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# ARSON MEASUREMENT, ANALYSIS, AND PREVENTION

## Executive Summary

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Arson, the crime of intentionally setting fire to property, has long been a major problem in the United States. In fact, with the exception of burglary, no other crime accounts for more direct property loss than arson. According to the National Fire Protection Association (NFPA) (see Hall, 1990), in 1989 the direct property loss from fires of incendiary or suspicious origin was 1.7 billion dollars nationally. Not included in this figure, moreover, are indirect losses (e.g., cost of relocation, loss of tax revenue, escalation of insurance premiums) which constitute an estimated four dollars for every one dollar of reported direct fire loss (Insurance Bureau of Canada, 1981).

Even more tragic than the economic loss is the major threat to human life that this crime represents. The NFPA also reported that in 1989, 615 civilians died as a result of arson fires (Hall, 1990). Added to this, of course, are the physical injuries and psychological scars suffered by victims of this crime.

Over time, the growth of arson has been staggering, at least until the most recent years. From 1955 to 1975, the incidence of reported arson rose 1,500%; and from 1975 to 1981, it rose an additional 250%. Also, whereas in 1964 arson represented only 3% of fire losses, by 1981 it represented as much as 40% of losses due to fire (Karter, 1982).

In the 1980s, the incidence of arson declined somewhat. For example, from 1981 to 1989, the estimated number of incendiary or suspicious structural fires nationally dropped precipitously, from 154,500 to 97,000 (Hall, 1990). In part, this downward trend may be due to the successful efforts of community activists who have forced policy-makers to prioritize the arson problem. Additionally, improvements in the economy during the 1980s may also have contributed to the reduction in the incidence of arson. Finally, the downturn in arson, may be partially related to changes in the age structure of the U.S. population. Adolescents are particularly prone to setting deliberate fires; in fact, half the arrests for arson in this country involve persons under the age of 20 (FBI, 1990). The decline in the size of this age group during the 1980s would have logically produced a reduction in the number of arson incidents.

Unfortunately, this trend may also be short-lived. Expected resurgence in the relative size of this age group in the 1990s, the so-called "baby-boomerang effect" for the offspring of the original post-Word War II baby-boomers, may mean more crime, arson being one of them. Moreover, the economic recession that appears to be overtaking the nation is an ominous indicator of trouble in the years ahead.

A large volume of literature has been devoted to the topic of arson, growing as rapidly as the crime itself. Most that has been written, however, concerns the technical aspects of arson investigation, the psychological dynamics of pyromania, or even the economic aspects of this crime (e.g., see New York State Academy of Fire Science, n.d.). There are only a handful of quantitative studies that have focused on arson rates and their correlates (e.g., Karter and Donner, 1977, 1978; Institute for Puget Sound Needs, 1976; Shaenman et. al., 1977; Gunther, 1981; Bennett et al., 1987; and Pettiway, 1985a, 1985b, 1988) .

The small literature on fire and arson correlates is quite varied in scope (from single-city analyses to multi-city analysis), in unit of analysis (from city-wide rates to block group rates), in complexity (from two variable models to models encompassing dozens of correlates), in technical approach (from simple correlation to analyses of clusters), in methodological soundness (from straight-forward data analysis to adjustments for skewness), and in arson measurement (from population and housing based rates to indirect measures). Despite this diversity, researchers appear to reach similar conclusions about environmental, housing and demographic correlates of arson. Chiefly, the literature shows that indices of poverty, family dissolution, housing quality and building vacancy are consistently correlated with measures of arson incidence.

## Arson Data Sources

The purpose of this project was to replicate the statistical work of Karter, Pettiway, and others, while advancing the level of technical soundness. Regardless of technique, of course, the most fundamental issue in relation to the quality of results involves the data source itself. It is probable that the primary reason why arson, of all serious crimes, has received the least attention from a quantitative standpoint is because of the severe lack of reliable data on arson incidents.

In 1979, following a congressional mandate, the FBI elevated arson to the status of a Part I or "Index" offense and thus began collecting and disseminating reports of arson incidents (see FBI, 1980). The results of this endeavor, however, have been most disappointing and incomplete. Although nearly a decade has past since arson was made a Part I offense, the coverage still remains relatively poor. In 1989, for example, only 72 percent of agencies provided full reports of arson (FBI, 1990). More important, the pattern of missing agencies is not random.

In addition to the coverage problem is the superficial nature of these data. They are limited to the number of arson incidents, number of clearances for arson offenses, type of structures, and estimated monetary value from arson fire loss. Besides excluding suspicious fires altogether (which will grossly understate the enormity of the crime), these reports lack most of the critical pieces of information necessary to understand the nature of arson. Finally, and most important, UCR data on arson provide only monthly aggregates for entire reporting jurisdictions on all items. A data source to study the nature and correlates of arson would need to be incident-based.

Fortunately, an alternative data resource for studying arson has emerged in recent years. In the late 1970s, the National Fire Data Center was established by the Federal Emergency Management Agency (FEMA) to design a uniform fire reporting system. As this National Fire Incident Reporting System (NFIRS) developed and was experimented with by several states, participating states established a National Association of NFIRS States (see NFIRS News, 1981), and targeted January, 1982 as the start of the uniform, national implementation of this computerized fire data system. Two uniform reporting schedules have been developed: one for fire incidents and one for casualties (both fatalities and injuries to both fire fighters and civilians).

The NFIRS forms solicit a wide variety of data on each fire incident, be it structural (e.g., building), vehicular, or outdoors (e.g., brush and trash fires). Included among the data elements are:

- Time, day, and date
- Location, including zip code and census tract
- Name, address and telephone of owner and of occupant
- Type of situation found (structural fire, vehicular fire, hazardous condition, service call, false alarm, etc.)
- Number of alarms
- Number of injuries and fatalities
- Type of complex (single family or two-family dwelling, apartment, office, or educational complex, etc.)
- Property use (residential, storage, institutional, educational, commercial, industrial, restaurant, etc.)
- Ignition factor (incendiary, suspicious, accidental, natural, undetermined)
- Estimated total dollar loss
- Time from alarm to application of extinguishment agent

Next, the NFIRS Form solicits information on every victim of injury or death due to the fire incident. Included among these data elements are:

- Time, day, date of incident
- Name, address and telephone of victim
- Severity (injury or death)
- Affiliation (fire fighter, emergency personnel, civilian)
- Cause (trapped, overcome by smoke, trampled, etc.)
- Nature of injury (Burns, asphyxia, wound, shock, etc.)

