Luxembourg Income Study Working Paper Series

Working Paper No. 333

Crime, Punishment and the Measurement of Poverty in the United States, 1979-1997

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November 2002

Luxembourg Income Study (LIS), asbl

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Abstract

The rate of incarceration has increased dramatically in the U.S. since 1980. We explore the implications of this increased incarceration on national poverty measurement using micro data for the period 1979–1997. We make use of an as-yet unexplored data set on prisoner earnings, in conjunction with the *Current Population Survey* to compute earnings of the whole population. It is found that the traditional measurement of poverty, which omits this increased share of the population that has become institutionalized, understates the true degree of poverty in the nineteen nineties to a significant degree. This underestimation has increased during the time period of study. Furthermore, it is the depth of poverty associated with the higher incarceration rate, rather than the higher rate of incarceration alone that has had the greatest impact upon poverty. These results stand in marked contrast to western European economies and Canada.

[1]We are grateful to the *Criminal Justice Institute*, particularly Fred Rolon, for providing guidance with their data. In addition we thank Susumu Imai, Terra McKinnish, Brian Nolan, Lars Osberg and Buhong Zheng for comments on early drafts, and to seminar participants at the University of Colorado at Denver and the University of Colorado at Boulder where the paper was presented. The authors are professors in Economics at, respectively, Concordia University, Montreal, Quebec, Canada, H3G 1M8, and Dalhousie University, Halifax, Nova Scotia, Canada B3H 3J5. E-mail addresses: irvinei@vax2.concordia.ca and kuan.xu@dal.ca.

1 Introduction

Following upon more than two decades of bad news on the state of the lowest quintile in the income distribution, a number of recent papers have indicated that the rising economic tide of the mid and late nineties 'lifted most boats': the percentage of the U.S. population defined as being impoverished declined with the economic expansion. For example, Richard Freeman (2001), using time-series analysis, and James Hines, Hilary Hoynes and Alan Krueger (2001), using a balanced sample of panel data, have concluded that economic expansions in general, and the most recent one in particular, have benefited the poor.

This is a reassuring finding for policy makers, because the events of the seventies and eighties cast doubt on the long-held belief that growth benefits the least privileged as well as the affluent. In contrast to the experience of most of the twentieth century, the U.S. poverty rate failed to register any notable change between 1969 and the mid nineties, despite a real GDP growth in excess of 70%. Freeman has proposed that the seventies and eighties were characterized by falling wages in the lower part of the distribution, and this particular development was due to atypical occurrences such as skill-biased technological change.

Yet there is reason to worry about the interpretation of recent findings: we propose that there is a significant difference between the finding that recent economic expansions have acted to reduce poverty, and the view that poverty among the whole population has fallen in that same period to the degree that has been believed. The reason is that the incarcerated population in the U.S. has grown several-fold in the last two decades, as has the percentage that is under the care of the criminal justice system more generally—in the form of individuals on probation or parole. Yet, to date, no effort has been made to incorporate it into poverty estimates. Our objective, then, is to adopt the 'balanced

sample' idea of Hines, Hoynes and Krueger, and merge this sub-population with the non-incarcerated population in estimating poverty.

In terms of President Kennedy's nautical metaphor—'a rising tide lifts all boats', we propose that, while the rising tide of the nineties did indeed lift those boats that were in the water, many others become shipwrecked: clearance rates (the fraction of crimes cleared by arrest) and particularly sentencing rose during the eighties and nineties. The result was that about one and a half million more people were locked up in 2000 than in 1980. Such individuals are poor by any standard. Furthermore, their incomes—for the most part no more than a few dollars a day—place them very far below the poverty line. Consequently when they are included in the impoverished class, they not only increase the number in this group, but also significantly increase the average poverty gap, or income shortfall. While it has been proposed frequently that the high rate of economic inequality and poverty in the U.S. is a cause of criminal activity and subsequent incarceration, our perspective is that the reverse is also true: the increase in incarceration which aims at neutralizing criminals, and possibly rehabilitating them, brings poverty in its wake.[1]

The increase in sentencing has prompted several recent contributions on its economic impact: Kuziemko and Levitt (2001) examine, *inter alia*, the crowding-out effect on other prisoners of the increased number of drug offenders incarcerated in the eighties and nineties. They find that prisoners serving time for other crimes have experienced earlier releases from the penal system on account of the overcrowding in prisons, which in turn has been due to the failure of the system to expand its capacity in line with the rise in sentencing. The dynamic effects of a criminal record on labor-market performance have been investigated by Imai and Krishna (2001), Grogger (1995), Lochner (1999) and

[1]We are not proposing that incarceration is inappropriate, or 'welfare reducing' (the well-being of the vulnerable may increase for example), rather, its effect on the measurement of poverty should be recognized explicitly.

