The Impact of HIV/AIDS on Crime in South Africa[1]

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ABSTRACT

AIDS and crime rates are often treated in isolation from each other. This study, the first to empirically test whether HIV prevalence could influence crime rates, employs an interdisciplinary model of crime to fit the complex socio-demographic context of South Africa. I construct a provincial Crime-AIDS panel dataset for the period 1994 to 2003 and use different econometric models (OLS, Fixed-Effects, Instrumental Variables and a combined I.V plus F.E specification) to test the short-run relationship between HIV prevalence and crime rates in South Africa. The fixed-effects specifications are found to best capture the relationship between crime and HIV prevalence in South Africa. I find strong evidence that HIV prevalence is positively correlated with some types of monetary/property-related crimes. This study also assesses some of the behavioral mechanisms that could drive this positive relationship between AIDS and crime. I find evidence that those infected with HIV are also more likely to engage in other risky behaviors such as illegal drug use. Those infected with HIV may be more likely to engage in risky behaviors such as drug use and crime because their reduced life expectancy leads them to discount the future. I find no evidence of HIV/AIDS crowding-out police/law enforcement expenditure in favor of other government agency spending for the study period. I find weak evidence of a negative correlation between HIV/AIDS and some types of crime that are of a violent nature, possibly because HIV positive people become too sick to commit these types of crime. This study has important policy implications with regard to the planning, coordination, budgeting and execution of programs aimed at reducing crime and AIDS in South Africa. For example, a direct implication of the results presented in this study is that policies that decrease the incidence of HIV/AIDS, or increase the life expectancy of those with HIV/AIDS, will also contribute to reducing some types of property-related crimes.

1. INTRODUCTION

AIDS and crime are two of South Africa's highest policy priorities and according to international standards, South Africa rates exceptionally high with regard to both crime (Interpol, 1999) and HIV prevalence (UNAIDS, 2000). HIV prevalence has increased from 0.7% in 1990 to 17% in 1997 and has continued to climb from to 24.5% in 2000 to 26.5% in 2002 (Ministry of Health, 2003). The ASSA 2000 model (developed by the Actuarial Society of SA to project the prevalence of HIV/AIDS) predicts that out of the 5.3 million people that are infected with HIV in SA, approximately 236,000 are living with AIDS; 139,000 people are estimated to have died of AIDS (26% of all deaths in 2000) and approximately 64,000 babies became infected from their mothers (Dorrington, et al, 2001). South African crime statistics for 1999, compared to those of 90 other Interpol member countries show

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[1] This paper is part of a more comprehensive doctoral dissertation of the same title, recently submitted to the South African Journal of Economics.

that South Africa measures unacceptably high with regard to violent crime such as murder, rape, robbery and assault (Interpol, 1999).

Since South Africa's democratic transition in 1994, the country has embraced rigorous economic and social reform in order to stabilize the economy and redress past social imbalances. High levels of crime, inflexible labor markets, escalating unemployment and South Africa's status as an 'emerging' economy has spurred less than optimum levels of economic growth. Although significant progress has been made with regard to social, economic and institutional reform, these efforts are jeopardized by two significant threats, namely, high levels of crime and the current HIV/AIDS epidemic.

Politicians and experts in crime analysis have started to lead the debate that HIV/AIDS could cause an increase in crime rates in South Africa (see Schönteich, 1999 and The Economist Global Agenda, 2002) but no studies to date have attempted to link the two. The primary objective of this study is to test whether there is a causal relationship between HIV/AIDS and crime rates, i.e. whether an increase in HIV prevalence has caused an increase in crime rates in South Africa. A key element of this study is to identify which specifications and/models best capture this unique relationship.

A secondary objective of this study is to perform empirical tests to determine potential mechanisms which may drive the direction of the relationship. We could expect a positive relationship between crime and HIV/AIDS to be influenced by decreases in the life-expectancy of those who contract the disease, causing them to discount the present value costs of punishment more heavily, thus increasing their propensity to commit crime. We may also expect government spending on HIV/AIDS to crowd-out other government spending that could help reduce crime in South Africa, e.g. the funding for HIV/AIDS programs could divert allocated resources away from law enforcement programs and other agencies that could potentially reduce crime rates in South. A negative relationship between HIV/AIDS and crime could be driven by the debilitating effects of the disease because people may become too sick to commit crime. HIV/AIDS could therefore have an incapacitation affect on crime. This study tests whether these potential mechanisms influence the direction of the relationship between HIV/AIDS and crime in South Africa.

2. THEORETICAL BACKGROUND

According to economic theory, people make rational decisions to engage in various activities based on the expected costs and benefits. The benefits of engaging in crime could be monetary or non-monetary. The costs of engaging in crime could range from the opportunity costs of foregone wages as a result of not engaging in legal work to fines and imprisonment. Early studies such as Becker (1968) have lead economists to consider economic incentives to be a major contributor to an individual's decisions to engage in crime. To understand the theoretical link between HIV/AIDS and crime, we need to understand how HIV/AIDS affects the costs and benefits of individuals, thereby influencing their decision to commit crimes. Firstly, HIV/AIDS will result in shorter life expectancies for those who are infected with the disease, holding all other factors constant (no or limited antiretroviral treatment programs between 1994 and 2003). Shorter life expectancy will lower the present value costs of crime, e.g. people who are infected with HIV or have AIDS will place a lower present value on the cost of prison because they will be in prison for a shorter period of time. Discounting the future as a result of lower present value costs of

crime will increase the net present value (Benefits minus costs) of committing crime. Therefore, those infected with HIV may be more likely to commit crimes if they discount the future heavily. This therefore implies a causal relationship between HIV/AIDS and crime..

It should be noted that although shortened life expectancy resulting from HIV/AIDS can have an impact on people's decisions to commit crime, other factors such as sex, income, age, education, family and cultural background are traditionally known as some of the key determinants of criminal behavior. It should also be noted that individuals who are inherently risk takers are more likely to commit crime and contract HIV/AIDS. In this case we cannot argue that HIV/AIDS will cause crime to rise but that HIV/AIDS and crime are jointly determined (caused by the same factors). There is thus a potential endogenous relationship between HIV/AIDS and crime. This endogeneity problem will be addressed in the estimation of the crime equations in the methodology section.

3. PREVIOUS LITERATURE ON HIV/AIDS AND CRIME

Vast bodies of literature are available on both AIDS and crime. Due to the unique relationship being analyzed and the methodological issues posed by this potential causal relationship, we conducted an intensive review of the determinants of both HIV/AIDS and crime in developed and developing countries. This was complemented with studies on government expenditure and studies that focused on similar causal relationships. Below are some of the key findings of the literature review.

Early economic studies of crime including Becker (1968), Ehrlich (1973) and Sjoquist (1973) lead to the development of a general form of the crime function in developed countries as follows:

Crime = f (Economic, demographic, deterrence)

According to the above crime function, crime is a function of economic (unemployment, education, etc.), demographic (age, gender, etc.) and deterrence (police or justice) variables. Studies in developing countries such as Brown (2001) and Blackmore (2003) however adopted an interdisciplinary approach by including various socio-demographic variables such as the degree of urbanization and population density.

A survey of the literature found that many of the same variables determine both HIV/AIDS and crime rates. These variables include: education, income inequality, age, gender, degree of urbanization, unemployment, etc. Therefore the author of this study explored various estimation techniques due to potential simultaneity bias. Below are some of the key determinants of crime from the economics of crime literature.

A study by Lochner and Moretti (2004) estimated the impact of schooling on the probability of incarceration using the instrumental variable approach via 2SLS, found that one extra year of schooling reduces the probability of imprisonment by 0.1 percentage points for whites and 0.3-0.5 percentage points for blacks. The authors' noted that higher education educational levels, which are associated with higher wages, increase the opportunity costs of criminal behavior.

Studies of crime in developed countries such as the United States and the United Kingdom find that increased income inequality results in higher levels of crime (Freeman, 1999; Witt et al, 1999). In the United States a study by Katz and Murphy (1992) showed that income inequality is driven by the skilled-unskilled wage-gap.

The literature on police/law enforcement provide ambiguous results. A survey of relevant studies on deterrence effects (Daniel, 1998) found many studies that show positive or no relationships with crime rates. Empirical studies testing the underlying theory of deterrence (police) however provide conflicting results because although increases in expenditure for law enforcement may reduce the levels of crime, it could also result in higher levels of crime due to increased reporting.

Although the theory underlying the relationship between unemployment and crime is well-defined, i.e. unemployment could influence the opportunity cost of illegal activities, recent empirical studies provide mixed results. Early studies of the effect of unemployment on crime using individual level cross-sectional data show a significant effect of unemployment on crime.[2] These results are further supported by a comprehensive survey which reviewed 63 aggregate studies of crime and unemployment found that 31% of the estimates were positive and statistically significant, while only 2% were negative and statistically significant (Chiricos, 1987).

Age is an important variable that has been tested in many crime studies. In the United States, people between eighteen and 24 years of age are most likely to commit murder and those in this age group are almost three times more likely to commit a murder than a person in the 25 to 34 age-group, and more than six times more likely than a person aged 35 to 49.[3] A study by Grogger (1998) using the National Longitudinal Survey of Youth (NLSY) data, found that falling real wages is an important determinant of crimes involving youth over the last 20 years and that the wage differential between blacks and whites explain the higher crime participation rates for blacks as compared to whites.

Luiz (1995) analyzed the economic determinants of crime in South Africa between 1960 and 1993 using a time series model. The study uses Johansen co-integration techniques to determine the relationship between income per capita, police officers per capita, conviction rates and political instability on crime per capita. Using the Johansen technique, the researchers found no co-integrating relationships between the property crime variable and the economic variables. They did however find a negative relationship between total offenses per capita and income per capita. They study also found a negative relationship between the total murder rate per capita and the conviction rate and the political instability variable (repression index).

Brown (2001) was an initial post apartheid study of crime in South Africa which highlighted the need for an interdisciplinary theory of crime to explain the high levels of crime in South Africa. This study moved away from traditional narrow focused deterrence theory to incorporate law enforcement, economic and socioeconomic variables. The study

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2 Thornberry, Terrence and Christenson (1984); Farrington, Gallagher, Morley , Ledger, Raymond: and West (1986) both found significant increases in crime in relation to unemployment.

3 Compiled by the Federal Bureau of Investigations (FBI) in 1999 as part of the Supplementary homicide reports, 1976-97.

identified several important variables that may be relevant for South Africa, which include: the poverty gap index, GINI coefficient, unemployment rate, female/male ratio of unemployment, age, education, proportion of population living in urban areas, probability of prosecution and average length of prison stay.