The Massachusetts Fire Incident Reporting System (MFIRS), operational since the beginning of 1982, is managed by the

Massachusetts Department of Public Safety, Division of Fire Prevention. This computerized data base of fire incident and casualty reports completed by fire departments statewide for every fire is based on data collection schedules consistent with the NFIRS, with the notable addition of insurance data--name of carrier, level of insurance, and settlement.

## Data Definition

Two primary data sources were used to assemble the data files on arson and its socio-economic and demographic correlates: a) the 1980 Census of Massachusetts, Summary Count 3A and 3B (STF3A for census tracts and STF3B for zip codes) and b) the Massachusetts Fire Incident Reporting System (MFIRS) tapes for the years, 1983-1985.

The census file was used to construct a wide range of demographic and socio-economic variables for the analysis of arson rates. Census tapes provide data in the form of counts (e.g., counts of persons or of housing units) displayed in cross-tabulations for various sub-classifications. Although straightforward, calculation of rates requires careful matching of counts with their appropriate bases or denominators. In addition, since the records in the census files are hierarchically structured, ceratin census tracts are split across records. For these few instances, count data were aggregated before calculation of rates and summary statistics.

Finally, while the census data are not plagued with missing data (leaving aside the issue of census undercouting), data are suppressed in tables having a base of less than 30 persons or less than 10 housing units, in order to maintain the confidentiality of the data (i.e., for disclosure control). For most of our calculations, suppression was not a problem because the level of aggregation was sufficiently large. However, for some race-specific calculations, counts for non-whites were suppressed. Nevertheless, since race is not a major focus of this research, we were able to avoid much of the complexities that arise from suppression.

Tapes of fire incident data (MFIRS) for the years 1983-85 were obtained from the Office of the State Fire Marshal. The MFIRS file was aggregated by zip code and by census tract in order to obtain counts of both residential and vehicular fire and arson (fires determined incendiary or suspicious in origin). Other types of fire, mostly small ones such as brush fires, were not within the focus of this analysis.

By far the most significant problem faced in this research involved missing information on zip code and census tract on the fire incident reports. Since these are the very codes on which the data were to be aggregated, missing identifiers would render the incident as if the fire had never occurred.

Zip codes were unavailable for only 2395 records, a bit more than 3 percent of the 60,450 structural and vehicular incident reports in the three-year file. However, it was determined that of the 2395 records with missing zip codes, 2035 were from the Boston Fire Department. Thus, while a missing identifier rate of 3% is generally acceptable, the fact that these are not nearly random in distribution would seriously bias the calculated rates. An effort to recover the 2035 missing zip codes from a GBF/DIME file of Boston streets resolved three-quarters of the missing zip codes.

Tracts were unavailable for the majority of records. An attempt to match the records to GBF/DIME files for Massachusetts SMSAs was complicated by the fact that locations were not always entered as regular street addresses. More important, tract codes that were on record were frequently entered incorrectly in the tract field. After laborious matching of missing codes and repair of improperly entered codes, a minimum of 88% of the tracts were resolved for each of the nine largest cities in the state.

As explained below, small jurisdictions (having fewer than 200 residents or 200 cars) and those having no incidents of arson were omitted from the analysis. In the end, three files were used in the analysis. The first file contained data on 592 Massachusetts zip codes of which 306 were retained in the analysis; the second on the 389 census tracts in the nine largest cities of which 289 were analyzed; and finally, the 161 census tracts in the City of Boston of which 129 were retained.

## Methodological Approach

The overall objective of this research was to assess the demographic and socio-economic correlates of residential and vehicular arson rates in Massachusetts. More specifically, we hoped to disentangle the effects of racial composition, poverty, urbanness and other characteristics on the incidence of intentional firesetting.

In contrast to the consistency of substantive results, the existing studies of fire and arson correlates are quite uneven in their degree of methodological sophistication and strength. A variety of technical flaws, some minor and some significant, appear in these studies, specifically:

- failure to utilize appropriate denominators in the calculation of arson rates;

- failure to consider or adjust for irregularities in arson rates;

- failure to weight observations in cross-sectional analyses;

- failure to employ multivariate statistical methods and to correct for ill-conditioned or multi-collinear data.

## Rate Calculation

Perhaps it is due to tradition emanating from the FBI's Uniform Crime Reports or perhaps it is due to the inaccessibility of alternatives bases, many investigators have used population figures to turn arson counts into arson rates. Despite custom, people do not burn, buildings and cars do. Thus, it is clearly more appropriate to cast arson rates in terms of the availability of targets, for example, the number of buildings or housing units for residential arson, and the number of cars for vehicular arson.

The choice between using the number of housing units or the number of buildings in the calculation of residential arson rates is a matter of debate. We felt that, while the stock of housing units may be preferable for calculating fire rates, the count of buildings would be more defensible for arson risk measurement.

## Transformation for Skewness

Early examinations of the arson rate distributions uncovered certain outliers apparently resulting from recording peculiarities. Outliers were trimmed to the 99th percentiles. Additionally, we observed some inflated and unreliable rates calculated for a number smaller areas. Ultimately, these unreliable observations would have insignificant influence on the analytic results because of the population weighting scheme used (see discussion below). Still, we preferred to purge the data sets of these cases. Specifically, only those areas having at least 200 persons and 200 cars were retained for analysis.

Even after trimming the outliers and after eliminating rates considered unreliable due to small bases, a further data problem existed--skewness. As often occurs when examining rates of rare events in heterogenous areas, most observations are low in incidence while a few high-incidence areas severely skew the distribution. As shown in Table ES-1 and Figure ES-1 for the census tract files, both the residential arson rate (RARATE) and the vehicular arson rate (CARATE) are severely skewed. Such skewness, if uncorrected, can dramatically affect the analysis of the rates.