Kling (1998). The effects of possible widespread participation of inmates in the labor market have been investigated by Kling and Krueger (2001).

An alternative line of investigation—one which examines the causation running from inequality to crime—has been pursued by the following economists. Imrohoglu, Merlo and Rupert (2000, 2001) explore it in the context of a dynamic general equilibrium model. Their calibration is consistent with inequality having an extremely strong effect on the commitment of property crime, and that the US would have witnessed a greater decrease in property crime in the period 1980-1996 had the economic status of those at the lower tail of the distribution (primarily youth) improved rather than deteriorated. Glaeser, Sacerdote and Scheinkman (1996) propose that criminal behavior is influenced by the degree of social interaction—a perspective that is consistent with inequality driving crime. Akerlof (2002) and Akerlof and Kranton (2000) explore the relationship between dominant and oppositional cultures on the one hand, and crime on the other.

Our focus is in the spirit of the first of these lines of causation—the effect of incarceration on social status, rather than the reverse. In that context, we develop a structure that enables us to amalgamate two data sources consistently—the data for the non-incarcerated and incarcerated sub-populations. We show that Sen's index of poverty intensity (1976) is amenable to this task. From a methodological point of view, this is an extension of Xu and Osberg (2002).[2]

Our main findings are: first, the introduction of the incarcerated population into poverty measurement increases the intensity of poverty by between 9% and 15% in 1997 over and above the value obtained when the non-incarcerated population alone is

[2]The Sen index has been modified by Thon (1979) and Shorrocks (1995) and the resulting index is sometimes called the Sen-Shorrocks-Thon (SST) index. This latter has a one-to-one correspondence with the Sen (S) index and serves as its upper bound, as given by Propositions 3 and 4 in Xu and Osberg (2002). We prefer the S index primarily on account of its more transparent subgroup decomposition: the Gini index component of the SST includes the zero poverty-gap ratios of the non-poor as well as those ratios for the poor. In contrast, the corresponding component for the S index, is simply the Gini index of poverty gap ratios of the poor, which can be neatly decomposed by subgroup for the poor.

considered. We use an as-yet unaccessed data source on prisoner earnings to construct a distribution of earnings for the incarcerated population. Second, it is the depth of poverty experienced by inmates, as much as the increased rate of incarceration among the population as a whole, that has been responsible for this result. Third, the impact of adding the incarcerated population increases significantly during the time period we consider. Fourth, we show that, despite some imperfections in the data on prisoner-earnings, our estimates appear to be robust. Finally, these results stand in stark contrast to the experience of western European economies, which have lower incarceration rates and which have experienced much smaller increases in these rates.

The paper is developed as follows. In the next section some of the main results from the recent literature are summarized to provide a background. In addition, data on the numbers who have been 'ship-wrecked' in the eighties and nineties are detailed. In section 3 we show that the Sen index of poverty intensity is amenable to disaggregation—the merging of poverty intensity statistics based on different data sets: for the institutionalized and non-institutionalized populations.[3] Results are analyzed in section 4. Sensitivity analysis is carried out in section 5 and some concluding remarks are offered in section 6.

2 Recent Findings on Poverty in the United States

The level of income which differentiates the poor from the non-poor is a threshold called the poverty line.[4] When the poor are thus identified, there remains the question of defining a poverty measure, or statistic, that can be used as a meaningful metric across time, space or population subgroups.

[3]We use the terms 'incarcerated' and 'institutionalized' interchangeably

[4]While the research for the United States tends to use gross household incomes, that for many other countries, such as the United Kingdom and Canada, tends to use income net of taxes and transfers.

In the United States, there are two slightly different versions of the federal poverty line. One is the poverty 'threshold', which is updated annually by the Census Bureau. This poverty line forms the basis for the computation of the official measure of the poverty population.[5] The poverty 'guidelines' are the other version of the federal poverty line. These guidelines are updated each year by the Department of Health and Human Services for the purposes of administrating some federal programs.[6] Both versions of the federal poverty line differentiate the poor from the non-poor by means of a poverty line that varies with the size of households. For example, the poverty line of a two-person family will be higher than that of a one-person family, but the former will be less than double the latter. This implicitly incorporates some sharing rule.[7]

An alternative approach to establishing the poverty line involves the distribution of equivalent individual incomes, in particular when international comparative studies are involved. Generally, total household income is used to compute the equivalent individual income based on a sharing rule.[8] Then, the poverty line is computed as x%, say 50%, of such a median income of the survey year.