Blackmore (2003) analyzed the determinants of crime in South Africa using economic, social and demographic variables. The study uses a cross-provincial panel data model (estimating 15 unique crime equations). The dataset was constructed by collecting data on 15 different types of crime over an eight year period for each of the 9 provinces. This study used an interdisciplinary approach to identify the determinants of crime in South Africa, by analyzing the following explanatory variables: income per capita, ratio of woman to men, economically active proportion of the population, degree of urbanization, unemployment rate, proportion of population aged between 15-34 years, expenditure on total protection services as a percentage of GDP and drug related crime rate. According to this study, the most significant variables that explain crime rates in South Africa are income per capita, unemployment rates, proportion of woman to men and degree of urbanization. The least important determinant of crime in South Africa according to this study is expenditure of total protection services.

For this study, I construct a similar cross provincial panel data model but make significant methodological and data improvements compared to the Blackmore (2003) study. These improvements are hightlighted in the data section of this paper.

4. METHODOLOGY AND DATA

Empirical Model: A unique crime equation for South Africa

$$lnC_{it} = b0 + \gamma_t + b1*lnaids_{it} + b2*lnage_{it} + b3*lngender_{it} + b4*lnunemp_{it} + b5*lnrace_{it} + b6*lnincome_{it} + b7*lnGini_{it} + b8*lneduc_{it} + b9*lnurbanization_{it} + b10*lnlawenforcement_{it} + error_{it} \quad (1)$$

where lnC_{it} is the log of crime rates in province (i) at year (t). γ_t is a vector of year dummies. b1 is the coefficient on the log of HIV prevalence in province (i) at year (t); b2 is the coefficient on the log of age variable (the proportion of males between 15 and 24 years of age) in province (i) at year (t); b3 is the coefficient on the log of the gender variable (the proportion of women) in province (i) at year (t); b4 is the coefficient on the log of the unemployment variable (unemployment rate) in province (i) at year (t); b5 is the coefficient on the log of the race variable (proportion of blacks) in province (i) at year (t); b6 is the coefficient on the log of the income variable (income per capita) in province (i) at year (t); b7 is the coefficient on log of the income inequality variable (Gini coefficient) in province (i) at year (t) ; b8 is the coefficient on the log of the education variable (average years of education) in province (i) at year (t); b9 is the coefficient on the log of the urbanization variable (degree of urbanization) in province (i) at year (t) and b10 is the coefficient on the log of the law enforcement variable (police/law enforcement spending as a percentage of GDP) in province (i) at year (t).

The explanatory variables included in equation (1) were informed by a detailed analysis of available crime and HIV/AIDS studies. I use the log-log transformation in order to interpret the results as elasticities. I expect that both the income per capita and education variables to have negative coefficients because they may increase the opportunity costs of

engaging in criminal activities. I expect positive coefficients on the age, unemployment, race, Gini coefficient, and urbanization variables, similar to previous literature. The law enforcement variable could be subject to endogeneity bias because increases in the number of police or expenditure on law enforcement could be in response to rising crime rates. I am therefore not sure what the sign of this coefficient will be but I am primarily concerned about controlling for the effect of law enforcement on crime rates in South Africa.

Equation (1) is the general form of the crime equation used in this study. We can re-write equation (1) in structural form as:

$$\ln C_{it} = \beta_0 + \beta_1 \gamma_t + \beta_2 \ln H_{it} + \beta_3 \ln X_{it} + \varepsilon_{it} \qquad (2)$$

where $\ln C_{it}$ is the log of the crime rate per capita in province (i) at year (t); γ_t is a vector of year dummies; $\ln H_{it}$ is log of HIV prevalence in state (i) at year (t); X_{it} is a vector of logarithmically transformed socioeconomic variables and ε_{it} is the error term.

This study uses several different techniques to estimate the relationship between HIV/AIDS and crime. I start with OLS estimation of equation (2). To address potential simultaneity between the dependent variable (crime) and endogenous regressor (HIV/AIDS), I use the instrumental variables approach via two-stage least squares (2SLS) with province-level fixed-effects to control for unobserved differences between provinces. In addition to the OLS and a combined instrumental variables plus fixed-effects estimation, this study also estimates equation (2) using province-level fixed-effects without instrumental variables and a specification using instrumental variables without fixed-effects. In addition to the year dummies, I also estimate the crime equations using two other specifications of the time variable. I re-estimate the crime equations with a general time trend and then re-estimate the equations using provincial time trends plus a general linear time trend.

Rationale for using Instrumental Variables

Defining the problem and its implications

In the simplest case of our model of crime, represented by equation (2) above, crime is determined by HIV prevalence and socio-economic variables in South Africa. However, the vast body of available literature on HIV/AIDS and crime indicate that both are influenced by many of the same variables. Therefore H_{it} and C_{it} may be endogenous or simultaneously determined. One possible explanation is that individuals must assess their exposure to risk when both committing crime and engaging in unprotected sex. There could therefore be unobservables or omitted variables that could influence an individual's behavior in this regard. One such omitted variable is risk aversion. We can assume that the more risk averse a person is, the lower the probability of such person engaging in criminal activities and risky sexual behavior. In equation (2), we do not directly take risk aversion into account because it is difficult to measure. Therefore it is captured in the error term with all the other unobervables.

Because risk aversion is correlated with H_{it}, it is correlated with the error term, which implies that the coefficient on H_{it} is now biased. If we estimate equation (2) using OLS, we may not get consistent estimates on the coefficient on $H_{it.}$ This study attempts to address this problem of endogeneity bias by using an instrumental variables (I.V.) approach because we want a consistent estimate of the HIV/AIDS variable.

Implementation of the Instrumental Variables Approach.

The I.V. approach is dependent on finding good instruments for HIV/AIDS, which will introduce exogenous variation into the model. A good instrument should be:

a. Highly correlated with H_{it}.

b. Uncorrelated with the error term in the structural crime equation.

From our discussion above on the endogeneity problem and its implications, we note that there could be an omitted variable such as risk aversion that could be part of the error term and could therefore imply that H_{it} is correlated with the error term. We can reflect this by analyzing equation (2) below:

$$C_{it} = \beta_0 + \beta_1\gamma_{jit} + \beta_2 \ln H_{it} + \beta_3 \ln X_{it} + \varepsilon_{it} \quad (2)$$

But the true model for crime should however be:

$$C_{it} = \beta_0 + \beta_1\gamma_{jit} + \beta_2 \ln H_{it} + \beta_3 \ln X_{it} + \beta_4 \ln RA_{it} + \varepsilon_{it} \quad (3)$$

where RA_{it} is the log of the omitted variable (risk aversion per province per year). Therefore to overcome the potential simultaneity bias in equation (2), we need to find variables that fulfill the following properties: (a) highly correlated with H_{it} and (b) uncorrelated with the error term in equation (2).

I use 2SLS to estimate crime equation (2). In the first stage the reduced form equation can be represented as follows:

$$\ln\hat{H}_{it} = \gamma 1 \ln X_{it} + \gamma_2 \ln D_{it} + \gamma_3 \ln DS_{it} + \gamma_4 E_{it} + U_{it} \quad (4)$$

$$U_{it} = \gamma_4 \ln RA_{it} + \varepsilon_{it} \quad (5)$$

where $\ln D_{it}$, $\ln DS_{it}$ and $\ln E_{it}$ (log on condom distribution, log of district health care expenditure and log of education expenditure respectively) are instruments for $\ln H_{it}$ (log of HIV prevalence) and U_{it} is the error term consisting of the log of the risk aversion variable ($\ln RA_{it}$) and the other errors (ε). Equation (4) assumes that the predicted value of the log of HIV/AIDS ($\ln\hat{H}_{it}$) is correlated with lnHit. If our instruments ($\ln D_{it}$, $\ln DS_{it}$ and $_{\ln}E_{it}$) are uncorrelated with the omitted variable ($\ln RA_{it}$), then $\ln\hat{H}_{it}$ is uncorrelated with the error term (U_{it}).

In the second stage, I regress crime (lnCit) on the predicted value of HIV/AIDS ($\ln\hat{H}_{it}$) and a vector of socio-economic variables as represented below:

$$\ln C_{it} = \beta_0 + \beta_1\gamma_{jit} + \beta_2 \ln\hat{H}_{it} + \beta_3 \ln X_{it} + V_{it} \quad (6)$$

In the second stage, we get consistent estimates of β_2 because $\ln\hat{H}_{it}$ is now uncorrelated with the error term. The consistency of $\beta_2$hat in equation (6) depends on the assumption that $\ln\hat{H}_{it}$ is uncorrelated with V_{it} and therefore, that the instruments are not correlated with V_{it}. Thus the I.V. approach helps us address the problem of endogeneity bias but is sensitive to assumptions (a) and (b) listed above. If these assumptions don't hold then the I.V. estimate will not be efficient.

The implication of a 'bad' or 'weak' instrument is that the estimates generated via 2SLS may not have a high degree of explanatory power for the jointly endogenous variables

or are weakly correlated with the explanatory variables. In this study, we adopt an I.V. approach in order to solve the potential endogeneity problem. However, in cases where OLS could provide a poor estimate of the impact of HIV/AIDS on crime, the Instrumental Variables technique with 'weak' instruments may provide worse estimates than OLS (Startz and Nelson, 1990). Therefore, for each instrumental variable considered in this study, we test whether assumptions (a) and (b) hold. If they do not, then the OLS estimate is better.

A closer look at potential instrumental variables

As explained above, to solve the endogeneity problem between crime and HIV/AIDS in this study, we need to introduce exogenous variation in the HIV/AIDS variable. This would entail finding suitable instruments that are highly correlated with the endogenous variable (HIV/AIDS) but unrelated with the outcome variable (crime).

Health intervention programs for HIV/AIDS in South Africa for the study period focus primarily on prevention. These intervention programs can be considered as institutional or policy interventions aimed at influencing a particular health related problem. One of the objectives of the HIV Strategic Plan for South Africa is the widespread adoption of barrier methods (condom use). Condom distribution as an HIV/AIDS intervention strategy is considered effective because it has the potential to limit the transmission of the HIV/AIDS virus. An opinion survey conducted by the Human Sciences Research Council (2001) in South Africa found that AIDS encouraged the use of condoms among 69% of the sample population. The number of condoms distributed will therefore influence the spread of the disease but will not likely have an effect on crime rates in South Africa. Condom distribution can thus be considered a potential instrument for HIV/AIDS because it is highly correlated with the endogenous variable (AIDS) but unrelated to crime rates.