Fortunately, skewness was easy to correct by transforming by logarithms. A log transformation of the arson rates not only eliminated skewness, but even causes the distributions to approach normality in shape.

The log transformation does have its drawbacks. Most important, the log transformation is problematic for areas having zero rates, since the log of zero is undefined. We chose to eliminate cases having zero rates. Not only does it avoid some of the issues noted above, but on a theoretical level, it simply restricts the analysis to areas in which arson is a problem, no matter how small.

Most of the independent census variables considered for the analysis were also skewed (see Table ES-2). Some of the variables are skewed by the "rare event" phenomenon described above. Other variables, those that are percentages, tend to be skewed because of constraints of bounding at zero and one. Apparently, only the percentage measures which are moderate in central tendency are not subject to extensive skewness. LA log transformation was used for these variables as well.

## Weighting Scheme

Statistical methods designed for analyzing variation across micro-units, such as people, cannot necessarily be transferred without modification to aggregates. This is particularly true of analyses of inter-state, inter-city, or inter-tract cross-sectional variation. The more variable are the units in size, the more problematic.

First, geographic units, such as states, zip codes or even census tracts, are not the same size in terms of population. Application of statistical techniques without weighting tacitly and unjustifiably gives equal contribution to all observations regardless of size.

Second, data from smaller units are more variable or less reliable that those from larger units. To avoid heteroscedasticity common with aggregate cross-sections, observations should be weighted inversely proportional to their variance. This is essentially equivalent to a population-based weighting scheme, since the variance is inversely proportional to the number of units that make up the aggregate.

To correct for these concerns, all observations were weighted proportional to their population counts. For example, one well-populated census tract had a weight of 2.87 and thus counted in the analysis as if it were almost three distinct data points, whereas another tract with a .18 weight contributed very little to the overall results. In addition to its intuitive appeal, the weighting scheme effectively discounted unreliable rates from smaller units.

Finally, this approach has the additional advantage of minimizing the problem of missing and suppressed data. Undefined log-transformation for zero arson rates and Census Bureau suppression of potentially revealing information are problematic only for smaller or sparsely-populated areas. Had these observations not been eliminated because of data limitations, they would be greatly minimized in their importance after weighting the data.

Multicollinearity

Across all these data files, most of the socio-economic variables possessed moderate to strong associations with the arson measures, particularly measures of income and poverty, population and housing density, and housing type and occupancy. The two demographic variables, percent black and percent male and aged 10-19, were relatively weak and inconsistent in their association with the arson rates.

Obviously, arson correlates should be considered in combination, rather than individually. That is, it is likely that a good deal of overlap exists among the variables in their explanatory potentials.

In all the analyses we were interested in the partial effects of various components of the socio-economic and demographic profile to be determined through a multiple regression approach. Unfortunately, multicollinearity among the census variables was substantial.

As an alternative, we employed a factor analytic approach to extract from the socio-economic profiles the most prominent underlying dimensions. Next, factor scores on the major dimensions were generated for use as regressors in place of the large mix of census variables.

Thirteen socio-economic and housing variables were factor analyzed to extract the more prominent dimensions to the profile. As is customary, factors with eigenvalues greater than one were retained. By this criterion, retained factors were those which contributed more than their share to the total variance represented by the thirteen observable variables. Overall, the three factors account for three-quarters or more of the total variance withing each data set.

Tables ES-3 shows the factor matrix after rigid orthogonal rotation (Varimax) for the census tract data file. This rotation is designed to produce a so-called "simple structure" in that, to the extent possible, observable variables load strongly on only one underlying dimension or factor.

The first factor, labeled "Urbanness," has strong loadings for population and housing density (ZDENS1 and ZDENS2), on housing tenure (ZPTEN75), and percent rental units (PCTRENTU), and moderately on certain economic measures involving income. The second factor, labeled "Poverty," has high positive loadings for the unemployment rate (ZUR), percent of persons below the poverty line (ZPTPOVL), percent of one parent families (ZPTFAM1P), percent of units with more than one person per room (ZPGT1PRM), and percent of vacant housing units (ZPCTVAC), as well as a strong negative loading on the median income (ZMDNINC). The final factor, labeled "Housing Quality," has strong loadings for percent of housing units without complete pluming and percent without complete bath facilities (ZPCTNPLG and ZPCTNBAT) and modestly on the percent of without complete kitchen (ZPCTNKIT).

In addition to the fairly good level of fit, as measured by the cumulative percent of variance explained, most of the observable variables, with the exception of ZPCTNKIT, have reasonably high communalities. That is, for the most part, the three factors adequately substitute for the thirteen separate census variables.

## Regression Results

For all three data files, the rates of residential and vehicular arson were regressed on the three factors along with the two demographic control variables, followed by dummy variables for each of the nine largest cities in the state. The dummy variables were used to control for global city differences in arson experience combined with fire department differences in classification of fires as arson. These are shown in Table ES-4, columns (1) and (4) for the residential and vehicular arson rates, respectively.

As is customary with regression methods, the residuals were examined for any peculiarities which may have distorted the results. Inspection of residual plots showed a general normality to the shape of the residuals, owing largely to the transformations performed on all the variables to eliminate skewness. Despite the reduction in skewness, the analysis did reveal a few (but not an excessive number) of larger residuals, that is, cases in which the arson rates were significantly lower or higher than one would predict based on their socio-economic, demographic, and locational profile.

To ensure that the results are robust to the effects of outliers, observations with standardized residuals larger than 2.5 and 2.0 in absolute magnitude were successively removed and the results recomputed. These are shown for the census tract-level analysis in Columns (2) and (3) for residential arson and columns (5) and (6) for vehicular arson. The coefficients do not change markedly when outliers are eliminated. One consistent impact of eliminating observations with large residuals is that the multiple correlations increase. This is to be expected, because the removal of outliers homogenizes the distribution and removes the very cases which reduce the multiple correlation.

Overall, both arson rates are most strongly influenced by the Urbanness and Poverty factors. The Housing Quality factor is also significant in the residential arson equations, but is excluded from the vehicular arson equation because of its substantive irrelevance.