Table 1 summarizes the findings of some of the many recent poverty studies. The first column replicates Freeman's family poverty rate based on the official poverty lines for various family types proposed by the Census Bureau. Despite the decline in low-end wages in the seventies and eighties, his regression results indicate that poverty moves counter-cyclically.

[Please place Table 1 about here]

[5]See http://www.census.gov/hhes/poverty/threshld.html for more details.

[6]See http://aspe.hhs.gov/poverty/poverty.htm for more details.

[7]Orshansky (1965) was the first to present a refined version of the poverty thresholds expanded to include all types of family units. Four months later, the Office of Economic Opportunity adopted Orshansky's thresholds as a working or quasi-official definition of poverty.

[8]One popular rule proposed by OECD (1995) is that the first adult, who is 18 or older, has a one-person share of the family income while other adults take a 70% of the share each and the children under age 18 take a 50% share each. Another rule is to let the number of equivalent adults in a household be the square root of the actual size of the households.

The second column of the table replicates data from Hines, Hoynes and Krueger. Their PSID-based analysis indicates that employment and hours worked are strongly pro-cyclical, particularly in the case of lower-skill workers. Such patterns are readily mirrored in the poverty rate through the earnings changes that result.

Dickens and Ellwood (2001), in their large-scale comparative study of poverty developments in the U.S. and Britain, also report that the percentage of the U.S. population below the poverty line has fallen. The data in column 3 come from their paper. Their objective is to decompose long-term changes in poverty into its components, rather than to examine cyclicality.

The data in columns 4 and 5 are from Osberg and Xu (2000) and Osberg (2000), respectively. The poverty rate is computed using a poverty line equal to one-half of median equivalent individual income, and the number of the equivalent adults in each household is the OECD (1995) scale in column 4 and the square root rule in column 5.[9] Each of these studies use the Sen-Shorrocks-Thon (SST) index, which is very close to the Sen index that we examine presently. It combines the poverty rate with the poverty gap, or average income shortfall, and inequality of the income shortfalls below the poverty line in the population. It is noteworthy that this very different index also indicates a reduction in absolute poverty in the expansion of the nineties.

Taken together, this set of findings provides strong evidence that the most recent economic expansion help the households at the lower tail of the income distribution and also reduce the rate of poverty in the population. These studies are based on different data sets and use different methodologies, yet uniformly point in the same direction.[10]

[Please place Table 2 about here]

[9]See Footnote 8 for details on the two methods for computing equivalent individual incomes from a household income.

[10]See Triest (1998) and Jorgenson (1998) for more discussions on the measurement issues.

On the crime side, Table 2 details the correctional populations for specific years in the period 1980–2000. The total number of individuals under the supervision of the criminal justice system has increased from 1.84 million to 6.32 million. The relative increase in the jail and prison populations has been equally startling. Almost two million people are now in custody, compared to a half million in 1980. The percent of the population incarcerated has increased from .22% to .69%. As a percentage of the male labor force, the number is currently at about 2.5%. The main reason for this increase is that a greater percentage of those committing crimes are now incarcerated, as is indicated in the final two columns of Table 2. The trend in the commitment of crime has been a secondary factor—criminal activity increased in the eighties but fell in the nineties. It is to be noted however that at the beginning of our sample period, 1980, the rate of incarceration per violent crime was at a historic (post-war) low at a value of 227 per 1000. The corresponding figure for the early sixties was 726–761 per 1000.[11] Broadly the same pattern is true of the rate of incarceration per 1000 crimes of any kind. The rate was 100 in 1998, 23 in 1980 and 63 in 1960.

[Please place Table 3 about here]

Table 3 indicates that drug-related offences are a major factor in the increase in the federal prison population. At the state level, which supervises several times the number of prisoners, the percentage of inmates serving time for drug-related offences is approximately 22%. Thus, drug-related crimes account for about one quarter of prison terms at the federal and state levels combined. Violent crime accounts for almost half of all terms, while property offences account for about 22%, and the remainder, about 7%, comes under the category of 'public-order' offences. However, there have been significant differences among the rates at which incarceration for different types of crime have increased. Incarceration levels for non-violent crime have doubled, for violent crime have tripled and for drug offences have increased by about 1,100% (Schiraldi, Holman

[11] The figures for the sixties and seventies are not provided in the table.

and Beatty, 2000). While we do not specifically investigate the increase in crime by race in this paper, the increase has been much greater for non-whites than whites.

