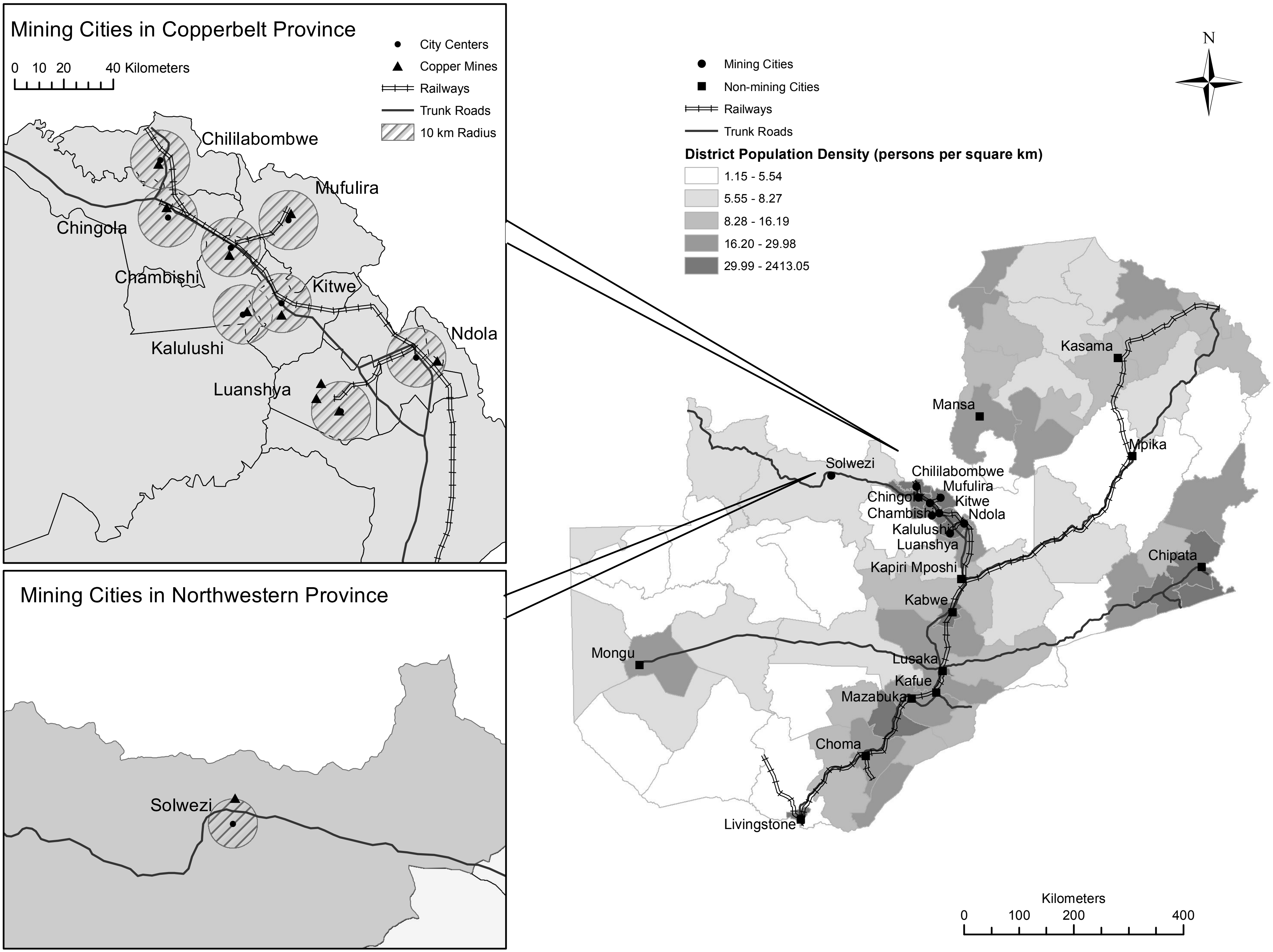

Figure 2: World Copper Price and Zambia GDP per capita, 1980-2010

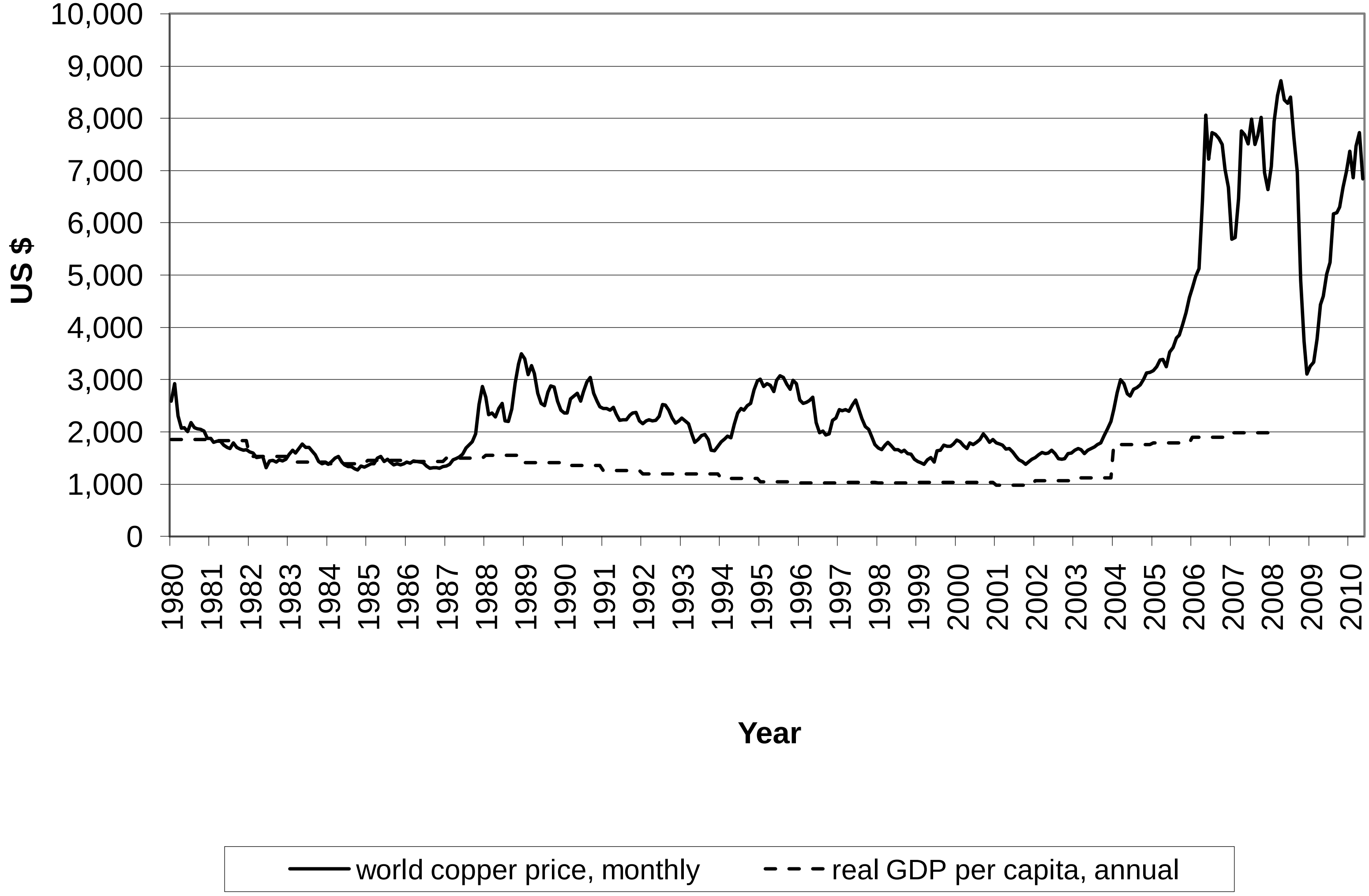

Figure 3: Copper Production, Zambia 2000-2008

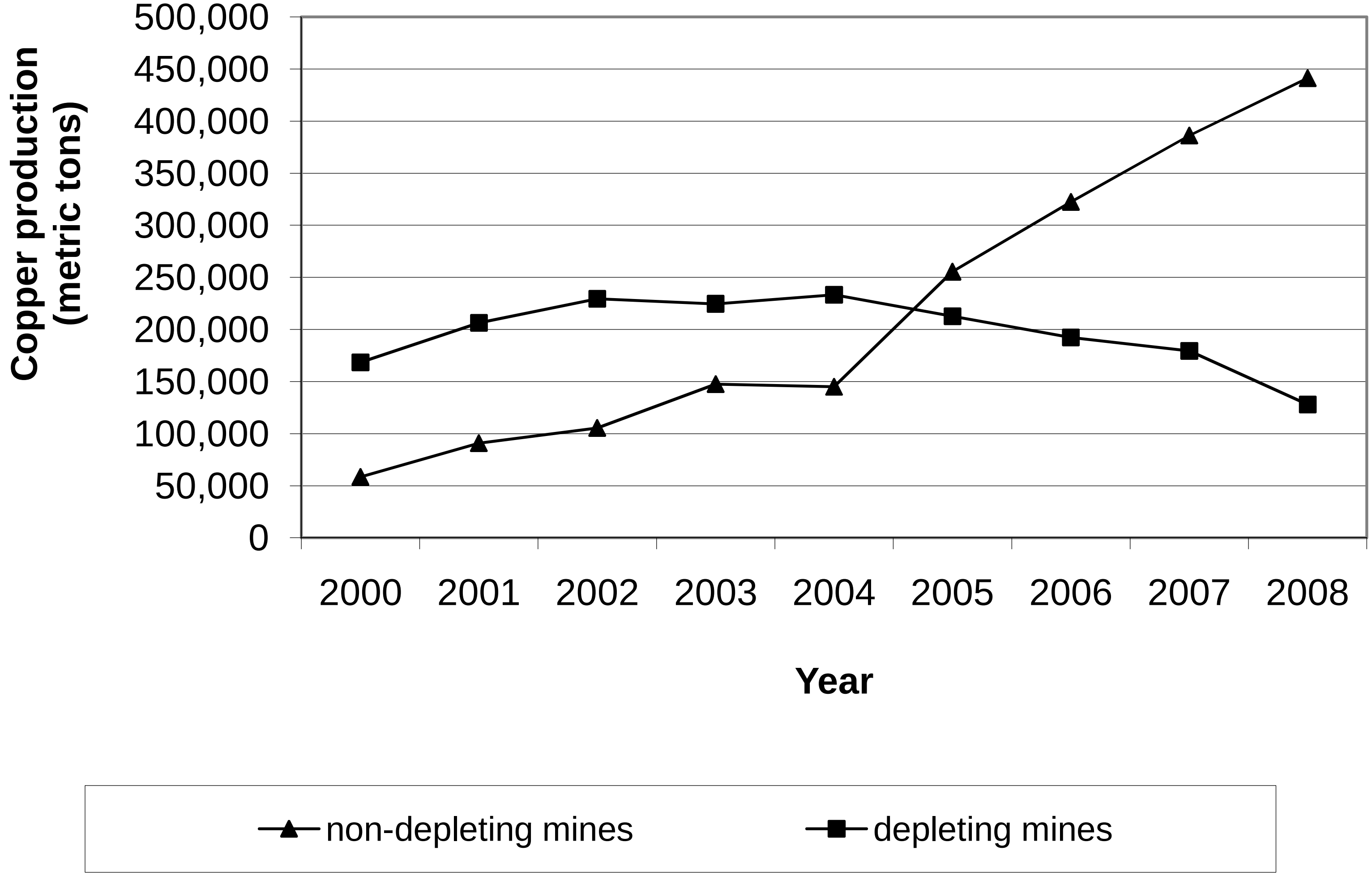

Figure 4: Employment at Copper Mines, Zambia 1999-2008

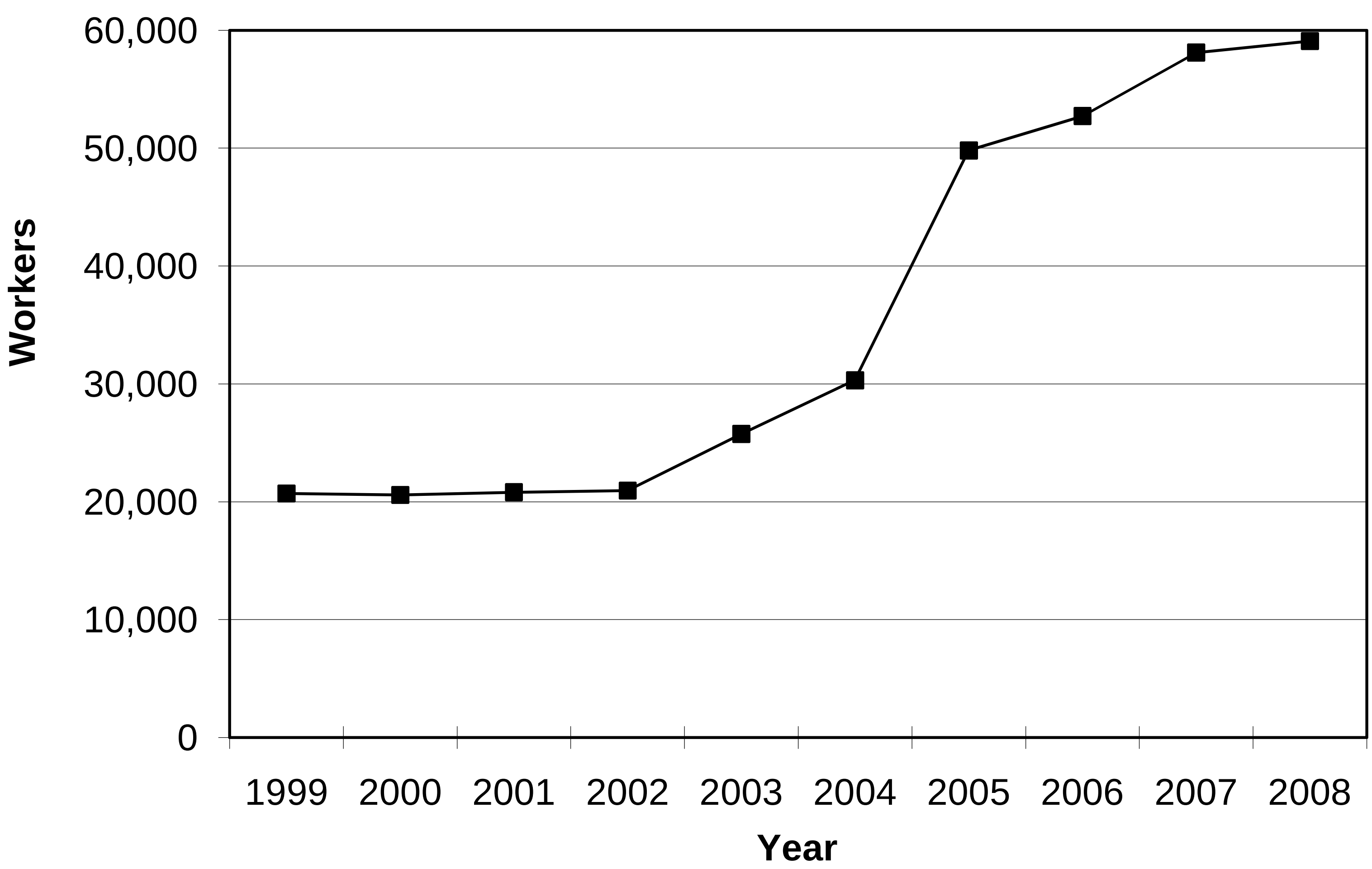

Table 1: City Sizes in Zambia, 2000

city	population	rank	mining city
Lusaka	1,084,703	1	no
Ndola	374,757	2	yes
Kitwe	363,734	3	yes
Kabwe	176,758	4	no
Chingola	147,448	5	yes
Mufulira	122,336	6	yes
Luanshya	115,579	7	yes
Livingstone (Maramba)	97,488	8	no
Kasama	74,243	9	no
Chipata	73,110	10	no
Chililabombwe	54,504	11	yes
Kalulushi	52,770	12	yes
Mazabuka	47,148	13	no
Kafue	45,890	14	no
Mongu	44,310	15	no
Mansa	41,059	16	no
Choma	40,405	17	no
Solwezi	38,121	18	yes