The effect of the percentage of population that is black, although significant for some specifications, is relatively weak overall. Interestingly, the race effect in arson statistics is far weaker than in other types of crime. Moreover, most of whatever race effect does exists is subsumed by the socio-economic variables in the equations.

The weak effect of the age/sex variable is also noteworthy. The age effect for arson has frequently been discussed in the literature. However, the age factor is strongest for smaller fires, such as brush fires or trash fires, which were not included in the arson measures used here. In addition, whatever age effects that do exist, they tend not to show up in cross-sectional analyses. That is, cross-sectionally, there does not tend to be much variation among the units, in terms of the percent 10-19 male. What does not vary cannot exert much predictive power.

As suggested by the multiple correlations, car arson rates are generally more difficult to explain across all specifications. This is a result of cross-unit displacement in car arson reports. That is, car fires are counted corresponding to the location of the fire not to the address of the owner. Cars that are abandoned and torched in an area far away from their garagings constitute a significant source of measurement error, which cannot be examined in a regression model and which attenuate the multiple correlations.

There is substantial inter-city variation in the car arson problem, not related to urbanness or poverty. Car arson is acutely problematic in Boston and Lawrence, as reflected in the dummy coefficients. Boston is the base contrast in the census tract data; all eight city dummies are negative, and all but that for Lawrence are significantly negative.

While the factor analysis performed on the socio-economic census variables achieved a number of methodological advantages, these do not come without the imposition of several rigid assumptions, the most stringent of which is that the factors are uncorrelated. Next, we relaxed the restriction that Urbanness, Poverty, and Housing Quality are necessarily independent dimensions, by permitting an oblique rotation of the factors.

The oblique solution for the census tract file is shown in Table ES-5. Note that while the overall fit of the factor solution, as measured by the percent of variance explained and by the set of communalities is unchanged by an oblique rather than orthogonal rotation, modest correlations among the factors emerge. While this is reasonable in the real world, there are certain drawbacks.

First, the "simple structure" in which observed variables tend to align themselves with one and only one dimension (as in Varimax rotation) no longer holds. Indeed, since the solution allows Urbanness and Poverty, for example, to be correlated, many variables load strongly on both. Thus, while the solution is no longer as "clear-cut" as before, we can still safely assign the same substantive meanings to the three factors.

Second, one of the two justifications for employing factor analysis in the first place (multicollinearity among predictors, with the other being data dimension reduction) is negated by allowing the factors to be correlated. This concern notwithstanding, the regression equations were re-estimated using the oblique factors.

As shown in Table ES-6 for the census tract file, the results are similar to the earlier findings using the orthogonal factors. Because only the rotation is different, not the overall fit of the factor solution, many of the regression statistics are unchanged by substituting oblique factors for orthogonal. In particular, the effects of the variables outside of the factor solution, specifically ZPCTBL, PCT1019M as well as the constant term, are unchanged. Additionally, the measures of overall fit of the regression equations (e.g., multiple correlations and standard errors) are also invariant to the type of factor rotation.

One notable difference among the factors themselves is that Housing Quality appears to have stronger effects under the oblique rotation. This is likely a consequence of the fact that the factors are no longer simple or "clear-cut" in meaning. That is, the Housing Quality factor contains some moderate loadings for variables representative of Poverty and Urbanness.

Examination of the entire set of regression results revealed nothing that is terribly surprising. Overall the fits are quite good, but this, of course, can be expected of aggregated data such as these. It is quite clear that the levels of urbanness and of poverty have the closet association with residential arson, and these relationships remain largely unchanged after inclusion of the city dummies. Neither of the demographic controls contribute much to the regression fits, and, in fact, they are often non-significant in their effects.

## Conclusion

The objectives of this research were for the most part successfully achieved. Although a number of unexpected data problems were encountered, the statistical results confirmed the important role of poverty and urbanness and the relatively unimportant role of race in the production of arson rates.

It is unfortunately the case that findings of this kind of analysis do not directly suggest strategies for arson prevention. The effects of poverty are far-reaching; the problem of arson is but a small part of the devastation of neighborhoods brought on by economic disorganization, joblessness and despair.

Although the rate of arson has subsided somewhat in recent years, the future does not look encouraging. Not only will the impending increase in the juvenile population mean more juvenile arson, but, more important, the recession overtaking the nation, and particularly the slow real estate market, would suggest that the recent downward trend in arson may soon reverse itself.

In the absence of major social change in American cities, the most effective strategies for attacking the arson problem combine enforcement and legislative initiatives. For years, arson has been one of the most profitable and low risk form of criminal activity. Efforts to minimize the incentives for arson and increase the likelihood of apprehension will likely have a positive impact. A number of programs and initiatives undertaken in Massachusetts in recent years demonstrate the inroads that can be made toward alleviating the arson problem.

Sadly, it is difficult to motivate most people to take arson as seriously as other forms of crime, even though arson often results in the loss of human life. Most Americans cannot identify with the victims of arson, in the same way that they can empathize with victims of street crime. Most crimes cut across all classes of society, as least to some degree; arson plagues only the underclasses--the poor and minorities.

Almost anyone might on occasion lie awake worrying that an intruder could break into his home and terrorize his family. Almost anyone might on occasion worry that her teenaged son will be shot down on the street by a drug-crazed criminal. But few of us ever worry that an arsonist will burn down our home, that is, of course, unless you are poor, powerless, and living in a building that you do not own and that someone else would prefer go up in smoke.

## References


Bennett, W.D., A.V. Merlo, and K.K. Leiker (1987). "Geographical Patterns of Incendiary and Accidental Fires in Springfield, Massachusetts, 1980-1984." Journal of Quantitative Criminology. 3 (1): 47-64.

Federal Bureau of Investigation (1980, and 1990). Uniform Crime Reports. U.S. Government Printing Office, Washington, D.C.

Gunther, P. (1981). Fire-Cause Patterns for Different Socioecono mic Neighborhoods in Toledo, Ohio. Fire Journal May: 52-58.

Hall, J. R. (1990). "U.S. Arson Trends and Patterns--1989." Fire Analysis Division, National Fire Protection Association.

Hammett, T.M. (1987). "Toward Comprehensive Anti-Arson Programs." Issues and Practices in Criminal Justice series, National Institute of Justice, Washington, D.C.