3 Data and Poverty Measurement

3.1 Non-incarcerated population

Data for the non-institutionalized population come from the income surveys maintained at the Luxembourg Income Study.[12] These data are from the March *Current Population Surveys*, which are monthly household surveys conducted by the *Bureau of the Census* for the *Bureau of Labor Statistics*. They provide a comprehensive body of information on the employment and unemployment experience of the population, classified by age, sex, race, and a variety of other characteristics.[13] We use the superscript 'N' to denote the non-institutionalized population.

The income variable we use is after-tax family income. This is a comprehensive measure of disposable personal income. It includes income from a wide variety of sources and also nets out taxes paid and contributions to various social insurance programs. A complete characterization is given in Appendix A. This measure of income is compatible with the manner in which the official poverty lines were originally developed. Nonetheless, these poverty lines have often be used in conjunction with a gross measure of income. The degree of bias which this introduces clearly depends upon the operation of the whole tax-transfer system in the neighborhood of the poverty line. We discuss the results of some simulations using gross income in the final section of the paper. An overview of the use of gross and net measures is to be found in the US Government's *Department of Housing and Health Services*.[14]

[12]The data cover 1979, 1986, 1991, 1994, and 1997.

[13]See http://www.bls.gov/cps/home.htm for details.

[14]See http://aspe.hhs.gov/poverty/papers/hptgssiv.htm. In particular, note the following remarks:

The surveys contain m household incomes, $y_{H1}, y_{H2}, \ldots, y_{Hm}$, with respective household sizes, $n_1, n_2, \ldots, n_m$, and sampling weights, $w_1, w_2, \ldots, w_m$, where w_i represent the number of households in the population of type i. Based on a certain sharing rule (see Footnote 8), individual members in a household are assigned an individual equivalent income, y_i, which can be computed from the household income, y_{Hi}. This yields the vector $y_1, y_2, \ldots, y_m$. The sample data can be denoted by $\{y_i, w_i, n_i\}_{i=1}^m$. The total number of people in this population is $N^N = \sum_{i=1}^m n_i w_i$.

There are several reasons for using individual-equivalent incomes in poverty analysis. First, poverty measures in the literature are often defined on individual, rather than household, incomes. Second, the household has different interpretations in different countries and, hence, international comparative studies are conventionally based on individual equivalent incomes. Third, in order to merge the sample data for the non-institutionalized population with the data for the institutionalized population, it is convenient to have the smallest denominator—individual incomes, because the institutionalized individuals have already been detached from their families and must be treated as individuals in analyzing their welfare.

There is an extensive literature on poverty measurement (see, for example, Atkinson 1987 and Zheng 1997). The poverty rate, despite its great popularity in applied work, universally emerges from such reviews as a poor summary index. Principally this is because the poverty rate may fail to register a change following an income transfer from a poor person to a less poor person or vice versa: it fails the transfer axiom.[15] This is

> "While the poverty thresholds had been calculated on the basis of after-tax money income, they were applied to income data—the Census Bureau's Current Population Survey—that used a before-tax definition of money income; this was done because when the thresholds were being developed, the Current Population Survey was the only good source of nationally representative income data. Orshansky was aware of the inconsistency involved, but there was no other alternative; she reasoned that the result would yield 'a conservative underestimate' of poverty."

[15] A heuristic example of such a failure is this: a transfer from a very poor person to one just below the poverty line may lift the latter individual out of poverty: the poverty rate thereby declines. However, this is achieved by an adverse transfer of resources in society.

more than a semantic point, because so much of government policy is focussed upon the well being of those households with zero or near-zero incomes. A major function of the transfer system is to alleviate the hardships faced by households on very low incomes—as opposed to those whose own incomes leave them just slightly below the poverty line.

Use of the poverty rate solely as the nation's poverty index, and therefore as an implied social welfare function, could have insidious consequences: a government would maximize social welfare, so defined, by directing its income support or income generating measures at the most "affluent" of the poor. To make matters worse, the poverty gap and the poverty rate may move in opposite directions simultaneously. Sen's index (1976) is designed to overcome some of these problems. It has three components, which we develop in turn: the poverty rate, the poverty gap and a measure of inequality among the poor—which in essence is a Gini index of poverty gaps for that population.