The White paper on health care reform in South Africa targets primary health care as one of the key policy priorities for the South African government.[4] Primary health care in this study is measured via district health services (DHS) expenditure per capita. This variable was also considered a potential instrument because many AIDS intervention programs are implemented at this first contact/clinic level of health service delivery in South Africa. Expenditure on district health services should therefore be correlated with HIV prevalence but otherwise unrelated to crime rates in South Africa.

The Education Department in South Africa provides many education related programs that have significant impacts on other departments and other government policy objectives. Spending on education per capita was considered a potential instrument because of the intersectoral collaboration between the Health Department and the Education Department with regard to fighting the AIDS epidemic. Numerous programs such as secondary school sex education and AIDS awareness programs are housed in the Education Department. We could, therefore, expect spending on education per capita to be correlated with HIV prevalence and otherwise unrelated to crime rates as no joint expenditure driven programs between the Education Department and law enforcement/police services exists.

In the results section, we assess which of the above potential instruments fulfill our conditions for being a good and appropriate instrumental variable for this study.

[4] The White paper for health care reform, the official policy document in South Africa was signed into effect in 1996.

Fixed Effects model (FEM)

There are two specific reasons why I employ fixed effects in the models. First, fixed-effects help control for province-specific, time-invariant unobservable influences on crime. Within the context of this study, the FEM is an appropriate way to deal with pooled panel data because the provincial dummies capture systematic differences among the panel observations. Therefore the fixed-effects control for cross provincial fixed-effects, i.e. provincial specific differences, and fixed-year-effects control for unobservables that cause crime rates in a particular province to differ from that of other provinces. The fixed year-effects also help control for demographic changes and the business cycle and all other differences in provincial crime rates that are not captured by the explanatory variables.

The second reason for using fixed-effects is that it also helps solve the endogeneity problem. In this regard the following previously mentioned points should be noted:

- Our estimate on the HIV/AIDS variables may be biased because it may be correlated with unobservables or omitted variables in the error term.
- The FEM helps control for various unobservable influences on crime across provinces and over time.

For example, risk aversion may be part of the unobservables in the error term. Therefore, by implication the FEM also helps solve the endogeneity problem by controlling for province-specific, time-invariant unobservable influences, such as risk aversion, on crime committed in South Africa.

Combined Fixed-effects and I.V. Model

Few studies employ a combined fixed-effects and Instrumental Variables model. Advances in recent years in statistical programs have simplified the use of such combined models. This study uses a combined fixed-effects plus instrumental variables model because of the nature of the econometric issues presented in this study and limited empirical guidance in the literature. As previously mentioned both the Instrumental Variables approach and the Fixed-Effects model help solve our endogeneity problem. Currently, there is insufficient literature to support which does a better job and whether a combined model will perform better. This study therefore explores whether a combined model will provide more precise or consistent estimates on our coefficients than separate specifications (OLS, I.V. only and Fixed-Effects only).

Hypotheses

The primary question that this study attempts to address is whether there is a causal link between HIV prevalence and crime rates between provinces in South Africa.

This study also attempts to determine potential mechanisms that could drive a relationship between HIV/AIDS and crime rates in South Africa. The secondary hypotheses are:

Secondary Hypothesis 1: Increases in the prevalence of HIV decreases the present value costs of punishment of those infected (due to decreased life-expectancy), which will increase crime rates in States/Provinces. According to this hypothesis, those who are infected with the disease will tend to discount the future more heavily because they know that they will not bear all the associated costs of punishment, due to their decreased life spans. This group of people will therefore be less deterrable through criminal sanctions such as imprisonment than those not infected with the disease. Those infected with HIV would also be expected to engage in other risky behaviors. This study will therefore attempt to ascertain whether instrumented HIV prevalence affects other risky behaviors [driving while under the influence (DUI) and drug related offenses (DR)] that people with shorter life expectancies may be subject to. I therefore re-estimate equation (2) using two specific crime rates (DUI_{it} and DR_{it}) as dependent variables. I replace the dependent variable C_{it} [(crime rate in state (i) at time (t)] with DUI_{it} [(the rate of driving while under the influence of alcohol in state (i) at time (t)] and DR_{it} [(the rate of drug related offenses in state (i) at time (t)]. I then estimate these crime equations using the 4 specifications described earlier.

Secondary Hypothesis 2: Increases in the prevalence of HIV will crowd-out government spending on other programs, which will increase crime rates in States/Provinces. According to this hypothesis, increases in HIV prevalence will cause government to divert funds away from programs or agencies that could reduce crime toward programs or agencies which focus on HIV/AIDS. To test this hypothesis, I will run a series of OLS, two-stage least squares, fixed-effects and combined fixed-effects plus instrumental variable models, re-estimating equation (2) using expenditure from various governmental agencies as the dependent variable (instead of the crime rates) and the predicted value of HIV prevalence as the key explanatory variable. Below are some of the equations I estimate:

$$\ln EXP_{it} = \beta 1 \ln Z_{it} + \beta_2 \ln H_{it} + \varepsilon_{it} \quad (7)$$

$$\ln \hat{H}_{it} = \gamma_1 \ln Z_{it} + \gamma_2 \ln D_{it} + \gamma_3 \ln DS_{it} + \ln E_{it} \quad (4i)$$

Equation (7) represents the log of government expenditure ($\ln EXP_{it}$) as a function of specific determinants of government spending ($\ln Z_{it}$) and HIV prevalence ($\ln H_{it}$). Four types of government expenditures are examined, i.e. total government spending per capita (G); expenditure on health services per capita (HS); expenditure on law enforcement per capita (L) and expenditure on education per capita (E) in state (i) and year (t).

Z_{it} = population density, degree of urbanization, age structure (0-15 age cohort and above 64 years of age), income/GDP per capita, educational attendance (secondary school enrollment/attendance) and unemployment rates in state (i) and year (t). This study selected specific explanatory variables for government expenditure based on relevant economic theory and the literature surveyed.

Similar to previous studies, we expect the explanatory variables (Z) captured in equation (7) to influence the level of government expenditure in South Africa. I expect the coefficients on population density, degree of urbanization, targeted age-cohorts, unemployment rates and school attendance to be positively correlated with government

expenditure but income/GDP per capita to be negatively correlated with government expenditure.

Data Approach

This study will use a cross-provincial panel data model. Blackmore (2003) motivated the use of a cross provincial data analysis because using provincial data added significant degrees of freedom to the model and substantial amounts of provincial variation (additional variance in the variables that are specific to a particular province). I use the latest available data (December 2004 release of crime data) to construct a cross provincial panel data set of the 9 provinces over 10 years instead of 8 years. This is a unique dataset because it includes socio-demographic, crime and HIV prevalence data between 1994 and 2003. Instead of using simultaneous equations (see Blackmore, 2003), this study uses fixed-effects to control for time-invariant unobservables between provinces and an instrumental variables model to correct for potential simultaneity bias. Specifications also include time controlled variables (provincial time trends and year fixed effects).

I collect data on 19 types of crime over a 10 year period (1994-2003) for each of the 9 provinces (90 observations for each of the 19 crime types). Compared to Blackmore (2003) this study incorporates two additional years of data (2002 and 2003) and includes important additional socioeconomic variables such as degree of urbanization and the human development index (HDI). An advantage of a panel dataset of this nature is that it is possible to control for the province-specific, time invariant characteristics through the use of province-specific intercepts or fixed effects (Weinhold, 1999). A potential problem in the estimates of this study (using panel data which have a small number of provinces) is that of serial correlation and heteroskedasticity. I correct for this problem by using robust clustered standard errors (clustered by province). These robust standard errors are consistent in the presence of heteroskedasticity. Bertrand, et al (2004) analyze various standard correction methods for serial correction and observe that while parametric corrections perform badly in short time series, techniques available in standard statistical programs provide a viable solution for the applied researcher. Thus the robust standard errors with corrections for clustering by province performed in STATA used in this study correct for serial correlation in our panel data.

Numerous data sources are used to construct the CRIME-AIDS data set. Data on crime was collected from the Crime Information Bulletin for 2004 from the South African Police Services. HIV prevalence data was obtained from antenatal survey data from the National Department of Health (1994 to 2003). Socio-economic variables were derived from various October Household Surveys, Labour Force Surveys, Income and Expenditure Surveys, and Census data. Data on governmental expenditure was obtained from various Intergovernmental Fiscal Reviews between 1995 and 2003 from the National Treasury in South Africa.

The ANC survey data produced by the Department of Health in South Africa is not derived from a nationally representative sample as it only samples pregnant women. This inherent weakness in the data results in the estimates of HIV prevalence being biased upwards as those sampled are sexually active and more prone to HIV infection than the entire population, including children and older people. The measurement error in this study could be represented as follows:

$$E = HIVP - HIVP^*$$

Where E represents the measurement error, HIVP the observed HIV prevalence among the adult female population in South Africa and HIVP* the actual HIV prevalence in the population. Measurement error in an explanatory variable, according to Wooldridge (2003), will increase the error variance if we assume that the measurement error (E) is uncorrelated with the observed value of HIV prevalence (HIVP). This would imply that while most of the estimation properties remain unaffected, the variances on the coefficient of HIV prevalence will be larger if we use HIVP than if we had used HIVP*. This measurement error could bias the estimates in this study towards insignificance. The estimates generated from the ANC survey data are however the only available scientific source of AIDS data available in South Africa and many other countries for the given study period. Therefore, this dissertation takes cognizance of the bias generated by using the given AIDS variable. The results should therefore be interpreted taking the above into consideration.

5. Results and Interpretation

A. OLS Results for Time-Controlled Models (Year-Dummy-Variable Models, General-Time-Trend Models and General-Time-Trend plus Provincial-Time-Trend Models)

The baseline (OLS) estimates of the relationship between HIV/AIDS and crime in South Africa are presented in table 1. The results indicate that the impact of HIV prevalence on crime rates is sensitive to the type of crime being analyzed. This study finds that the HIV coefficients on 3 of the crime types (Assault 1: assault with intent to do grievous bodily harm, Assault 2: common assault, and public violence) are negative and consistently significant across all OLS specifications. Coefficients on HIV prevalence are negative and significant in at least 2 out of 3 OLS specifications for the following types of crime: Rape, Residential burglary and Commercial crime. Similarly, we find positive and significant coefficients in 2 out of 3 OLS specifications for Stock theft.