Institute for Puget Sound Needs (1976). An Analysis of Arson in a Socio-Economic Framework, Unpublished report prepared for the Seattle Mayor's Task Force on Arson.

Insurance Bureau of Canada (1981). "A Viewpoint of Insurance." Insurance Bureau of Canada.

Jackson, P.G. (1988). "Assessing the Validity of Official Data on Arson." Criminology 26 (1):181-195.

Karter, M.J. (1982). "Fire Loss in the Unites States during 1981." Fire Journal 76 (September).

Karter, M.J., and A. Donner (1978). The Effects of Demographics on Fire Rates. Fire Journal. January: 53-65.

Karter, M.J., and A. Donner (1977). Fire Rates and Census Characteristics--An Analytical Approach (Final Report II), NFPA Grant No. 76043.

National Fire Data Center (1980). "National Fire Incident Reporting System News." Federal Emergency Management Agency, United States Fire Administration, Washington, D.C.

New York State Academy of Fire Science (n.d.). "Selected Articles on Arson and Related Subjects."

Pettiway, L.E. (1983-84). Arson and American City Types. Journal of Environmental Systems. 13 (2): 157-176.

Pettiway, L.E. (1985a). Measures of Opportunity and the Calculation of the Arson Rate: The Connection Between Operationalization and Association. Journal of Quantitative Criminology. 1 (3): 241-268.

Pettiway, L.E. (1985b). The Context Of Arson Incidence: Neighborhood and Environmental Factors. Journal of Environmental Systems 15 (2): 127-158.

Pettiway, L.E. (1988). Urban Spatial Structure and Incidence of Arson: Differences Between Ghetto and Nonghetto Environments. Justice Quarterly, 5 (1): 113-129.

Schaenman, P.S., J.R. Hall, A.H. Schainblatt, J.A. Swartz, and M.J. Karter (1977). Procedures for Improving the Measurement of Local Fire Protection Effectiveness. The Urban Institute, Washington, D.C.

Table ES-1: Descriptive Statistics for Arson Measures for Census Tracts

| Variable | N | Min | Max | Sum | Mean | SD | Skew |
|---|---|---|---|---|---|---|---|
| NPERSONS | 389 | 0 | 11072.00 | 1411670.00 | 3628.97 | 1822.21 | .78 |
| NUMCARS | 388 | 0 | 4609.75 | 509052.75 | 1311.99 | 887.45 | .89 |
| RTN | 387 | 0 | 98 | 8651.00 | 22.35 | 15.81 | 1.50 |
| RAN | 388 | 0 | 34 | 2040.00 | 5.26 | 5.90 | 1.92 |
| CTN | 389 | 0 | 270 | 21424.00 | 55.07 | 48.36 | 1.75 |
| CAN | 388 | 0 | 248 | 12208.00 | 31.46 | 41.13 | 2.09 |
| RARATE | 306 | .43 | 114.50 | 4125.86 | 13.48 | 16.62 | 2.50 |
| LRARATE | 306 | -.84 | 4.74 | 593.60 | 1.94 | 1.21 | -.07 |
| CARATE | 306 | .44 | 721.15 | 14602.22 | 47.72 | 88.57 | 3.75 |
| LCARATE | 306 | -.81 | 6.58 | 830.67 | 2.71 | 1.56 | .12 |

NPERSONS: Number persons
NUMCARS: Number of automobiles (estimated)
RTN: Residential-building fires
RAN: Residential-building arson fires
CTN: Automobile fires
CAN: Automobile arson fires
RARATE: Residential arson per 1000 residential building
LRARATE: Log residential arson per 1000 residential bldgs
CARATE: Automobile arson per 1000 automobiles
LCARATE: Log automobile arson per 1000 automobiles

Table ES-2: Descriptive Statistics for Census Measures for Tracts

| | N | Min. | Max. | Mean | SD | Skew |
|---|---|---|---|---|---|---|
| UR | 289 | 0.00 | 19.13 | 5.17 | 2.41 | 2.00 |
| ZUR | 287 | 0.08 | 2.95 | 1.56 | 0.42 | -0.02 |
| LFP | 289 | 0.40 | 81.13 | 63.43 | 6.12 | -0.82 |
| ZLFP | 289 | 3.71 | 4.40 | 4.14 | 0.10 | -1.23 |
| PTLPOVL | 289 | 0.44 | 44.98 | 9.38 | 6.80 | 1.80 |
| ZPTLPOVL | 289 | -0.81 | 3.81 | 2.02 | 0.67 | -0.02 |
| MDNINC | 289 | 6650 | 47542 | 18799.7 | 6049.47 | 1.02 |
| ZMDNINC | 289 | 8.80 | 10.77 | 9.79 | 0.32 | -0.14 |
| PCTFAM1P | 289 | 0.00 | 69.56 | 19.05 | 11.12 | 1.70 |
| ZPTFAM1P | 287 | 1.24 | 4.24 | 2.82 | 0.51 | 0.20 |
| PGT1PPRM | 289 | 0.00 | 17.52 | 2.37 | 1.99 | 3.77 |
| ZPGT1PRM | 284 | -2.08 | 2.86 | 0.64 | 0.73 | -0.61 |
| DENSITY1 | 289 | 1.82 | 14.22 | 4.15 | 1.63 | 2.66 |
| ZDENS1 | 289 | 0.60 | 2.65 | 1.37 | 0.31 | 1.10 |
| DENSITY2 | 289 | 1.01 | 6.00 | 1.60 | 0.86 | 2.83 |
| ZDENS2 | 289 | 0.01 | 1.79 | 0.38 | 0.38 | 1.70 |
| PTEN75 | 289 | 26.28 | 84.29 | 44.86 | 9.38 | 1.21 |
| ZPTEN75 | 289 | 3.27 | 4.43 | 3.78 | 0.20 | 0.38 |
| AVEOCC | 289 | 3.78 | 15.68 | 11.11 | 2.08 | -0.94 |
| ZAVEOCC | 289 | 1.33 | 2.75 | 2.39 | 0.22 | -1.90 |
| PCTVAC | 289 | 0.89 | 29.00 | 5.39 | 4.55 | 2.02 |
| ZPCTVAC | 289 | -0.11 | 3.37 | 1.41 | 0.72 | 0.39 |
| PCTVBLDG | 289 | 0.52 | 28.49 | 4.58 | 4.34 | 2.25 |
| ZPTVBLDG | 289 | -0.65 | 3.35 | 1.20 | 0.76 | 0.50 |
| PCTRENTU | 289 | 5.04 | 100.00 | 37.33 | 22.27 | 0.89 |
| ZPCTRENT | 289 | 1.62 | 4.61 | 3.44 | 0.63 | -0.21 |
| PCNTNPLG | 289 | 0.02 | 14.41 | 1.38 | 1.69 | 3.79 |
| ZPCTNPLG | 289 | -3.91 | 2.67 | -0.39 | 1.50 | -1.12 |
| PCNTNBAT | 289 | 0.13 | 25.58 | 3.39 | 3.20 | 3.15 |
| ZPCTNBAT | 289 | -2.04 | 3.24 | 0.72 | 1.23 | -1.12 |
| PCNTNKIT | 289 | 0.05 | 33.54 | 1.37 | 2.40 | 9.47 |
| ZPCTNKIT | 289 | -3.10 | 3.51 | -0.20 | 1.04 | -0.53 |
| PCTBL | 289 | 0.02 | 90.52 | 3.18 | 10.13 | 6.07 |
| ZPCTBL | 289 | -4.20 | 4.51 | -0.46 | 1.81 | -0.16 |
| PCT1019M | 289 | 0.00 | 15.23 | 8.94 | 1.82 | -0.70 |
| ZPT1019M | 288 | 0.76 | 2.72 | 2.17 | 0.23 | -1.98 |