If the poverty line is z, let there be q $(< m)$ households whose individual equivalent income is less than z. We can also compute the individual poverty-gap ratios, or the relative income shortfalls below the poverty line, as

$$x_i = \begin{cases} \frac{z-y_i}{z} & \text{if } y_i < z, \\ 0 & \text{if } y_i \geq z. \end{cases} \tag{1}$$

To compute the Gini index in the customary way, we sort sample records $\{x_i, w_i, n_i\}_{i=1}^m$ according to poverty gap ratios x_i in non-decreasing order. This implies that the first $(m-q)$ of the x_i's are zero for the non-poor households while the remaining q x_i's are nonzero and non-decreasing for the poor households. Thus the total number of the poor in this population is $Q^N = \sum_{i=m-q+1}^m n_i w_i$.

Using the sample survey data with sampling weights, we can compute the poverty rate of this population,

$$H^N = \frac{\sum_{i=m-q+1}^m n_i w_i}{\sum_{i=1}^m n_i w_i}, \tag{2}$$

and the average poverty gap ratio (or the poverty gap) of the poor,

$$I^N = \frac{\sum_{i=m-q+1}^{m} n_i w_i x_i}{\sum_{i=m-q+1}^{m} n_i w_i}. \tag{3}$$

Finally, we can compute a measure of inequality among the poor. We begin by selecting from the sample records $\{x_i, w_i, n_i\}_{i=1}^{m}$ those q records where $x_i > 0$ where these x_i's are in non-decreasing order resulting $\{x_i, w_i, n_i\}_{i=1}^{q}$. The Gini index of the poverty gap ratios of the poor for the non-incarcerated population is computed by[16]

$$G^N = 1 - \sum_{i=1}^{q} \left(\frac{n_i w_i}{\sum_{j=1}^{q} n_j w_j} \right) \left(\frac{\sum_{k=1}^{i} n_k w_k x_k + \sum_{k=1}^{i-1} n_k w_k x_k}{\sum_{j=1}^{q} n_j w_j x_j} \right). \tag{4}$$

Sen's generalized index, which we will term a poverty intensity index, obeys a set of ethically defensible axioms. It can be formulated as the product of the poverty rate (H^N), the poverty gap (I^N), and a transform of the Gini measure of the poor ($1+G^N$):[17]

$$S^N = H^N \cdot I^N \cdot (1 + G^N). \tag{5}$$

Thus, in addition to being ethically defensible, the Sen index is (logarithmically) decomposable. However, even when measured in this way, the poverty intensity index based only on the non-incarcerated population in the U.S. has become increasingly inadequate as a poverty measure on account of the growing importance of the incarcerated population.

[16]This is just a transform of the well-known representation of the Gini index with unit weights and a single person in each household:

$$G^N = 1 - \frac{1}{q^2 \overline{x}} \sum_{i=1}^{q} (2q - 2i + 1) x_i,$$

where $\overline{x} = \frac{1}{q} \sum_{i=1}^{q} x_i$.

[17]This decomposition was first mentioned in Clark, Hemming, and Ulph (1981) and later discussed in detail in Bishop, Formby, and Zheng (1997). Note that G measures inequality while $1 + G$ measures equality. See Xu and Osberg (2002) for details.

3.2 The incarcerated

Data for the incarcerated population are obtainable from *Corrections Yearbook*, published annually by the *Criminal Justice Institute* (CJI), and from the *Bureau of Justice Statistics*' (BJS) *Sourcebook*. While the income surveys of the Luxembourg Income Study are relatively complete and cover most of the last two decades, the data for the incarcerated population poses two challenges: first to assemble meaningful income or earnings data for this subpopulation and, second, to interpret it in a way that permits valid welfare comparisons between incarcerated and non-incarcerated populations on the basis of their incomes.

While the number of individuals under the care of the criminal justice system is well documented in the BJS *Sourcebook*, Section 6, it contains no information on the earnings of this population. The CJI's *Corrections Yearbook* presents data for the total earnings of inmates in state prisons, by state and in federal prisons. This yields mean earning estimates for inmates in each state, and we attribute similar earnings to inmates in the jail system.[18]

The above information can be summarized as follows. We use the superscript 'I' to represent the institutionalized population. For each of the US states, denoted by s, we have the number of inmates, N_s, and an estimate of earnings per inmate (based on a sample of each state's prison system) y_s. Thus, we have records $\{y_s, N_s\}_{s=1}^{k}$ for the institutionalized population. The total number of the institutionalized is $N^I = \sum_{s=1}^{k} N_s$. These data are incomplete for the purpose of establishing the complete income distribution of the incarcerated population, because there is no information available