The OLS estimates provide a baseline for our analysis of the impact of HIV prevalence on crime rates in South Africa but they could be misleading or biased. One reason why I suspect that the OLS estimates maybe be biased is because crime rates and HIV prevalence in South Africa may be endogenous or simultaneously determined. As previously explained, there could therefore be unobservables or omitted variables (such as risk aversion) which could influence an individual's decision to engage in crime or risky sexual behavior. These difficult to measure missing variables are captured in the error term. In our crime models, because the omitted variables are correlated with HIV prevalence, they are also correlated with the error term, which implies that the OLS estimates may be biased.

To address these issues, I estimate other models with different specifications. I first estimate the crime models using the instrumental variables approach. Next, I estimate the models using fixed-effects and lastly we use a combined instrumental variables/fixed-effects specification to estimate the crime models. These models are considered to generate more consistent and precise estimates of the AIDS coefficients, free from possible asymptotic bias from endogeneity and omitted variables.

Table 1: Results for OLS Specifications

TYPE OF CRIME	OLS		
	YEAR DUMMY	GENERAL TREND	PROV TREND
(1)	(2)	(3)	(4)
Total Crime	-0.1941***	-0.2361**	-0.2193383
	(0.0463)	(0.0992)	(0.1188)
Murder	0.1259	0.1035881	-0.0569749
	(0.1172)	(0.1709)	(0.1532)
Rape	-0.2410***	-0.2659**	-0.2345393
	(0.0408)	(0.1071)	(0.1332)
Attempted Murder	0.2629**	0.183954	-0.1742376
	(0.1066)	(0.1639)	(0.2136)
Assault1	-0.6091***	-0.5794***	-0.3275**
	(0.1061)	(0.1471)	(0.1288)
Assault2	-0.4057***	-0.5042***	-0.3824**
	(0.0584)	(0.0762)	(0.1410)
Assault3	-0.0080	-0.1560741	-0.3583*
	(0.0769)	(0.1406)	(0.1820)
Aggravated Robbery	0.1850	0.0547412	-0.2009143
	(0.2217)	(0.2434)	(0.1548)
Common Robbery	-0.2064	-0.2234227	-0.1912203
	(0.1182)	(0.1482)	(0.1483)
Culpable Homicide	0.0251	-0.0430151	-0.1851191
	(0.0746)	(0.1237)	(0.1595)
Public Violence	-1.1006***	-1.0700**	-0.7838**
	(0.3305)	(0.3398)	(0.2369)
Residential Burglary	-0.2076**	-0.2124758	-0.3314*
	(0.0708)	(0.1269)	(0.1624)
Business Burglary	-0.0546	-0.0053177	0.0853822
	(0.0817)	(0.1349)	(0.1438)
Theft of Motor Vehicle	0.1761	0.0932613	-0.2293175
	(0.1762)	(0.2239)	(0.1786)
Theft out of Motor Vehicle	0.0098	-0.0236842	-0.1228485
	(0.0973)	(0.1335)	(0.1421)
Stock Theft	0.4775**	0.5585**	0.2287294
	(0.1587)	(0.2309)	(0.2190)
Illegal Possession of Firearms	0.3144*	0.2281215	0.0441188
	(0.1420)	(0.1711)	(0.1393)
Commercial Crime	-0.3047**	-0.2724**	-0.2269152
	(0.0932)	(0.1062)	(0.1552)
Shop Lifting	-0.1088**	-0.1277243	-0.1670335
	(0.0436)	(0.0919)	(0.1312)

Notes: * indicates significance at 10% (p<0.1), ** indicates significance at 5% (p<0.05), *** indicates significance at 1% (p<0.01). Standard errors are reported in brackets using the robust method described by White (1980), clustered by province. This model includes fixed year effects and is population weighted. All variables have been transformed into logarithmic values. Source: Author's calculations from panel created from SAPS Crime Bulletin 2004 (crime data 1994 to 2003), Antenatal Survey data (1994 to 2003), various OHS, LFS and IES datasets (1994-2003) and Intergovernmental Fiscal Reviews (1995-2003).

B. Instrumental Variables versus OLS estimates

Selection of Instrumental Variables

If the selected instrumental variables fulfill the conditions of a good I.V., then we expect them to be uncorrelated with the omitted variables, implying that the predicted value of HIV prevalence will be uncorrelated with the error term. We should therefore get consistent unbiased estimates of HIV prevalence, solving the endogeneity problem.

The test of relevance of the instruments (appendix 1) reveals that neither the rate of condom distribution nor primary health care expenditure is significantly related to HIV prevalence. Therefore, these two variables do not fulfill the first condition to be a good I.V. I find that lagged condom distribution is significant in two of the specifications but the coefficients have an unexpected sign, i.e. a positive sign. The correlation between education spending per capita and HIV prevalence is found to be negative and significant for 2 out of 3 specifications while lagged education spending per capita is negative and significantly related to HIV prevalence across all specifications. To be confident that the instruments are truly exogenous I test the over-identifying restrictions. I conduct the over-identification tests with only two I.V.s, i.e. lagged condom distribution and lagged education expenditure per capita because these two variables were the only ones which fulfilled the first condition to be a good I.V. Appendix 2 captures the results of the tests of over-identifying restrictions. I find that for many of the crime types, $N*R^2$ is greater than the critical value of the chi-square at 5% or 10% levels of significance. We therefore reject the null hypothesis that all of the instruments are exogenous and accept the alternative that at least one instrument is endogenous. I suspect that lagged condom distribution is endogenously determined because the tests of relevance find an unexpected positive sign which may indicate that condom distribution is not a natural experiment but a government generated response to rising provincial HIV prevalence.

Taking the above into consideration, I find that lagged education spending per capita is the best instrumental variable tested in this study while contemporaneous education expenditure was found to be endogenously determined with HIV prevalence. Unfortunately, with only one I.V. it is not possible to test the correlation between the instrument and the error term in the structural equation, i.e. the over-identification restriction test. I however do not believe that the instrument is correlated with the error term in the second stage of the crime equation because gradual changes in education and health expenditure between provinces in South Africa for the study period was driven by the government's redistributive policies.

Comparison of OLS and I.V. Estimates

A comparison of the OLS and I.V. estimates in Table 2 indicates that the coefficients are mostly the same sign and are significant at similar levels. The tests for endogeneity bias (appendix 3) show that only for stock theft are the HIV prevalence residuals statistically significant across all models (YDVM, PTTM and PTTM) in South Africa. I find that the I.V. coefficients on HIV prevalence are however not significant for stock theft.

Table 2: Results for OLS and I.V. Crime Specifications

TYPE OF CRIME	OLS			I.V.		
	YDVM	GTTM	PTTM	YDVM	GTTM	PTTM
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Total Crime	-0.1941***	-0.2361**	-0.2193	-0.3228*	-.5052**	-0.1294
	(0.0463)	(0.0992)	(0.1188)	(0.1442)	(0.2139)	(0.5387)
Murder	0.1259	0.1036	-0.0570	0.5184	0.7025*	0.5715
	(0.1172)	(0.1709)	(0.1532)	(0.3403)	(0.3602)	(0.8320)
Rape	-0.2410***	-0.2659**	-0.2345	-0.4216**	-0.3514	-0.2996
	(0.0408)	(0.1071)	(0.1332)	(0.1618)	(0.2325)	(0.5162)
Attempted Murder	0.2629**	0.1840	-0.1742	0.4875*	0.6694*	0.0171
	(0.1066)	(0.1639)	(0.2136)	(0.2484)	(0.3116)	(0.9415)
Assault1	-0.6091***	-0.5794***	-0.3275**	-0.7298***	-0.7362***	-0.5780
	(0.1061)	(0.1471)	(0.1288)	(0.1242)	(0.1563)	(0.3548)
Assault2	-0.4057***	-0.5042***	-0.3824**	-0.8711***	-0.7942**	-0.6665
	(0.0584)	(0.0762)	(0.1410)	(0.2551)	(0.3121)	(0.4816)
Assault3	-0.0080	-0.1561	-0.3583*	-0.0995	0.0166	-0.9750
	(0.0769)	(0.1406)	(0.1820)	(0.1913)	(0.2942)	(0.7812)
Aggravated robbery	0.1850	0.0547	-0.2009	0.7374	0.9939	0.8926
	(0.2217)	(0.2434)	(0.1548)	(0.5985)	(0.5994)	(0.9816)
Common Robbery	-0.2064	-0.2234	-0.1912	-0.0362	0.0429	0.4607
	(0.1182)	(0.1482)	(0.1483)	(0.1678)	(0.2399)	(0.7945)
Culpable Homicide	0.0251	-0.0430	-0.1851	-0.2189	-0.0625	-0.4769
	(0.0746)	(0.1237)	(0.1595)	(0.2239)	(0.3303)	(0.5800)
Public Violence	-1.1006***	-1.0700**	-0.7838**	-1.0409*	-1.0192	-0.3630
	(0.3305)	(0.3398)	(0.2369)	(0.5281)	(0.5490)	(0.9870)
Residential Burglary	-0.2076**	-0.2125	-0.3314*	-0.3382	-0.2211	-0.2069
	(0.0708)	(0.1269)	(0.1624)	(0.2172)	(0.2911)	(0.6056)
Business burglary	-0.0546	-0.0053	0.0854	-0.4260*	-0.3104	-0.2361
	(0.0817)	(0.1349)	(0.1438)	(0.2176)	(0.3197)	(0.6697)
Theft of Motor Vehicle	0.1761	0.0933	-0.2293	0.5072	0.7513	0.3329
	(0.1762)	(0.2239)	(0.1786)	(0.4618)	(0.5221)	(0.8941)
Theft out of Motor Vehicle	0.0098	-0.0237	-0.1228	-0.0181	0.1489	-0.0497
	(0.0973)	(0.1335)	(0.1421)	(0.2356)	(0.3158)	(0.6624)
Stock Theft	0.4775**	0.5585**	0.2287	-0.1434	-0.0758	-1.0116
	(0.1587)	(0.2309)	(0.2190)	(0.4824)	(0.5010)	(1.0308)
Illegal Possession of Firearms	0.3144*	0.2281	0.0441	0.4641	0.6841	0.3636
	(0.1420)	(0.1711)	(0.1393)	(0.4422)	(0.4789)	(0.7784)
Commercial Crime	-0.3047**	-0.2724**	-0.2269	-0.1923	-0.0048	-0.1008
	(0.0932)	(0.1062)	(0.1552)	(0.2484)	(0.3758)	(0.6702)
Shop Lifting	-0.1088**	-0.1277	-0.1670	-0.0499	0.0732	0.0032
	(0.0436)	(0.0919)	(0.1312)	(0.1779)	(0.2485)	(0.5809)

Notes: * indicates significance at 10% (p<0.1), ** indicates significance at 5% (p<0.05), *** indicates significance at 1% (p<0.01). Standard errors are reported in brackets using the robust method described by White (1980), clustered by province. This model includes fixed year effects and is population weighted. All variables have been transformed into logarithmic values. Columns (2-4) represent OLS estimates for the Year Dummy Variable (YDVM), General Time trend (GTTM) and Provincial plus General Time trend models (PTTM) respectively. Columns (5-7) represent the I.V. estimates for the 3 models. Source: Author's calculations from panel created from SAPS Crime Bulletin 2004 (crime data 1994 to 2003), Antenatal Survey data (1994 to 2003), various OHS, LFS and IES datasets (1994-2003) and Intergovernmental Fiscal Reviews (1995-2003).