Kapiri Mposhi	27,219	19	no
Mpika	25,856	20	no

Source: 2000 Census.

Table 2: Mean Sexual Behavior by Age and Gender of DHS and ZSBS Respondents

Sexual behavior:	money	multiple partners	proportion unprotected	alcohol	any partner	sex in past month	pregnant	married
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Females								
Age								
15-19	0.052	0.021	0.79	0.04	0.42	0.42	0.22	0.20
20-24	0.034	0.020	0.85	0.10	0.81	0.61	0.42	0.65
25-29	0.022	0.020	0.88	0.14	0.88	0.66	0.44	0.76
30-34	0.020	0.014	0.91	0.14	0.88	0.66	0.39	0.77
35-39	0.014	0.010	0.93	0.13	0.83	0.64	0.30	0.78
40-44	0.014	0.016	0.93	0.13	0.78	0.60	0.15	0.73
45-49	0.007	0.008	0.96	0.11	0.74	0.59	0.04	0.72
15-49	0.028	0.017	0.88	0.11	0.74	0.61	0.32	0.61
Panel B: Males								
Age								
15-19	0.066	0.059	0.64	0.02	0.32	0.31	-	0.01
20-24	0.096	0.153	0.65	0.07	0.69	0.48	-	0.28
25-29	0.074	0.201	0.75	0.13	0.90	0.67	-	0.70
30-34	0.054	0.195	0.84	0.14	0.94	0.75	-	0.84
35-39	0.046	0.193	0.85	0.14	0.94	0.75	-	0.88
40-44	0.029	0.174	0.90	0.14	0.94	0.74	-	0.89
45-49	0.025	0.166	0.93	0.12	0.94	0.79	-	0.91
50-54	0.013	0.134	0.92	0.12	0.92	0.74	-	0.90
55-59	0.020	0.115	0.95	0.11	0.91	0.74	-	0.90
15-59	0.059	0.151	0.80	0.10	0.76	0.64	-	0.56

Notes: Data come from the 2001 and 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds. Money is an indicator variable equal to one if the respondent engaged in transactional sex in the past twelve months. Multiple partners is an indicator variable equal to one if the respondent had more than one partner in the past twelve months. The ZSBS asks all respondents to report whether they engaged in transactional sex. The DHS only asks male respondents whether they engaged in transactional sex. Proportion unprotected is defined as the proportion of reported sex acts that were committed without using a condom in the past twelve months. Alcohol is an indicator variable equal to one if the respondent consumed alcohol before sex in the past twelve months. Any partner is an indicator variable equal to one if the respondent had any sexual partner in the past twelve months. Sex in the past month is an indicator variable equal to one if the respondent had sex in the past month. Pregnant is an indicator variable equal to one if the respondent reported being pregnant at any time in the past twelve months. Married is an indicator variable equal to one if the respondent was married at the time of the survey.