[18] We assume that jails administered by counties and municipalities provide similar earnings as state-run prisons. This may lead to a slight overestimate of earnings because jails typically house prisoners sentenced to short-terms, or individuals awaiting trial, or awaiting transit, and work programs are therefore not as well developed as in state or federal prisons where most inmates are held. However, earnings are small in virtually all of the institutions and, if the assumption of equal wages in jails as in prisons leads to an overestimate of earnings we would prefer to introduce this possible bias, because it *reduces* the degree of poverty that might be attributable to incarceration.

on the distribution of earnings within prisons, only the total amount paid in each state to the inmates who worked. Two alternative strategies present themselves. The first is to generate an artificial income distribution from a synthetic distribution for each state, based on a knowledge of the sample mean income and an assumed coefficient of variation. The choice could be one of two-parameter distributions such as the lognormal distribution or the Pareto, which are utilized frequently in distributional analysis and have a long tradition in the field (for example, Lydall, 1969 or Champernowne, 1973). However we prefer not to impose such strong priors on the data and instead adopt a second approach which may err on the side of underestimating poverty intensity.

This second strategy is to assume that the variation in incomes among the incarcerated arises from the fact that they are in different states. This amounts to defining the variation solely in terms of variation between states and ignoring the variation within states: variation arises as a result of different states paying different wages—which they do. Thus, for state s, all prisoners are attributed the same observed average earnings y_s. These incomes across states form an income distribution of this sub-population. Given the poverty line z and income distribution, we will be able to compute the poverty gap ratio for the institutionalized population in state s, x_s, according to

$$x_s = \begin{cases} \frac{z-y_s}{z} & \text{if } y_s < z, \\ 0 & \text{if } y_s \geq z. \end{cases} \tag{6}$$

The records $\{N_s, x_s\}_{s=1}^{k}$ sorted in non-decreasing order can be used to compute the poverty measures for the institutionalized population. If first $(k-q)$ of the x_s's are zero and remaining q are positive, the total number of the poor in this population is $Q^I = \sum_{s=k-q+1}^{k} N_s$. In the event that all x_s are positive, that is all institutionalized people are poor, then $q = k$ and $Q^I = \sum_{s=1}^{k} N_s$. This is indeed what emerges from the data.

Based on the above information, we can define and estimate the poverty rate (H^I), the poverty gap (I^I), and the Gini index of poverty gap ratios (G^I) for this population. The poverty rate is

$$H^I = \frac{\sum_{s=k-q+1}^{k} N_s}{\sum_{s=1}^{k} N_s}. \tag{7}$$

When $N_s = Q_s$ for all s, $\sum_{s=1}^{k} Q_s = \sum_{s=1}^{k} N_s$ and $H^I = 1$. The poverty gap of this population is

$$I^I = \frac{\sum_{s=1}^{k} Q_s x_s}{\sum_{s=1}^{k} Q_s}. \tag{8}$$

The Gini index of poverty gap ratios of the institutionalized population can be computed for the following two cases. If all institutionalized people are poor or $x_s > 0$ for all s, then

$$G^N = 1 - \sum_{s=1}^{k} \left(\frac{N_s}{\sum_{t=1}^{k} N_t} \right) \left(\frac{\sum_{t=1}^{s} N_t x_t + \sum_{t=1}^{s-1} N_t x_t}{\sum_{t=1}^{k} N_t x_t} \right). \tag{9}$$

If some institutionalized people in some states are not poor, that is, if their x_s's are zero, then we select $q(< k)$ non-negative x_s's and sort data $\{x_s, N_s\}_{s=1}^{q}$ by x_s in non-decreasing order. The Gini index can be computed by equation (9) but with k being replaced by q. Sen's poverty intensity index for the institutionalized population is then

$$S^I = H^I \cdot I^I \cdot (1 + G^I). \tag{10}$$

At this point, it is necessary to address the question of whether or not it is reasonable to compare the earnings of an incarcerated individual with the earnings of a non-incarcerated individual. The earnings of most inmates are no more than a handful of dollars per day, while most of the non-institutionalized population who are impoverished earn several times that amount. Moreover, there is a difference in the demands that such incomes must satisfy: the incarcerated individual has lodging and food supplied, in large measure, whereas the non-incarcerated must buy such goods completely out of their measured income. How then can legitimate comparisons be made if these earnings amounts do not reflect purchasing power?