C. OLS versus Fixed-Effects Estimates

As mentioned in the methodology, the fixed-effects approach helps to address endogeneity and omitted variables bias. According to Table 3, we find two distinct patterns emerging from the comparison of the estimated coefficients between the OLS and F.E specifications:

Consistent results between OLS and F.E. for specific crime types

The results from Table 3 indicate that the signs of the following coefficients remain the same for both the OLS and F.E. specifications but the magnitudes differ:

- Assault with intent to do grievous bodily harm (Assault 1)
- Common Assault (Assault 2)
- Public Violence
- Rape

The coefficients on HIV prevalence for the above types of crime are negative for both the OLS and F.E. estimates. Most of the estimated coefficients for Indecent Assault (Assault3) are also negative except for the provincial time trend model (PTTM). Although we find consistency of signs (negative) between OLS and F.E. estimates, the levels of significance of the associated coefficients vary between specifications. I find that the estimates from the F.E. specifications are generally less significant than those of the OLS specifications. The above types of crime are however significant in at least one of our time-controlled models for the fixed-effects specifications.

The findings from the comparison between the estimates from the OLS and the F.E. specifications provide evidence of the existence of a negative effect between violent types of crime and HIV prevalence in the F.E. models, albeit a weak one. When we control for various province-specific, time-invariant unobservable influences on crime rates using fixed-effects, the relationship between HIV prevalence and violent types of crime such as assaults, rape and public violence becomes less significant than those captured in the OLS models.

Change of Signs and or significance levels of coefficients between OLS and F.E. for specific crime types

The results from Table 3 indicate that the signs and or levels of significance of the following coefficients on HIV prevalence change from negative in the OLS to positive in the F.E. specifications:

- Common robbery
- Residential burglary
- Business burglary
- Theft out of motor vehicle
- Commercial crime

Table 3: Results for OLS and F.E. Crime Specifications

TYPE OF CRIME	OLS			FE		
	YDVM	GTTM	PTTM	YDVM	GTTM	PTTM
	(1)	(2)	(3)	(6)	(7)	
Total Crime	-0.1941***	-0.2361**	-0.2193	0.0277	0.0057	0.0260
	(0.0463)	(0.0992)	(0.1188)	(0.0435)	(0.0554)	(0.0736)
Murder	0.1259	0.1036	-0.0570	0.1005*	0.0319	0.0076
	(0.1172)	(0.1709)	(0.1532)	(0.0554)	(0.0531)	(0.0459)
Rape	-0.2410***	-0.2659**	-0.2345	-0.0480	-0.0250	-0.0417*
	(0.0408)	(0.1071)	(0.1332)	(0.0421)	(0.0382)	(0.0232)
Attempted Murder	0.2629**	0.1840	-0.1742	0.0256	-0.0380	0.0357
	(0.1066)	(0.1639)	(0.2136)	(0.1393)	(0.1226)	(0.0601)
Assault1	-0.6091***	-0.5794***	-0.3275**	-0.0716*	-0.0048	0.0067
	(0.1061)	(0.1471)	(0.1288)	(0.0425)	(0.0865)	(0.0972)
Assault2	-0.4057***	-0.5042***	-0.3824**	-0.0112	-0.1261*	-0.0187
	(0.0584)	(0.0762)	(0.1410)	(0.1138)	(0.0680)	(0.0711)
Assault3	-0.0080	-0.1561	-0.3583*	-0.0480	-0.1437	-0.0797
	(0.0769)	(0.1406)	(0.1820)	(0.1592)	(0.0908)	(0.1278)
Aggravated Robbery	0.1850	0.0547	-0.2009	0.0404	-0.1058	-0.1234
	(0.2217)	(0.2434)	(0.1548)	(0.1720)	(0.1602)	(0.1585)
Common Robbery	-0.2064	-0.2234	-0.1912	0.1339*	0.2713*	0.2210
	(0.1182)	(0.1482)	(0.1483)	(0.0772)	(0.1433)	(0.1381)
Culpable Homicide	0.0251	-0.0430	-0.1851	-0.0126	-0.1055**	-0.0927
	(0.0746)	(0.1237)	(0.1595)	(0.0340)	(0.0497)	(0.0753)
Public Violence	-1.1006***	-1.0700**	-0.7838**	-0.1879	-0.2859**	-0.2278
	(0.3305)	(0.3398)	(0.2369)	(0.1595)	(0.1163)	(0.2081)
Residential Burglary	-0.2076**	-0.2125	-0.3314*	0.0726*	0.0899	0.0561
	(0.0708)	(0.1269)	(0.1624)	(0.0383)	(0.0913)	(0.0795)
Business Burglary	-0.0546	-0.0053	0.0854	0.0920*	0.2362***	0.2110***
	(0.0817)	(0.1349)	(0.1438)	(0.0563)	(0.0797)	(0.0681)
Theft of Motor Vehicle	0.1761	0.0933	-0.2293	0.0799	0.0673	0.0090
	(0.1762)	(0.2239)	(0.1786)	(0.0695)	(0.0939)	(0.0717)
Theft out of Motor Vehicle	0.0098	-0.0237	-0.1228	0.2824***	0.2231**	0.2076**
	(0.0973)	(0.1335)	(0.1421)	(0.0833)	(0.0910)	(0.0900)
Stock Theft	0.4775**	0.5585**	0.2287	0.1302	0.1209	0.0331
	(0.1587)	(0.2309)	(0.2190)	(0.1094)	(0.1393)	(0.0879)
Illegal Possession of Firearms	0.3144*	0.2281	0.0441	0.2034	0.1599	0.0475
	(0.1420)	(0.1711)	(0.1393)	(0.1420)	(0.1154)	(0.0568)
Commercial Crime	-0.3047**	-0.2724**	-0.2269	-0.0317	0.1159**	0.1486*
	(0.0932)	(0.1062)	(0.1552)	(0.0669)	(0.0482)	(0.0824)
Shop Lifting	-0.1088**	-0.1277	-0.1670	-0.0226	-0.0858*	-0.0155
	(0.0436)	(0.0919)	(0.1312)	(0.0791)	(0.0487)	(0.0608)

Notes: * indicates significance at 10% (p<0.1), ** indicates significance at 5% (p<0.05), *** indicates significance at 1% (p<0.01). Standard errors are reported in brackets using the robust method described by White (1980), clustered by province. This model includes fixed year effects and is population weighted. All variables have been transformed into logarithmic values. Columns (2-4) represent OLS estimates for (YDVM), (GTTM) and (PTTM) respectively. Columns (5-7) represent the I.V. estimates for the 3 models. Source: Author's calculations from panel created from SAPS Crime Bulletin 2004 (crime data 1994 to 2003), Antenatal Survey data (1994 to 2003), various OHS, LFS and IES datasets (1994-2003) and Intergovernmental Fiscal Reviews (1995-2003).

The coefficients on HIV prevalence for business burglary and theft out of motor vehicle are positive and significant for all 3 fixed-effects specifications. The coefficients on HIV prevalence for common robbery are positive and significant for the year dummy variable model (YDVM) and the general time trend model (GTTM). Similarly, the coefficients on commercial crime are positive and significant for both time trend models (GTTM AND PTTM). The coefficient on HIV Prevalence for Residential burglary is positive and significant for the year dummy variable model (YDVM).

The fixed-effects findings indicate that HIV prevalence is positively related to certain types of crime. Therefore, the comparison of the OLS and Fixed-effects models provides new evidence regarding the impact of HIV prevalence on certain crime types, i.e. increases in HIV prevalence leads to higher rates of specific non-violent property-related/monetary types of crime.

Why the change in sign and level of significance (between OLS and Fixed-Effects) for certain types of crime?

On average, the coefficients on HIV prevalence for many crime types for the fixed-effects specification are higher (less negative or more positive) than those of the OLS specification. This implies that in the cross-section, provinces with low crime rates have high HIV prevalence. This study finds that specific variables or unobservables that do not change over time but vary by province such as the implications of urban-rural distribution, may cause the negative cross-sectional relationship between crime rates and HIV prevalence between provinces (refer to discussion in appendix 4). The fixed-effects specifications are therefore controlling for these unobservables or time invariant differences between provinces such as urban-rural distribution, culture/traditional practices and racial composition and do not capture a causal relationship between HIV prevalence and crime rates between provinces. Therefore, I conclude that the fixed-effects specification is better than the OLS specification, which leads us to have a lot of confidence in the positive estimates generated by the fixed-effects specification.

4. Fixed-Effects versus Combined I.V plus F.E.

This study also explored whether a combined I.V. plus F.E. specification could help solve the endogeneity and omitted variables bias and therefore provide more precise or consistent estimates of our coefficients than separate I.V. only and Fixed-Effects only specifications. I find that all of the coefficients on HIV prevalence for the I.V./F.E. specifications are statistically insignificant. This specification also generates large standard error errors, which casts doubt on the efficiency of this estimator. Insignificant findings for the tests of relevance (correlation of the I.V. with HIV prevalence) and the lack of strong evidence of endogeneity for key types of crime that have a significant relationship to HIV prevalence in the fixed-effects specifications, indicate that the combined I.V./F.E. estimates are not better than the fixed-effects estimates.

Therefore, the remainder of this paper focuses on the fixed-effects estimates and not the combined I.V./F.E. specifications. The systematic analysis of the various specifications in the preceding sections indicates that the fixed-effects specifications are the most efficient

and reliable estimators for this study. Future analyses will focus on the F.E. estimator because we have established that they perform better than the other specifications.

Behavior of explanatory variables

Most of the variables included as independent variables in the crime equations behaved according to expectation, i.e. are in line with economic theory and findings from previous literature. Below is a summary of the results for the fixed-effects year-dummy variable specifications, supplemented with different specifications of the time variable where appropriate.

The age variable (percentage of males between 15-24 years of age) is mostly positive and significant for the fixed-effects specifications. All F.E specifications find a significant positive effect on thefts and burglaries but the trend models also pick up significant positive effects for rape and robberies. This study therefore concludes that males between the ages of 15-24 have a significant effect on the rates certain violent and property-related types of crime.