| | |
|---|---|
| UR | Unemployment rate |
| LFP | Labor force participation |
| PTLPOVL | Pct persons below poverty |
| MDNINC | Median income |
| PCTFAM1P | Pct of families with 1 parent |
| PGT1PPRM | Pct units with > 1 person per room |
| DENSITY1 | Persons per building |
| DENSITY2 | Units per building |
| PTEN75 | Pct occ tenure since 1975 |
| AVEOCC | Average occupancy tenure |
| PCTVAC | Pct vacant housing units |
| PCTVBLDG | Pct vacant buildings |
| PCTRENTU | Pct occupied units rented |
| PCNTNBAT | Pct housing units without compl bath |
| PCNTNPLG | Pct housing units without compl plumbing |
| PCNTNKIT | Pct housing units without compl kitchen |
| PCTBL | Pct black |
| PCT1019M | Pct age 10-19 male |

Table ES-3: Varimax Rotated Factor Solution for Tracts

| | Factor 1 (Urbanness) | Factor 2 (Poverty) | Factor 3 (Hous Qual) | Communality |
|---|---|---|---|---|
| ZUR | -0.1227 | 0.8386 | 0.2162 | 0.765 |
| ZPTLPOVL | 0.5834 | 0.6982 | 0.2322 | 0.882 |
| ZMDNINC | -0.4609 | -0.6769 | -0.2789 | 0.748 |
| ZPTFAM1P | 0.3477 | 0.7443 | 0.1250 | 0.691 |
| ZPGT1PRM | 0.0684 | 0.6868 | 0.0507 | 0.479 |
| ZDENS1 | 0.8584 | 0.2079 | 0.2476 | 0.841 |
| ZDENS2 | 0.8902 | 0.1280 | 0.3397 | 0.924 |
| ZPTEN75 | 0.8588 | 0.0526 | 0.1727 | 0.770 |
| ZPCTVAC | 0.3844 | 0.5092 | 0.4556 | 0.615 |
| PCTRENTU | 0.8406 | 0.3036 | 0.3561 | 0.926 |
| ZPCTNBAT | 0.1844 | 0.1104 | 0.8850 | 0.829 |
| ZPCTNPLG | 0.3121 | 0.1884 | 0.8201 | 0.805 |
| ZPCTNKIT | 0.2703 | 0.2141 | 0.5550 | 0.427 |
| Eigenvalue | 6.8923 | 1.7157 | 1.0943 | |
| Pct of Var | 53.0% | 13.2% | 8.4% | |
| Cum. Pct | 53.0% | 66.2% | 74.6% | |

| | |
|---|---|
| ZUR | Log unemployment rate |
| ZPTLPOVL | Log pct persons below poverty |
| ZMDNINC | Log median income |
| ZPTFAM1P | Log pct families with 1 parent |
| ZPGT1PRM | Log pct units with > 1 person per room |
| ZDENS1 | Log persons per building |
| ZDENS2 | Log units per building |
| ZPTEN75 | Log pct occ tenure since 1975 |
| ZPCTVAC | Log pct vacant housing units |
| PCTRENTU | Log pct occupied units rented |
| ZPCTNPLG | Log pct housing units without compl bath |
| ZPCTNBAT | Log pct housing units without compl plumbing |
| ZPCTNKIT | Log pct housing units without compl kitchen |

Table ES-4: Regression Results for Tracts (Varimax Solution)