When individuals are incarcerated they suffer deprivation in a dimension not experienced by others. Incarceration forms a punishment that impairs their well-being. It is intended to be not only a form of rehabilitation, but also a form of retribution. Poverty and inequality analyses in essence use incomes as an approximate indicator of the well-being of all those being considered. Yet it would be most unreasonable to deem that a prisoner who earns $2,000 per year and who 'benefits' from food and lodging ('imputed income') to the value of $10,000 per year is equally well off as one having an income of $12,000 but who is a free member of society. In Sen's (1998) terms,

> 'The value of living must reflect the importance of the diverse capabilities for which it is a necessary requirement.'

The assumption we make in this research is that an inmate's earning shortfall below the poverty line is a measure of his 'poverty', regardless of the additional value of food and lodging upon which his earnings need not be expended. His punitive status prevents him from utilizing his capabilities, and his low measured income is a reflection of this low level of well-being.

This may seem to be a strong assumption, but it appears much more defensible than the alternatives. One alternative is to ignore completely the plight of a rapidly increasing share of the whole population, as poverty analysis has done to date for the most part—that is, to pretend that this growing segment is not impoverished, or that it does not exist. The other alternative—adding an imputed living allowance to an inmate's observed earnings—would imply that many prisoners are considerably better off than the non-incarcerated poor. Yet, if given the choice between which status they would prefer, it would be hard to find many who would choose incarceration with a specified imputed income, over a less fettered life with the same actual income. The latter has potentialities denied to the incarcerated. But perhaps the strongest argument for our treatment is one of revealed preference: if indeed there were an equality of well-being between incarcerated and free individuals, whose imputed and actual incomes were

the same, we would expect that, at the point of being charged, the inmate should not challenge the punishment! Such occurrences, we suggest, are rare.

In summary, incomes in this context are a practical, reasonable, and objective proxy for well-being in poverty analysis. Accordingly, the costs of the prison system should properly be viewed as the costs borne by society in carrying out retribution, rehabilitation and neutralization, not as taxpayer transfers to individuals under supervision.

3.3 A complete poverty index

Based on the previous discussion, we can measure poverty for both populations: the non-institutionalized and institutionalized based on the Sen index and its components. From a statistical inference standpoint, it has been established that (for the non-institutionalized population) the sample poverty rate (H^N), average poverty gap (I^N) and equality measure of the poor ($1 + G^N$) are unbiased and converge to their population counterparts as the sample size increases.[19] For the institutionalized population, we also have the poverty rate (H^I), poverty gap (I^I), and equality measure of the poor ($1 + G^I$).

The subgroup decomposability of the Sen index is a vital feature for our analysis, because it furnishes a means of merging the two data bases to arrive at more comprehensive measures of the true extent of poverty. Given that the total size of the population is $N = N^N + N^I$, the proportion of the non-institutionalized people in the total population is $W^N = \frac{N^N}{N}$ and the proportion of the institutionalized people is $W^I = \frac{N^I}{N}$. Furthermore, given that the total size of the poor population is $Q = Q^N + Q^I$, the proportion of the poor in the non-institutionalized population is $P^N = \frac{Q^N}{Q}$ and the proportion of the poor in the institutionalized population is $P^I = \frac{Q^I}{Q}$. The poverty rate of the population is given by

$$H = W^N H^N + W^I H^I, \tag{11}$$

[19] See Bishop, Formby and Zheng (1997).

while the poverty gap of the population can be computed directly from

$$I = P^N I^N + P^I I^I. \tag{12}$$

To understand the subgroup decomposition of the inequality of the poor (that is, the Gini index, G), we define the weight-adjusted proportion of poverty deprivation of the non-institutionalized population as $B^N = P^N \left(\frac{P^N I^N}{I}\right)$ and that of the institutionalized population as $B^I = P^I \left(\frac{P^I I^I}{I}\right)$. We also need to define the between-group Gini index of poverty gap ratios, G^B. G^B is computed as the Gini index, where the individual poverty gap ratios are replaced with the subgroup average poverty gap ratios. Generally, because $I^N \leq I^I$,

$$G^B = 1 - \left[\left(\frac{Q^N I^N}{Q^N I^N + Q^I I^I}\right)\left(\frac{Q^N}{Q}\right) + \left(\frac{2Q^N I^N + Q^I I^I}{Q^N I^N + Q^I I^I}\right)\left(\frac{Q^I}{Q}\right)\right].^{20} \tag{13}$$

The Gini index of poverty gap ratios of the poor in the population is

$$G = G^B + B^N G^N + B^I G^I + R, \tag{14}$$

where R is a factor defining the degree of segregation of the two sub-populations.[21] If the two sub-populations were completely segregated, in the sense that the incomes of the incarcerated population were all below the lowest income of the non-incarcerated population, then $R = 0$. Otherwise, $R \neq 0$.