The results of this study largely confirms a negative and significant relationship between the gender variable (proportion of the population that are female) and crime rates in South Africa. All the fixed-effects trend models and some year dummy variable models pick up highly significant negative coefficients for violent crimes (assaults), robberies, thefts and burglaries.

This study finds that unemployment rates are mostly positively related to crime rates. The fixed-effects estimates are very consistent and positive except for two types of crime (culpable homicide and DUI have negative but insignificant coefficients). All three fixed-effects specifications find a significant positive relationship between unemployment and business burglary.

The race variable (proportion of the population that is black) finds positive effects for all types of crime excluding drug related crime and DUI in some F.E specifications. The coefficients on the race variables are positive and most significant for violent crimes such as assaults and property related crimes such as thefts, robberies and burglaries.

The Gini coefficient (income inequality measure) found that the all fixed-effects estimates are mostly insignificant but are positive and significant for all rates of aggravated robbery. This study therefore concludes that although most types of crime show insignificant effects from income inequality, there is evidence that aggravated robbery rises significantly with income inequality.

This study finds that the HDI (human development index) produces ambiguous results. The fixed-effects estimates find significant coefficients for assaults and commercial crime (they generally drop with increases in the HDI), while thefts and burglaries rise with the HDI.

This study finds mixed results for the income per capita variable. The fixed-effects trend models yield positive estimates of the income variable but are mostly insignificant, while the YDVM is significant for rape, attempted murder, assault 1, public violence, DUI and thefts and burglaries. The fixed-effects specifications find a positive (although weak) relationship between certain crime and income per capita. This finding challenges the

expectations of the economic model of crime but could be highly related to the impact of urbanization in South Africa, which is accompanied by rising incomes and crime rates.

This study finds that for most crime types the education variable behaves according to economic theory i.e. are negatively related to education. We find that violent crimes (rape, assaults and public violence) in particular have a significant negative relationship to increases in the average years of education.

The coefficients on the urbanization variable (degree of urbanization) are positive in the fixed-effects specifications and most significant for the YDVM. The sign and levels of significance of this variable indicate that the degree of urbanization is highly significant predictor of crime rates in South Africa.

This study expected to find a negative relationship between law enforcement expenditure per capita and crime rates in South Africa. We find that the law enforcement variable (police expenditure per capita) is generally negatively related to crime for the fixed-effects specifications. This variable is found to be the least significant explanatory variable and consistent evidence of a negative statistically significant relationship is only found for two crime rates (business burglaries and illegal possession of firearms) across the fixed-effects specifications.

Secondary Hypotheses (1):

I find a positive relationship between HIV prevalence and certain crime types (theft out of motor vehicle, commercial crime Common robbery, residential burglary and business burglary). One of the potential mechanisms through which we expect HIV prevalence to increase crime rates is the effect of HIV/AIDS on life-expectancy, i.e. HIV/AIDS decreases the present value costs of punishment of those infected (due to decreased life-expectancy). Therefore the monetary incentives of these crimes coupled with being relative non-violent provide a good rationale for the positive effects found for these types of crimes.

The objective of this hypothesis is to ascertain whether HIV prevalence affects/increases other risky behaviors that people with shorter life-expectancies may be subject to. This will serve as an indicator of whether HIV positive people tend to discount the future and engage in more risky behavior. To test whether HIV prevalence has an effect on other types of risky behavior, I analyze the impact of HIV prevalence on driving while under the influence of alcohol or drugs (DUI) and drug related crime. We cannot directly measure whether HIV infected people tend to discount the future and engage in risky behaviors but we can test for an impact of HIV prevalence on these types of crime (DUI and drug related crime).

The results of HIV prevalence on DUI and DR in South Africa are captured in Table 4. We find that for DUI, the results are statistically insignificant for all F.E. specifications. This could be expected due to low vehicle ownership in high HIV prevalence areas which may be rural in nature. The results for drug related crime (DR) however find that the relationship between HIV prevalence and drug related crime is significant in the $YDVM_{FE}$ estimates.

Table 4: Comparison of the AIDS coefficient between OLS and F.E. Crime specifications for Drug Related Crime (DR) and Driving While under the Influence (DUI)

	OLS			FE		
Type of Crime	Year Dummy Model	General Trend Model	Provincial Trend Model	Year Dummy Model	General Trend Model	Provincial Trend Model
(1)	(2)	(3)	(4)	(5)	(6)	(7)
DUI	-0.2047	-0.1339	-0.1253	0.1360	0.2036	0.0684
	(0.1479)	(0.1410)	(0.1280)	(0.1683)	(0.1603)	(0.1555)
Drug Related Crime	0.3177**	0.1280	-0.1772	0.1855*	-0.0527	-0.1388
	(0.1125)	(0.1345)	(0.1299)	(0.1089)	(0.1125)	(0.1022)

Notes: * indicates significance at 10% (p<0.1), ** indicates significance at 5% (p<0.05), *** indicates significance at 1% (p<0.01). Standard errors are reported in brackets using the robust method described by White (1980), clustered by province. This model includes fixed year effects and is population weighted. All variables have been transformed into logarithmic values. Source: Author's calculations from panel created from SAPS Crime Bulletin 2004 (crime data 1994 to 2003), Antenatal Survey data (1994 to 2003), various OHS, LFS and IES datasets (1994-2003) and Intergovernmental Fiscal Reviews (1995-2003).

The results obtained above provide evidence that HIV prevalence has a significant effect on drug related crime (DR). The year dummy variable model (YDVM) for all F.E specifications find positive coefficients on HIV prevalence for drug related crime. We find that in the YDVM a 1% change in the HIV prevalence rate results in a 0.18% change (increase) in the rate drug related crime for the F.E specification. The increase in the HIV prevalence rate of 268.56% between 1994 and 2003 implies that the rate of drug related crime increased by 48.34% for this period.

This provides evidence that those infected with HIV do engage in other risky behaviors such drug related crime. Taking the above into consideration, we cannot reject the null hypothesis and conclude that HIV prevalence has a significant effect on other types of risky illegal behavior.

Statement of secondary hypotheses (2):

Increases in the prevalence of HIV will crowd-out government spending on other programs, which will increase crime rates in States/Provinces.

Do increases in HIV prevalence cause government to divert funds away from programs or agencies that could reduce crime toward those which focus on HIV/AIDS? Table 20 captures the results of the impact of HIV prevalence on government expenditure in South Africa. I find that for all models, HIV prevalence has a mostly negative or insignificant impact on total government, health services and education expenditure across the OLS and F.E. specifications. The I.V. estimates are found to be insignificant predictors of the effect of HIV prevalence on all types of government expenditure. The results obtained for the impact of HIV prevalence on law enforcement expenditure are mostly positive and statistically insignificant for the OLS and F.E. specifications.

Table 20: Comparison of AIDS coefficients across specifications (OLS, I.V. and F.E.) for Government Expenditure Model

Type of	HIV Prevalence (HIVP)		
Expenditure	OLS	IV	FE
(1)	(2)	(3)	(4)
YEAR DUMMY MODEL			
Total Government Expenditure	**-0.0722*** **	0.0668	**-0.2413** **
	(0.0100)	(0.6170)	(0.1189)
Health Services Expenditure	**-0.1632*** **	0.1934	**-0.1225** **
	(0.0449)	(1.8556)	(0.0560)
Law Enforcement Expenditure	0.1477	-17.1965	0.6245
	(0.4328)	(73.7314)	(1.3083)
Education Expenditure	**-0.0662*** **	-0.5348	**-0.1572*** **
	(0.0177)	(1.9911)	(0.0575)
GENERAL TIME TREND MODEL			
Total Government Expenditure	**-0.0779*** **	-0.1605	**-0.2259*** **
	(0.0223)	(0.5325)	(0.0660)
Health Services Expenditure	**-0.1579*** **	0.0018	-0.0859
	(0.0466)	(1.0459)	(0.0705)
Law Enforcement Expenditure	0.1237	-16.0105	0.1899
	(0.4385)	(53.5646)	(1.0434)
Education Expenditure	**-0.0665*** **	-0.6588	-0.1460
	(0.0194)	(1.9505)	(0.0683)
PROVINCIAL TIME TREND MODEL			
Total Government Expenditure	**-0.1494** **	-1.0763	-0.1657
	(0.0528)	(8.2250)	(0.1384)
Health Services Expenditure	**-0.1515*** **	-0.2467	-0.0280
	(0.0440)	(1.5712)	(0.0867)
Law Enforcement Expenditure	0.4221	-46.5129	-0.2746
	(0.4301)	(440.1848)	(0.2673)
Education Expenditure	**-0.1259** **	-1.8530	-0.1038
	(0.0377)	(15.5024)	(0.0961)

Notes: * indicates significance at 10% (p<0.1), ** indicates significance at 5% (p<0.05), *** indicates significance at 1% (p<0.01). Standard errors are reported in brackets using the robust method described by White (1980), clustered by province. This model includes fixed year effects and is population weighted. All variables have been transformed into logarithmic values. Source: Author's calculations from panel created from SAPS Crime Bulletin 2004 (crime data 1994 to 2003), Antenatal Survey data (1994 to 2003), various OHS, LFS and IES datasets (1994-2003) and Intergovernmental Fiscal Reviews (1995-2003).

The results obtained above for the government expenditure regressions indicate that there is no evidence that increases in HIV prevalence in provinces results in increased spending for health and education agencies and reduced spending for law enforcement/police. The opposite is actually true. I find that the coefficients on HIV

prevalence for the education and health equations are negative and significant in many of the specifications, implying that when HIV prevalence is high, spending on health and education is low. The regressions also find the relationship between HIV prevalence and law enforcement spending to be evenly split (positive/negative) and always insignificant, indicating that when HIV prevalence is high, expenditure on law enforcement/police services are not lower.

We therefore reject the null hypothesis and conclude that HIV prevalence does not result in increases in government expenditure on health and education which in turn reduce (crowd-out) spending on law enforcement. This implies that increases in HIV prevalence does not crowd-out spending on other programs in South Africa for the study period considered.

It should however be noted that the in the future this could become a significant driving mechanism of the epidemic. The crowding out of other government expenditure because more funds are diverted to AIDS programs may be borne out over the next decade because the newly implemented antiretroviral treatment programs which are being phased in the medium term will consume larger proportions of available public funds. This would imply that trade-offs will have to be made between the prioritization of AIDS expenditure and other government services. Therefore, future research on the mechanisms driving the relationship between HIV/AIDS may bear new in insight into this causal relationship.