Table 3: Mean Characteristics of DHS and ZSBS Respondents by Location

Sample:	mining cities	rest of Zambia	districts on copper transportation routes
	(1)	(2)	(3)
Consumer durables			
Floor	0.73	0.34	0.51
Refrigerator	0.28	0.11	0.17
Television	0.49	0.21	0.33
Radio	0.66	0.56	0.62
Car	0.05	0.03	0.04
Motorcycle	0.00	0.00	0.01
Bicycle	0.27	0.41	0.40
Demographic characteristics			
In-migrant	0.22	0.17	0.19
Female	51.9	51.4	50.5
Age	28.5	28.9	28.7
Sexual behavior			
Money exchanged	0.05	0.05	0.05
Multiple partners	0.07	0.08	0.08
Proportion unprotected sex	0.83	0.84	0.83
Alcohol use at sex	0.17	0.09	0.11
Any partner	0.69	0.76	0.73
Sex in past month	0.56	0.63	0.63
Pregnant	0.26	0.33	0.30
Married	0.49	0.60	0.57
Health			
HIV positive	0.163	0.145	0.165

Notes: Data come from the 2001 and 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds. Data on HIV status come from a single cross-section, the 2007 DHS. Floor is an indicator variable for improved (i.e., brick, concrete, tile, or wood, instead of earth) floor. Refrigerator, television, radio, car, motorcycle, and bicycle are also indicator variables. In-migrant is an indicator variable equal to one if the respondent had resided in the same household for less than twelve months at the time of the interview date. A mining city is defined as the area within a 10 kilometer radius of the approximate centroid of the urban area around each mining agglomeration. The districts on the copper transportation routes are: Chibombo, Chinsola, Choma, Isoka, Kabwe, Kafue, Kalomo, Kapiri Mposhi, Kasama, Kazungula, Livingstone, Lusaka, Masaiti, Mazabuka, Mkushi, Monze, Mpika, Nakonde, and Sernje.

Table 4: Pre-Boom Trends in Consumer Durables Ownership

Dependent variable:	floor	refrigerator	television	radio	car	motorcycle	bicycle
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Time trend	-0.393	-0.075	-0.267	-0.117	-0.017	-0.005	0.100
	(0.115)	(0.057)	(0.101)	(0.094)	(0.028)	(0.003)	(0.070)
Mining area * time trend	-0.029	-0.026	-0.009	0.068	-0.008	-0.001	0.020
	(0.047)	(0.019)	(0.027)	(0.027)	(0.009)	(0.001)	(0.042)
Observations	1,466	1,484	1,484	1,484	1,479	1,479	1,482

Notes: Data come from the 2001 DHS survey round, which includes data from calendar years 2001 and 2002. Mining area is an indicator variable equal to one if the respondent resides in a mining area (i.e., within 10 kilometers of the center of a mining city). Standard errors are in parentheses and are clustered by Standard Enumeration Area (SEA). All specifications include an indicator variable euqal to one if the respondent resides in a mining area (i.e., within 10 kilometers of the center of a mining city). All specifications include year fixed effects, month fixed effects, and district fixed effects.

Table 5: Pre-Boom Trends in Sexual Behavior and Migration

Dependent variable:	money	multiple partners	proportion unprotected	alcohol	any partner	sex in past month	pregnant	married	resident less than one year
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Time trend	0.015	0.007	0.022	-	0.048	-0.014	0.117	0.069	-0.075
	(0.044)	(0.034)	(0.051)	-	(0.040)	(0.059)	(0.053)	(0.034)	(0.059)
Mining area * time trend	-0.003	0.005	0.033	-	-0.022	-0.021	0.065	0.017	-0.018
	(0.021)	(0.013)	(0.020)	-	(0.013)	(0.014)	(0.025)	(0.014)	(0.023)
Observations	1,927	3,670	2,917	-	3,670	3,295	1,743	3,670	3,665

Notes: Data come from the 2001 DHS survey round, which includes data from calendar years 2001 and 2002. Information on alcohol consumption at sex is not available in pre-boom survey data. Mining area is an indicator variable equal to one if the respondent resides in a mining area (i.e., within 10 kilometers of the center of a mining city). Standard errors are in parentheses and are clustered by Standard Enumeration Area (SEA). All specifications include an indicator variable equal to one if the respondent resides in a mining area (i.e., within 10 kilometers of the center of a mining city). All specifications include indicator variables for female and for five-year age groups. All specifications include year fixed effects, month fixed effects, and district fixed effects.

Table 6: Effect of Copper Boom on Household Consumer Durable Ownership

Dependent variable:	floor	refrigerator	television	radio	car	motorcycle	bicycle
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: Baseline specification							
CU output, 0-10km	0.235	0.203	0.267	0.118	0.021	-0.002	-0.068
	(0.133)	(0.087)	(0.109)	(0.084)	(0.023)	(0.002)	(0.093)
Observations	11,409	11,438	11,445	11,460	11,432	11,433	11,438
Panel B: Boom output only							
CU output, 0-10km	0.232	0.202	0.265	0.126	0.021	-0.002	-0.060
	(0.132)	(0.089)	(0.110)	(0.087)	(0.024)	(0.002)	(0.088)
Observations	11,409	11,438	11,445	11,460	11,432	11,433	11,438
Panel C: Mining-specific trend							
CU output, 0-10km	0.190	0.188	0.219	0.142	0.006	-0.002	0.001
	(0.146)	(0.115)	(0.132)	(0.090)	(0.029)	(0.002)	(0.095)
Observations	11,409	11,438	11,445	11,460	11,432	11,433	11,438
Panel D: Comparison group excludes districts on copper transportation routes							
CU output, 0-10km	0.266	0.226	0.305	0.155	0.026	0.000	-0.075
	(0.143)	(0.091)	(0.112)	(0.089)	(0.024)	(0.002)	(0.092)
Observations	7,330	7,349	7,352	7,364	7,346	7,347	7,350
Panel E: Lagged output							
CU output, 0-10km	0.376	0.140	0.177	0.298	0.008	-0.002	0.141
	(0.234)	(0.243)	(0.238)	(0.145)	(0.077)	(0.004)	(0.114)
Lagged CU, 0-10km	-0.170	0.072	0.112	-0.221	0.016	-0.001	-0.253
	(0.261)	(0.265)	(0.253)	(0.171)	(0.094)	(0.005)	(0.137)
Observations	11,350	11,380	11,387	11,403	11,376	11,377	11,382
P > F(CU+Lagged=0)	0.155	0.027	0.016	0.401	0.429	0.253	0.315
Panel F: Value of output							
CU value, 0-10km	0.187	0.168	0.255	0.090	0.035	-0.002	-0.136
	(0.155)	(0.108)	(0.126)	(0.095)	(0.035)	(0.003)	(0.111)
Observations	11,409	11,438	11,445	11,460	11,432	11,433	11,438