| Variable | Residential (1) | Residential (2) | Residential (3) | Vehicular (4) | Vehicular (5) | Vehicular (6) |
|---|---|---|---|---|---|---|
| Urbanness | 0.568 | 0.550 | 0.564 | -0.105 | -0.106 | -0.114 |
| | 10.461 | 10.935 | 12.018 | -1.826 | -1.959 | -2.209 |
| Poverty | 0.503 | 0.477 | 0.517 | 0.862 | 0.865 | 0.898 |
| | 8.536 | 8.813 | 10.094 | 13.961 | 14.993 | 16.066 |
| Hous Qual | 0.324 | 0.323 | 0.335 | | | |
| | 6.608 | 7.180 | 7.914 | | | |
| Pct Bl | 0.059 | 0.071 | 0.070 | -0.075 | -0.083 | -0.089 |
| | 2.343 | 3.074 | 3.267 | -2.864 | -3.397 | -3.798 |
| Pct 10-19m | 0.045 | 0.042 | 0.044 | 0.035 | 0.033 | 0.030 |
| | 2.424 | 2.458 | 2.741 | 1.803 | 1.804 | 1.727 |
| Boston | | | | | | |
| Brockton | -0.072 | -0.161 | -0.135 | -1.632 | -1.679 | -1.649 |
| | -0.382 | -0.933 | -0.843 | -8.179 | -9.083 | -9.427 |
| Cambridge | -0.357 | -0.445 | -0.453 | -1.210 | -1.249 | -1.246 |
| | -1.744 | -2.388 | -2.553 | -5.612 | -6.269 | -6.407 |
| Fall River | 0.026 | -0.088 | 0.079 | -1.303 | -1.368 | -1.400 |
| | 0.130 | -0.476 | 0.433 | -6.284 | -6.972 | -7.033 |
| Lawrence | 0.267 | 0.460 | 0.620 | -0.870 | -0.977 | -0.873 |
| | 1.203 | 2.175 | 2.947 | -3.726 | -4.323 | -3.793 |
| Lowell | -0.155 | -0.262 | -0.232 | -1.844 | -1.806 | -1.774 |
| | -0.759 | -1.383 | -1.322 | -8.532 | -8.888 | -9.228 |
| New Bedford | -0.448 | -0.518 | -0.463 | -2.462 | -2.523 | -2.431 |
| | -2.241 | -2.847 | -2.708 | -11.691 | -12.955 | -12.986 |
| Springfield | -0.146 | -0.252 | -0.178 | -2.531 | -2.654 | -2.664 |
| | -0.832 | -1.533 | -1.157 | -13.967 | -15.476 | -16.143 |
| Worcester | -0.306 | -0.375 | -0.261 | -1.697 | -1.751 | -1.661 |
| | -1.854 | -2.501 | -1.820 | -9.745 | -10.882 | -10.559 |
| Constant | 1.436 | 1.526 | 1.500 | 3.298 | 3.376 | 3.378 |
| Multiple R | 0.781 | 0.814 | 0.845 | 0.830 | 0.854 | 0.869 |
| $R^2$ | 0.610 | 0.663 | 0.715 | 0.688 | 0.729 | 0.755 |
| Adjusted $R^2$ | 0.591 | 0.646 | 0.700 | 0.675 | 0.717 | 0.744 |
| S.E. | 0.780 | 0.706 | 0.652 | 0.824 | 0.758 | 0.715 |
| N | 293 | 283 | 270 | 293 | 283 | 270 |

Table ES-5: Oblique Rotated Factor Solution for Tracts

| | Factor 1 (Urbanness) | Factor 2 (Poverty) | Factor 3 (Hous Qual) | Communality |
|---|---|---|---|---|
| ZUR | 0.0572 | 0.8323 | 0.3452 | 0.7650 |
| ZPTLPOVL | 0.7199 | 0.8094 | 0.5245 | 0.8818 |
| ZMDNINC | -0.6086 | -0.7767 | -0.5302 | 0.7484 |
| ZPTFAM1P | 0.4765 | 0.8002 | 0.3690 | 0.6905 |
| ZDENS1 | 0.9131 | 0.3773 | 0.5115 | 0.8413 |
| ZDENS2 | 0.9515 | 0.3190 | 0.5899 | 0.9242 |
| ZPTEN75 | 0.8735 | 0.2142 | 0.4087 | 0.7701 |
| ZPCTVAC | 0.5474 | 0.6291 | 0.6399 | 0.6146 |
| PCTRENTU | 0.9342 | 0.4850 | 0.6286 | 0.9256 |
| ZPGT1PRM | 0.1824 | 0.6883 | 0.2106 | 0.4790 |
| ZPCTNBAT | 0.3864 | 0.2770 | 0.9043 | 0.8294 |
| ZPCTNPLG | 0.5074 | 0.3628 | 0.8948 | 0.8054 |
| ZPCTNKIT | 0.4137 | 0.3392 | 0.6399 | 0.4269 |
| Factor 1 | 1.0000 | | | |
| Factor 2 | 0.3360 | 1.0000 | | |
| Factor 3 | 0.5000 | 0.3966 | 1.0000 | |
| Eigenvalue | 6.8923 | 1.7157 | 1.0943 | |
| Pct of Var | 53.0% | 13.2% | 8.4% | |
| Cum. Pct | 53.0% | 66.2% | 74.6% | |

| | |
|---|---|
| ZUR | Log unemployment rate |
| ZPTLPOVL | Log pct persons below poverty |
| ZMDNINC | Log median income |
| ZPTFAM1P | Log pct families with 1 parent |
| ZPGT1PRM | Log pct units with > 1 person per room |
| ZDENS1 | Log persons per building |
| ZDENS2 | Log units per building |
| ZPTEN75 | Log pct occ tenure since 1975 |
| ZPCTVAC | Log pct vacant housing units |
| PCTRENTU | Log pct occupied units rented |
| ZPCTNPLG | Log pct housing units without compl bath |
| ZPCTNBAT | Log pct housing units without compl plumbing |
| ZPCTNKIT | Log pct housing units without compl kitchen |

Table ES-6: Regression Results for Tracts (Oblique Solution)