6. Discussion of Results

Theft out of motor vehicles, business burglaries and common robberies could be considered monetary or property related types of crime because there is a monetary incentive to commit these types of crime. According to the economic model/theory of crime, criminals may decide to commit these crimes based on a cost-benefit decision. This study finds strong evidence that for these monetary crimes, the relationship with HIV prevalence is positive.

Secondary hypotheses 2 (crowding-out effect of government expenditure by HIV prevalence) found mostly insignificant results and cannot be considered to be a good explanation for what causes the direction of the relationship between crime rates and HIV prevalence in South Africa for the given study period.

Change in crime rates explained by HIV/AIDS

Table 5 presents the percentage change in crime rates explained by HIV/AIDS. The change in crime rates explained by HIV/AIDS is calculated as the following ratio: [The predicted change in crime rates/the actual change in crime rates caused by HIV prevalence (between 1994 and 2003)] * 100.

The predicted change in crime rates caused by HIV prevalence is derived from the regression results (I use the fixed-effects year dummy variable specification for common robbery, residential burglary, business burglary and theft out of motor vehicles, and the general time trend specification for commercial crime) taking into account the growth rate of HIV prevalence for the given period. The actual change in crime rates is calculated from the 2004 SAPS crime statistics bulletin.

Table 5: Change in crime rates explained by HIV/AIDS

Type of Crime	Predicted change in crime rate caused by HIV 1994 to 2003	Actual change in crime rate between 1994 to 2003	Ratio of actual change to predicted change 1994 to 2003
(1)	(2)	(3)	(4)
Common robbery	35.96	192.57	18.67
Residential burglary	19.50	29.36	66.40
Business burglary	24.71	-26.22	-94.22
Theft out of motor vehicle	75.84	-6.21	-1221.50
Commercial crime*	31.13	-11.40	-273.09

Notes: Commercial crime* is calculated using the fixed-effects general time trend estimates. All other crime types utilize the fixed-effects year-dummy variable estimates. Author's calculations based on regression results and 2004 SAPS crime bulletin.

The percentage of change in crime rates explained by HIV/AIDS for select significant crime types indicate that the percentage change in common robbery and residential burglary explained by HIV/AIDS is 18.67% and 66.40% respectively between 1994 and 2003. The percentage of crime caused by HIV/AIDS for common robbery (18.67%) for the given period translates to 130,904 common robberies that can be explained by rising HIV prevalence. I find that although the predicted change in these crime rates caused by HIV/AIDS increases by 24.71%, 75.84% and 31.13% for business burglary, theft out of motor vehicle and commercial crime respectively, the actual crime rates for these crime types have gradually declined between 1994 and 2003. This suggests that these crime rates would have fallen more in the absence of HIV/AIDS. The percentage change (decrease) in these crime rates explained by HIV/AIDS however represents 94.22%, 1221.50% and 273.09% for business burglary, theft out of motor vehicle and commercial crime respectively.

The above findings indicate that HIV/AIDS does explain a significant percentage of the change in crime rates in South Africa between 1994 and 2003. These findings are largest for common robbery (18.67%), which supports the hypothesis that those infected with HIV/AIDS are more likely discount the present value costs of incarceration/punishment and engage in risky illegal behaviors. Future empirical work could extend this analysis to provincial level comparisons and analysis.

Magnitude of rising property crime resulting from increased HIV prevalence

The above discussion of the change in crime rates arising from increased HIV prevalence has important financial implications for South Africa. Measuring the appropriate costs are however difficult because the costs of property related crimes may not be limited to financial/monetary costs. Indirect costs arising from a car hijacking could include time spent in court, costs associated with the lack of mobility, costs related to rising insurance premiums and also intangible psychological costs. Calculating monetary losses are also difficult due to many different sub-categories of crime being aggregated into the main crime categories issued by the South Africa Police Services, making the calculation of average values of crime types problematic.

One way to get an idea of the magnitude of the impact of HIV/AIDS on property crime is to estimate the number of these crimes for future periods. I estimate the number of property related crimes committed in South Africa based on the elasticities of the HIV/AIDS coefficients generated by the regressions (fixed-effects year dummy variable specification for common robbery, residential burglary, business burglary and theft out of motor vehicles, and the general time trend specification for commercial crime) in this study, assuming that HIV prevalence continues to grow at the same rate as that of the study period. Column 4 in table 6 presents the predicted number of property related crimes that will be caused by rising HIV prevalence in 2004. I find that HIV/AIDS will cause thefts out of motor vehicles to rise by 48, 568 cases in 2004 assuming that HIV prevalence grows at the same rate over the next year.

Limited information and data on monetary costs associated with property related crimes makes it difficult to estimate the monetary value of the additional costs resulting from rising HIV/AIDS. Future empirical work could estimate the average costs of the various types of property crimes in order to estimate the monetary loss to South Africa arising from increased property crime caused by rising HIV/AIDS.

Table 6: Predicted number of crimes resulting form rising HIV

Type of Crime	HIV/AIDS Coefficient (elasticity)	Number of crime in 2003	Number of crime caused by HIV/AIDS in 2004
(1)	(2)	(3)	(4)
Common robbery	0.1339	95551	12794
Residential burglary	0.0726	299290	21728
Business burglary	0.0920	64629	5946
Theft out of motor vehicle	0.2824	171982	48568
Commercial crime*	0.1159	55869	6475

Notes: Commercial crime* is calculated using the fixed-effects general time trend estimates. All other crime types utilize the fixed-effects year-dummy variable estimates. Author's calculations based on regression results and 2004 SAPS crime bulletin.

6. Conclusions

This study finds strong evidence of a significant positive relationship between HIV prevalence and some types of monetary/property related crime. These results are most significant for the fixed-effects year-dummy variable model, which show that a 1% change in the HIV prevalence rate results in a 0.28% increase in the rate of thefts out of motor vehicles, 0.073% increase in residential burglaries and 0.13% increase in common robberies. We tested some of the potential behavioral mechanisms that may be driving this causal relationship and found evidence that HIV infected people may engage in more risky behaviors such as drug related types of crime. This finding of a positive relationship between monetary/property-related types of crime and HIV prevalence could indicate that those infected with HIV may consider the benefits of crime to outweigh the associated costs which could result in an increase in the amount of crime committed in South Africa. No evidence could be found that HIV/AIDS crowds-out other government spending.

This study also finds evidence of a negative relationship between HIV prevalence and some types of violent crime in South Africa (assault, rape, public violence and culpable homicide). However the evidence for this negative relationship is weak. The coefficients on the HIV prevalence for these crime types are significant in only one out of three specifications of the crime equations.

The findings of this study illustrate that policy makers must take cognizance of the positive relationship between monetary/property related crime and HIV prevalence with regard to:

- The inclusion of AIDS as a significant factor in the planning and co-ordination of all crime prevention programs.
- Development of policies which decrease the incidence of HIV/AIDS, or increase the life expectancy of those with HIV/AIDS, which will in turn also contribute to reducing some types of property-related crimes
- Targeting additional resource allocations towards property related types of crime.
- Developing programs which will serve multiple purposes, i.e. programs such as AIDS awareness interventions which will decrease the spread of the disease but could also decrease levels of crime (due to the causal relationship between HIV prevalence and crime).

An important policy implication arising from this study is that HIV prevalence and crime cannot be treated in isolation from each other, within the complex socio-demographic context in South Africa. Policy makers should therefore take cognizance of the findings of this study and use it to inform future planning, budgeting and implementation strategies. This study recommends joint planning and execution of programs aimed at reducing HIV prevalence and crime rates in South Africa due to the causal relationship found in this study. Intersectoral policy interventions will more efficiently target resources and reduce the duplication of funding between programs and agencies. This study provides significant insight into the relationship between HIV prevalence and crime rates in South Africa but is limited by the availability of detailed representative data on crime and HIV prevalence at regional and lower levels. Future studies incorporating additional years of data (longer panels) and detailed data/information on other important policy variables such as the influence of AIDS orphans, migration, religion, and youth crimes will help better understand the relationship between AIDS and crime in South Africa.

Appendix 1: Relevance of Instruments for Crime Models

Instruments	Coefficient of IV		
	YEAR DUMMY	GENERAL TREND	PROV TREND
(1)	(2)	(3)	(4)
Condom Distribution	-0.1078	-0.1152	-0.0323
Lagged Condom Distribution	0.2253	0.2263*	0.1753**
Primary Health Care (District health services)	0.2071	0.1539	0.2013
Lagged Education Expenditure	-0.3219*	-0.2963*	-0.4591*

Notes: * indicates significance at 10% (p<0.1), ** indicates significance at 5% (p<0.05), *** indicates significance at 1% (p<0.01). Standard errors are reported in brackets using the robust method described by White (1980), clustered by province. Columns (2-4) indicate whether the coefficients on the Instrumental Variables (I.V.) are statistically significant across models (Year Dummy Variable Model [YDVM], General Time Trend Model [GTTM] and Provincial time trend plus General time trend Model [PTTM]). These models include fixed year effects and are population weighted. All variables have been transformed into logarithmic values. Source: Author's calculations from panel created from SAPS Crime Bulletin 2004 (crime data 1994 to 2003), Antenatal Survey data (1994 to 2003), various OHS, LFS and IES datasets (1994-2003) and Intergovernmental Fiscal Reviews (1995-2003).

Appendix 2: Test of over-identifying restrictions: Sargan N*R-sq test

Type of Crime	YDVM		GTTM		PTTM	
	chi-sq (1)	p-value	chi-sq (1)	p-value	chi-sq (1)	p-value
Total Crime	1.83	0.18	0.01	0.93	0.01	0.93
Murder	3.24	0.07	5.60	0.02	0.88	0.35
Rape	4.68	0.03	2.09	0.15	2.30	0.13
Attempted Murder	0.00	0.96	0.91	0.34	1.16	0.28
Assault1	0.19	0.66	0.65	0.42	1.47	0.23
Assault2	5.66	0.02	1.33	0.25	0.09	0.76
Assault3	1.36	0.24	0.55	0.46	2.44	0.12
Aggravated Robbery	0.01	0.94	4.08	0.04	2.09	0.15
Common Robbery	0.06	0.81	0.40	0.53	0.48	0.49
Culpable Homicide	10.83	0.00	2.60	0.11	5.55	0.02
Public Violence	1.67	0.20	0.90	0.34	0.43	0.51
Residential Burglary	3.32	0.07	0.17	0.68	0.30	0.58
Business Burglary	11.66	0.00	7.73	0.01	7.40	0.01
Theft of Motor Vehicle	0.27	0.60	0.77	0.38	0.20	0.65
Theft out of Motor Vehicle	1.10	0.29	0.21	0.65	0.11	0.74
Stock Theft	4.48	0.03	1.33	0.25	1.42	0.23
Illegal Possession of Firearms	0.09	0.76	1.03	0.31	0.11	0.74
Drug Related Crime	1.39	0.24	0.44	0.51	1.67	0.20
DUI	3.59	0.06	2.03	0.15	0.14	0.71
Commercial Crime	0.16	0.69	0.16	0.69	0.44	0.51
Shop Lifting	4.47	0.03	6.49	0.01	1.25	0.26

Source: Author's calculations from Panel created from SAPS Crime Bullettin 2004 (Crime data for 1994 to 2003), Various OHS, IES, LFS datasets between 1994 and 2003.