Notes: Data come from the 2001 and 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds. CU output, or copper output, is measured in '00,000s of metric tons. Lagged CU is copper output produced 13-24 months prior to the interview month. CU value, or value of copper output, is defined as metric tonnes of CU output times the LME spot price for copper (2005 US$ '0,000s). Standard errors are in parentheses and are clustered by Standard Enumeration Area (SEA). All specifications include indicator variables for female and for five-year age groups. All specification include controls for total copper output in all of Zambia and for whether the respondent lives within 10 kilometers of the center of a mining city. All specifications include year fixed effects, month fixed effects, district fixed effects, and a linear time trend. Panel B distinguishes between local copper ouptut produced prior to the boom (i.e., the 2001 and 2003 survey rounds) and during the boom (i.e. the 2005 and 2007 survey rounds), and reports the effect of local copper output produced during the boom. Panel D excludes the following districts: Chibombo, Chinsola, Choma, Isoka, Kabwe, Kafue, Kalomo, Kapiri Mposhi, Kasama, Kazungula, Livingstone, Lusaka, Masaiti, Mazabuka, Mkushi, Monze, Mpika, Nakonde, and Sernje.

Table 7: Effect of Copper Boom on Sexual Behavior and Migration

Dependent variable:	money	multiple partners	proportion unprotected	alcohol	any partner	sex in past month	pregnant	married	resident less than one year
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Baseline specification									
CU output, 0-10km	-0.059	-0.044	-0.017	-0.055	-0.031	-0.042	-0.047	-0.055	0.133
	(0.028)	(0.025)	(0.039)	(0.038)	(0.027)	(0.035)	(0.033)	(0.032)	(0.056)
Observations	16,301	25,171	18,646	21,501	25,171	21,831	12,953	25,171	25,135
Panel B: Boom output only									
CU output, 0-10km	-0.059	-0.044	-0.016	-0.054	-0.027	-0.041	-0.043	-0.054	0.128
	(0.028)	(0.025)	(0.039)	(0.036)	(0.026)	(0.036)	(0.033)	(0.031)	(0.053)
Observations	16,301	25,171	18,646	21,501	25,171	21,831	12,953	25,171	25,135
Panel C: Mining-specific trend									
CU output, 0-10km	-0.048	-0.043	-0.036	-0.071	0.004	-0.041	-0.023	-0.042	0.109
	(0.027)	(0.025)	(0.043)	(0.042)	(0.032)	(0.042)	(0.036)	(0.033)	(0.061)
Observations	16,301	25,171	18,646	21,501	25,171	21,831	12,953	25,171	25,135
Panel D: Comparison group excludes districts on copper transportation routes									
CU output, 0-10km	-0.056	-0.046	-0.033	-0.058	-0.033	-0.038	-0.064	-0.053	0.132
	(0.028)	(0.024)	(0.040)	(0.038)	(0.029)	(0.037)	(0.034)	(0.034)	(0.057)
Observations	9,873	15,581	11,727	13,248	15,581	13,702	8,104	15,581	15,554
Panel E: Lagged output									
CU output, 0-10km	-0.018	-0.028	-0.115	-0.150	-0.039	0.008	0.091	-0.091	0.059
	(0.042)	(0.043)	(0.087)	(0.088)	(0.075)	(0.085)	(0.079)	(0.069)	(0.087)
Lagged CU, 0-10km	-0.047	-0.018	0.116	0.120	0.011	-0.057	-0.172	0.042	0.096
	(0.038)	(0.045)	(0.096)	(0.103)	(0.084)	(0.091)	(0.091)	(0.081)	(0.092)
Observations	16,223	25,018	18,530	21,501	25,018	21,692	12,878	25,018	24,982
P > F(CU+Lagged=0)	0.024	0.082	0.980	0.536	0.361	0.197	0.039	0.173	0.016
Panel F: Value of output									
CU value, 0-10km	-0.081	-0.068	0.014	-0.051	-0.064	-0.043	-0.046	-0.067	0.219
	(0.032)	(0.028)	(0.045)	(0.051)	(0.038)	(0.048)	(0.046)	(0.041)	(0.070)
Observations	16,301	25,171	18,646	21,501	25,171	21,831	12,953	25,171	25,135