| Variable | Residential (1) | (2) | (3) | Vehicular (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Urbanness | 0.695 | 0.674 | 0.693 | -0.106 | -0.102 | -0.114 |
| | 12.819 | 13.389 | 14.546 | -2.083 | -2.120 | -2.511 |
| Poverty | 0.631 | 0.605 | 0.644 | 0.717 | 0.720 | 0.743 |
| | 10.947 | 11.429 | 12.715 | 11.909 | 12.684 | 13.755 |
| Hous Qual | 0.565 | 0.555 | 0.572 | | | |
| | 11.560 | 12.271 | 13.132 | | | |
| Pct Bl | 0.059 | 0.071 | 0.069 | -0.053 | -0.064 | -0.065 |
| | 2.343 | 3.074 | 3.162 | -1.945 | -2.457 | -2.651 |
| Pct 10-19m | 0.045 | 0.042 | 0.045 | 0.038 | 0.036 | 0.038 |
| | 2.424 | 2.460 | 2.833 | 1.870 | 1.896 | 2.085 |
| Boston | | | | | | |
| Brockton | -0.072 | -0.161 | -0.143 | -1.778 | -1.824 | -1.793 |
| | -0.382 | -0.930 | -0.893 | -8.642 | -9.466 | -10.032 |
| Cambridge | -0.357 | -0.443 | -0.453 | -1.196 | -1.240 | -1.230 |
| | -1.744 | -2.377 | -2.550 | -5.316 | -5.884 | -6.111 |
| Fall River | 0.026 | -0.088 | 0.073 | -1.223 | -1.278 | -1.275 |
| | 0.130 | -0.477 | 0.399 | -5.670 | -6.186 | -6.195 |
| Lawrence | 0.267 | 0.459 | 0.613 | -0.814 | -0.922 | -0.937 |
| | 1.203 | 2.169 | 3.024 | -3.345 | -3.863 | -4.098 |
| Lowell | -0.155 | -0.226 | -0.240 | -1.902 | -1.964 | -1.831 |
| | -0.759 | -1.216 | -1.368 | -8.448 | -9.328 | -9.210 |
| New Bedford | -0.448 | -0.519 | -0.475 | -2.476 | -2.539 | -2.479 |
| | -2.241 | -2.850 | -2.744 | -11.267 | -12.326 | -12.624 |
| Springfield | -0.146 | -0.253 | -0.188 | -2.687 | -2.824 | -2.761 |
| | -0.832 | -1.538 | -1.205 | -14.401 | -15.839 | -16.200 |
| Worcester | -0.306 | -0.375 | -0.288 | -1.714 | -1.772 | -1.710 |
| | -1.854 | -2.497 | -1.985 | -9.445 | -10.436 | -10.428 |
| Constant | 1.436 | 1.525 | 1.491 | 3.278 | 3.355 | 3.305 |
| Multiple R | 0.781 | 0.814 | 0.845 | 0.813 | 0.836 | 0.856 |
| $R^2$ | 0.610 | 0.662 | 0.713 | 0.661 | 0.700 | 0.732 |
| Adjusted $R^2$ | 0.591 | 0.646 | 0.699 | 0.647 | 0.686 | 0.719 |
| S.E. | 0.780 | 0.707 | 0.652 | 0.858 | 0.800 | 0.739 |
| N | 293 | 284 | 268 | 293 | 284 | 268 |

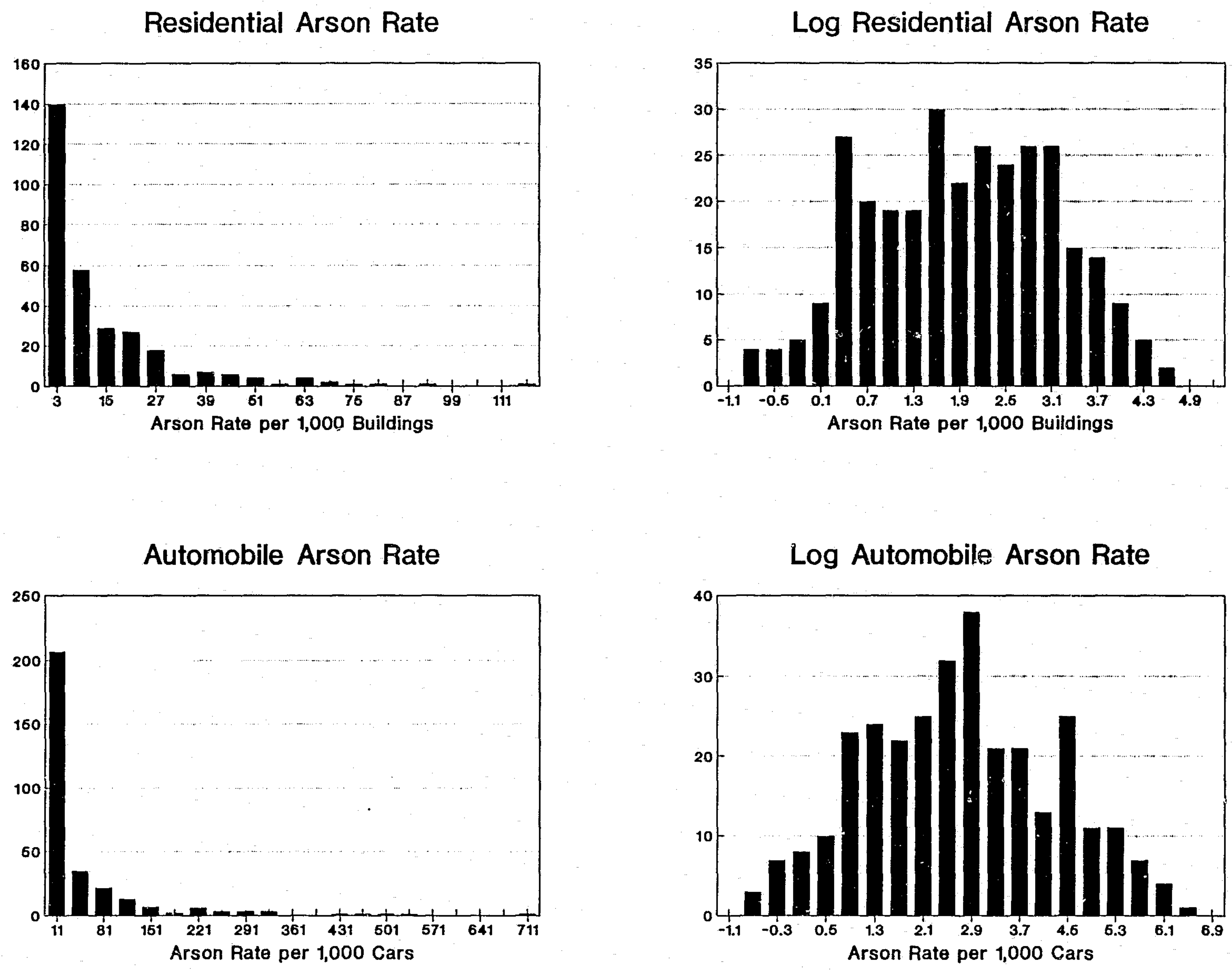


Figure ES-1: Arson Rates for Census Tracts