Appendix 3: Endogeneity Tests for Crime Specifications

TYPE OF CRIME (Dependent Variable)	HIV PREVALENCE RESIDUALS		
	YEAR DUMMY	GENERAL TREND	PROVINCIAL TREND
(1)	(2)	(3)	(4)
Total Crime	0.1914	-0.0366	-0.0969
Murder	-0.6573	-0.9258**	-0.6844
Rape	0.2699	0.1057	0.0708
Attempted murder	-0.4148	-0.7815*	-0.2092
Assault1	0.2032	0.2392	0.2744
Assault2	.7369***	0.4861	0.3102
Assault3	0.0996	-0.3021	0.6731
Aggravated Robbery	-0.9222	-1.4294**	-1.1913
Common Robbery	-0.3178	-0.4472	-0.7123
Culpable Homicide	0.3719	0.0124	0.3193
Public Violence	-0.0954	-0.0662	-0.4573
Residential Burglary	0.1942	0.0039	-0.0083
Business Burglary	0.5815***	0.4476	0.3512
Theft of Motor Vehicle	-0.5707	-1.0216*	-0.6110
Theft out of Motor Vehicle	0.3726	-0.2699	-0.0771
Stock Theft	0.9779*	0.9552**	1.3566*
Illegal Possession of Firearms	-0.3134	-0.7484	-0.3503
Drug Related Crime	0.2307	-0.2010	0.9236
DUI	-0.6198	-0.5119	0.0689
Commercial Crime	-0.2097	-0.4308	-0.1372
Shop Lifting	-0.1248	-0.3263	0.2923

Notes: * indicates significance at 10% (p<0.1), ** indicates significance at 5% (p<0.05), *** indicates significance at 1% (p<0.01). Standard errors are reported in brackets using the robust method described by White (1980), clustered by province. Columns (2-4) indicates whether the coefficient on the residual of the AIDS variable (lnhiv_res) is statistically significant. These models include fixed year effects and are population weighted. All variables have been transformed into logarithmic values. Source: Author's calculations from panel created from SAPS Crime Bulletin 2004 (crime data 1994 to 2003), Antenatal Survey data (1994 to 2003), various OHS, LFS and IES datasets (1994-2003) and Intergovernmental Fiscal Reviews (1995-2003).

Appendix 4: Unobservables causing a negative cross-sectional relationship between crime rates and HIV prevalence between provinces

I find that, on average, the coefficients on HIV prevalence for many crime types for the fixed-effects specification are higher (less negative or more positive) than those of the OLS specification. This implies that in the cross-section, provinces with low crime rates have high HIV prevalence. Table 7 presents the average crime rates and HIV prevalence for three provinces and the regional variation within and between provinces. Mpumalanga (MP) and the North West (NW) are rural provinces, while the Western Cape (WC) is more urban. The last two rows of Table 7 indicate that the two rural provinces have high levels of HIV prevalence but low crime rates, while the more urban province (Western Cape) has low levels of HIV prevalence but high rates of crime. This pattern is also consistent within provinces.

Table 7: Provincial and Regional HIV and Crime rates for the year 2000

	Mpumalanga			North West				Western Cape		
	East High Veld	High Veld	Low Veld	Rusten-burg	Klerks-dorp	Mafi-keng	Vry-burg	Cape metro	South Cape	Bo-land
Murder	294	371	308	76	20	6	9	1110	380	853
Rape	1006	1412	1138	169	81	72	98	1764	927	1988
Attempted Murder	512	641	519	99	41	18	21	1602	279	640
Assault 1	5987	7441	6657	772	427	376	778	7217	6275	12974
Assault 2	4380	4205	3498	1652	873	379	384	11104	7424	16065
Aggravated Robbery	1263	2482	1580	372	100	121	45	5889	399	733
Common Robbery	1384	1387	1065	515	396	154	138	6998	877	1673
Assault 3	85	82	65	29	33	5	18	630	224	494
Kidnapping	68	112	56	16	3	1	3	192	34	97
Abduction	66	55	58	8	9	6	13	226	27	107
Child Abuse	34	105	18	5	2	2	1	120	153	205
Culpable Homicide	315	365	265	54	32	12	25	307	183	480
Public violence	12	24	24	8	1	0	2	105	35	48
Arson	176	165	184	30	15	25	12	268	152	275
Malicious property damage	2735	3201	2125	702	546	149	228	7927	3168	7327
Crimen Injuria	796	1028	740	396	247	79	144	2440	1590	3637
Residential Burglary	7513	7480	6261	1646	836	381	499	16765	5565	13301
Business Burglary	2260	2158	1983	476	428	132	243	4465	2152	5488
Theft of Motor Vehicle	1428	1443	1143	842	401	50	40	6005	350	1032
Theft out of motor vehicle	3468	3114	3312	1615	1130	214	416	24784	2451	7271
Stock Theft	2976	1225	188	77	68	54	123	45	801	1022
Illegal possession of firearms	228	346	285	31	17	12	11	974	100	273
Drug Related Crime	723	455	615	166	272	40	41	4534	1405	4024
DUI	728	534	444	105	147	30	15	1427	720	1383
All other thefts	11068	15291	12726	5595	3093	585	1155	32740	9843	19981
Commercial Crime	979	1024	959	409	361	198	95	3628	801	1543
Shoplifting	1210	1600	1800	604	403	142	151	4215	1444	2782
Mean crime rate	**1915**	**2139**	**1778**	**610**	**370**	**120**	**174**	**5462**	**1769**	**3915**
Mean HIV prevalence	**36**	**20.7**	**35.2**	**27.3**	**28.4**	**24.4**	**17.1**	**8.8**	**10.5**	**6.2**

Source: Author's calculations from SAPS Crime Bulletin 2004 (crime data for 2000) and 2000 Antenatal HIV Seroprevalence Survey data.

The degree of urbanization variable was found to have a significant positive relationship in our panel data analysis. Table 7 illustrates that in some provinces for the year 2000, we can expect to find a negative relationship between HIV prevalence and crime rates depending on the degree of urbanization. This indicates that there is evidence of more crime and less HIV prevalence in urban provinces such as the Western Cape, while in some rural provinces such as Mpumalanga and North West, there is more HIV prevalence and less

crime. Therefore, the degree of urbanization is one such variable that is different by province and does not change drastically over time.

Another variable that has come to the attention of the media in South Africa is the impact of culture on HIV prevalence. Cultural practices such as female circumcisions in rural areas using unsafe unsterile methods have been shown to contribute to the spread of AIDS in South Africa (Brady, 1999). Other taboo practices such as the rape of babies and sleeping with virgins to cure the disease have also been reported by several media sources (Bowley and Pitcher, 2002). These practices are predominantly found in rural communities and provinces and are often not reported to the police. Data or statistics for such practices are not available in South Africa. Table 7 shows that rural provinces have lower total crime rates than urban provinces. Our finding of high HIV prevalence in some rural provinces but low crime rates in these provinces could be driven by some of the cultural practices mentioned above.

Racial composition between provinces is another variable that does not change significantly over time in our panel dataset. Table's 8A-C presents the racial distribution of people between provinces for the year 2001. We find that for our rural provinces (Mpumalanga and North West), the percentage of blacks is above 90%, while in the urban province (Western Cape), blacks comprise approximately 28% of the provincial population in 2001. It is therefore evident that there is a distinct concentration of race groups between provinces in South Africa.

Table 8A: Racial and Urban distribution for EC, FS and GP

Race	Eastern Cape			Free State			Gauteng		
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	*Total*
% Black African	31.73	53.87	*85.60*	64.33	23.05	*87.39*	70.81	3.16	*73.97*
% Colored	7.28	1.07	*8.36*	2.54	0.56	*3.10*	3.59	0.04	*3.63*
% Indian/Asian	0.35	0.01	*0.36*	0.14	0.01	*0.15*	2.51	0.01	*2.52*
% White	5.10	0.58	*5.69*	8.07	1.30	*9.37*	19.27	0.61	*19.88*

Notes: Author's calculations from census 2001 person weighted data.

Table 8B: Racial and Urban distribution for KZN, LP and MP

Race	KwaZulu-Natal			Lim-popo			Mpuma-langa		
	Urban	Rural	*Total*	Urban	Rural	*Total*	Urban	Rural	*Total*
% Black African	34.04	48.51	*82.55*	9.97	86.64	*96.61*	35.31	56.08	*91.39*
% Colored	1.55	0.09	*1.64*	0.12	0.10	*0.22*	0.60	0.15	*0.75*
% Indian/Asian	9.74	0.27	*10.01*	0.18	0.03	*0.20*	0.37	0.03	*0.40*
% White	5.40	0.40	*5.80*	2.02	0.94	*2.96*	6.20	1.26	*7.45*

Notes: Author's calculations from census 2001 person weighted data.

Table 8C: Racial and Urban distribution for NC, NW and WC

Race	Northern Cape			North West			Western Cape		
	Urban	Rural	*Total*	Urban	Rural	*Total*	Urban	Rural	*Total*
% Black African	29.03	7.86	*36.90*	35.83	55.12	*90.95*	26.10	1.67	*27.76*
% Colored	39.99	9.69	*49.68*	1.23	0.35	*1.58*	45.20	7.12	*52.32*
% Indian/Asian	0.28	0.01	*0.29*	0.26	0.03	*0.29*	1.01	0.01	*1.02*
% White	10.15	2.99	*13.14*	5.73	1.44	*7.18*	17.56	1.33	*18.89*

Notes: Author's calculations from census 2001 person weighted data.

South Africa has a diverse socio-demographic composition. Different provinces display varying rates of economic convergence/growth, cultural practices and levels of equitable service delivery. Therefore, our OLS specifications may not be able to control for many of these missing/omitted variables. This study therefore uses the fixed-effects specifications to control for province-specific, time-invariant unobservable influences on crime rates.

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