Notes: Data come from the 2001 and 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds. CU output, or copper output, is measured in '00,000s of metric tons. Lagged CU is copper output produced 13-24 months prior to the interview month. CU value, or value of copper output, is defined as metric tonnes of CU output times the LME spot price for copper (2005 US$ '0,000s). Standard errors are in parentheses and are clustered by Standard Enumeration Area (SEA). All specifications include indicator variables for female and for five-year age groups. All specification include controls for total copper output in all of Zambia and for whether the respondent lives within 10 kilometers of the center of a mining city. All specifications include year fixed effects, month fixed effects, district fixed effects, and a linear time trend. Panel B distinguishes between local copper output produced prior to the boom (i.e., the 2001 and 2003 survey rounds) and during the boom (i.e., the 2005 and 2007 survey rounds), and reports the effect of local copper produced during the boom. Panel D excludes the following districts: Chibombo, Chinsola, Choma, Isoka, Kabwe, Kafue, Kalomo, Kapiri Mposhi, Kasama, Kazungula, Livingstone, Lusaka, Masaiti, Mazabuka, Mkushi, Monze, Mpika, Nakonde, and Sernje.

Table 8: Heterogeneity by Gender in Effect of Copper Boom on Sexual Behavior and Migration

Dependent variable:	money	multiple partners	proportion unprotected	alcohol	any partner	sex in past month	pregnant	married	resident less than one year
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CU output, 0-10km	-0.064	-0.058	-0.020	-0.128	-0.060	-0.100	-0.047	-0.082	0.163
	(0.031)	(0.030)	(0.036)	(0.041)	(0.034)	(0.036)	(0.033)	(0.036)	(0.061)
Female*CU output, 0-10km	0.036	0.025	0.005	0.135	0.055	0.114		0.052	-0.058
	(0.036)	(0.029)	(0.034)	(0.057)	(0.040)	(0.046)		(0.045)	(0.050)
Observations	16,301	25,171	18,646	21,501	25,171	21,831	12,953	25,171	25,135

Notes: Data come from the 2001 and 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds. CU output, or copper output, is measured in '00,000s of metric tons. Standard errors are in parentheses and are clustered by Standard Enumeration Area (SEA). All specifications include indicator variables for female and for five-year age groups. All specifications include controls for total output in all of Zambia, for whether the respondent resides within 10 kilometers of the center of a mining city, and for the interactions with the female indicator variable. All specifications include year fixed effects, month fixed effects, district fixed effects, and a linear time trend.

Table 9: Heterogeneity by Age in Effect of Copper Boom on Sexual Behavior and Migration

Dependent variable:	money	multiple partners	proportion unprotected	alcohol	any partner	sex in past month	pregnant	married	resident less than one year
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CU output, 0-10km	-0.004	-0.077	0.210	-0.009	0.074	-0.150	-0.123	-0.020	0.157
	(0.042)	(0.033)	(0.086)	(0.049)	(0.070)	(0.092)	(0.048)	(0.030)	(0.072)
Age 20-29 * CU output, 0-10km	-0.107	-0.001	-0.219	-0.155	-0.266	-0.019	0.067	-0.191	0.062
	(0.049)	(0.053)	(0.095)	(0.068)	(0.080)	(0.107)	(0.063)	(0.080)	(0.071)
Age 30-39 * CU output, 0-10km	-0.067	0.032	-0.293	-0.131	-0.105	0.199	0.186	0.095	-0.043
	(0.047)	(0.085)	(0.094)	(0.082)	(0.086)	(0.112)	(0.063)	(0.046)	(0.089)
Age 40-49 * CU output, 0-10km	-0.015	0.066	-0.329	-0.159	-0.045	0.104	0.077	-0.072	-0.063
	(0.060)	(0.063)	(0.142)	(0.096)	(0.122)	(0.131)	(0.056)	(0.083)	(0.140)
Age 50-59 * CU output, 0-10km	-0.044	0.007	-0.186	-0.119	-0.042	0.014		0.030	0.012
	(0.043)	(0.063)	(0.089)	(0.129)	(0.111)	(0.136)		(0.049)	(0.162)
Female * CU output, 0-10km	-0.037	0.041	-0.391	-0.034	-0.074	-0.041		-0.099	0.003
	(0.067)	(0.039)	(0.149)	(0.046)	(0.081)	(0.140)		(0.043)	(0.082)
Female * Age 20-29 * CU output, 0-10km	0.097	0.007	0.406	0.210	0.219	0.257		0.274	-0.133
	(0.077)	(0.055)	(0.160)	(0.100)	(0.110)	(0.176)		(0.106)	(0.098)
Female * Age 30-39 * CU output, 0-10km	0.096	-0.046	0.451	0.216	0.171	0.136		0.124	-0.059
	(0.086)	(0.086)	(0.154)	(0.071)	(0.089)	(0.182)		(0.077)	(0.105)
Female * Age 40-49 * CU output, 0-10km	0.061	-0.063	0.585	0.223	0.035	-0.099		0.059	0.067
	(0.087)	(0.069)	(0.198)	(0.150)	(0.140)	(0.212)		(0.134)	(0.132)
Observations	16,301	25,171	18,646	21,501	25,171	21,831	12,953	25,171	25,135

Notes: Data come from the 2001 and 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds. Standard errors are in parentheses and are clustered by Standard Enumeration Area (SEA). CU output, or copper output, is measured in '00,000s of metric tons. All specifications include indicator variables for gender and for five-year age groups. All specifications include controls for total output in all of Zambia, for whether the respondent resides within 10 kilometers of the center of a mining city, as well as controls for whether the respondent resides within 10 kilometers of a mining city (and total copper output in all of Zambia) interacted with the age-group indicators, female indicator, and the interactions thereof. Excluded age category is Age 15-19. All specifications include year fixed effects, month fixed effects, district fixed effects, and a linear time trend.

Table 10: Mean Characteristics of In-Migrants and Non-Migrants in Mining Areas

	mining cities	
	non-migrants	in-migrants
	(1)	(2)
Consumer durables		
Floor	0.77	0.80
Refrigerator	0.32	0.35
Television	0.56	0.60
Radio	0.69	0.73
Car	0.06	0.06
Motorcycle	0.00	0.00
Bicycle	0.31	0.22
Demographic characteristics		
Female	0.50	0.55
Age	29.6	25.8
Sexual behavior		
Money exchanged	0.05	0.03
Multiple partners	0.07	0.07
Proportion unprotected sex	0.85	0.77
Alcohol use at sex	0.17	0.15
Any partner	0.69	0.68
Sex in past month	0.57	0.48
Pregnant	0.24	0.36
Married	0.49	0.43
Health		
HIV positive	0.155	0.148

Notes: Data come from the 2001 and 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds. The sample is limited to respondents residing in copper mining cities (i.e., within 10 kilometers of the center of one of the copper mining cities identified in Section 2). The in-migrant sample is further limited to respondents from the 2003 ZSBS, 2005 ZSBS, or 2007 DHS. Non-migrants defined as respondents residing in the same household for at least five years. In-migrants defined as respondents residing in the same household for less than twelve months.

Table 11: Heterogeneity by Migration Status in Effect of Boom on Household Consumer Durable Ownership

Dependent variable:	floor	refrigerator	television	radio	car	motorcycle	bicycle
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
CU output, 0-10km	0.233	0.222	0.289	0.090	0.042	-0.003	-0.014
	(0.135)	(0.097)	(0.108)	(0.091)	(0.031)	(0.002)	(0.089)
In-migrant * CU output, 0-10km	0.008	-0.054	-0.074	0.133	-0.079	0.001	-0.178
	(0.088)	(0.057)	(0.061)	(0.075)	(0.046)	(0.001)	(0.084)
Observations	11,399	11,428	11,435	11,450	11,421	11,422	11,428

Notes: Data come from the 2001 and 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds. CU output, or copper output, is measured in '00,000s of metric tons. In-migrant is an indicator variable equal to one if the respondent has resided in the same household for less than twelve months. Standard errors are in parentheses and are clustered by Standard Enumeration Area (SEA). All specifications include indicator variables for female and for five-year age groups. All specifications include controls for total copper output in all of Zambia and for whether the respondent resides within 10 kilometers of the center of a mining city. All specifications include year fixed effects, month fixed effects, district fixed effects, and a linear time trend.

Table 12: Heterogeneity by Migration Status in Effect of Boom on Sexual Behavior

Dependent variable:	money	multiple partners	proportion unprotected	alcohol	any partner	sex in past month	pregnant	married
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CU output, 0-10km	-0.049	-0.047	-0.005	-0.040	-0.021	-0.049	-0.032	-0.037
	(0.029)	(0.026)	(0.042)	(0.036)	(0.031)	(0.036)	(0.041)	(0.029)
In-migrant * CU output, 0-10km	-0.031	0.012	-0.048	-0.054	-0.044	0.043	-0.056	-0.064
	(0.023)	(0.025)	(0.058)	(0.053)	(0.047)	(0.052)	(0.073)	(0.060)
Observations	16,272	25,135	18,623	21,470	25,135	21,801	12,932	25,135

Notes: Data come from the 2001 and 2007 DHS survey rounds and the 2003 and 2005 ZSBS survey rounds. CU output, or copper output, is measured in '00,000s of metric tons. In-migrant is an indicator variable equal to one if the respondent has resided in the same household for less than twelve months. Standard errors are in parentheses and are clustered by Standard Enumeration Area (SEA). All specifications include indicator variables for female and for five-year age groups. All specifications include controls for total copper output in all of Zambia and for whether the respondent resides within 10 kilometers of the center of a mining city. All specifications include year fixed effects, month fixed effects, district fixed effects, and a linear time trend.