[20] If $I^I \leq I^N$, then

$$G^B = 1 - \left[\left(\frac{Q^I I^I}{Q^N I^N + Q^I I^I}\right)\left(\frac{Q^I}{Q}\right) + \left(\frac{2Q^I I^I + Q^N I^N}{Q^N I^N + Q^I I^I}\right)\left(\frac{Q^N}{Q}\right)\right].$$

The detailed derivation is given in Appendix C.

[21] While the term R is called the residual and was considered a nuisance term until recently, Silber (1989) gave it a clear and intuitive interpretation: it measures the intensity of the permutations which occur when, instead of ranking all the individual shares by decreasing income shares, one ranks them, firstly, by decreasing value of the average income of the population subgroup to which they belong and, secondly, within each subgroup, by decreasing individual income share. Lambert and Aronson (1993) have proposed a similar interpretation.

The poverty intensity of the total population, measured by the Sen index, can be computed by combining the poverty measures for populations N and I:

$$S = \left(W^N H^N + W^I H^I\right)\left(P^N I^N + P^I I^I\right)\left(1 + G^B + B^N G^N + B^I G^I + R\right). \qquad (15)$$

The term R can be computed as a residual from

$$R = G - \left(G^B + B^N G^N + B^I G^I\right) \qquad (16)$$

where G is computed directly based on the merged $\{w_i \times n_i, x_i\}$ and $\{N_s, x_s\}$ for all poor people, in households or in states, in the similar way as G^N is computed.

4 Findings

The main results are contained in Tables 4 through 8. For each year we have computed three sets of statistics: those in Panel A use a poverty line of one half the median income with the OECD household sharing rule—additional adults are assumed to require 70% of the income of the first adult and children under the age of 18 require 50%. Panel B defines the poverty income level/threshold in the same way, but uses a square root rule for the number of equivalent adults in the household. Panel C uses the US official poverty thresholds for families of different sizes.

[Please place Tables 4–8 about here]

The Sen index in the final column (5) of each table is the focal point. For each panel, rows one ('N') and two ('I') define that index for two sub-populations, while row three ('Total') is the weighted sum of the components that enter equation (15). The three components of the index are presented in columns 2, 3 and 4, with their associated

weights. The remaining entries at the bottom of each panel are the between-group Gini given in equation (13) and the R term defined in equation (16).

The weights associated with each component of the Sen index differ. The weight for the poverty rate is the share of the total *population* in each group I, N, while that for the poverty gap is the share of all *poor* in each group I, N. The weight for the incarcerated population's poverty gap is the highest among the three weights. It reflects the fact that this social group represents a larger proportion of the total poor than of the total population. In contrast, the weight for those incarcerated that is associated with the poverty rate is less than 1% of the weight for the non-incarcerated, reflecting the fact that less than one percent of the population is accounted for by inmates. Technically, the high rate for the income gap is the result of Sen's focus axiom (Sen 1976) which requires that we focus only upon the incomes of those below the poverty line. Shorrocks (1995) has since argued that it may be desirable to modify this axiom.

The Gini index of poverty gap ratios that we have computed for the incarcerated is an inequality measure of poverty across states. Because of the limitation of the data, we assume that the income, and therefore the poverty gap ratio, is the same for all inmates in a given state. By doing so we ignore the income inequality among the incarcerated population in each state, and thereby understate the actual Gini index for the population of inmates. Nonetheless, the understatement of the Gini is unlikely to be very serious. This is because the distribution of poverty gap ratios lies in the unit interval and the actual distribution lies in a much tighter range, between 0.8 and 1.0, reflecting the fact that the incomes of the incarcerated population are concentrated in the range 0%–20% of the poverty line.

Prior to examining the effect of including the incarcerated population, note that our benchmark results for the non-incarcerated population over the time period are consistent with the existing literature on the cyclical behavior of poverty—increasing through to the mid nineties, but decreasing significantly in 1997. Our index that uses

the 'official' poverty line attains a value very close to the value it attained in 1979, though our measures based upon a relative measure of the poverty line still exceed their corresponding 1979 values.

The central findings that emerge are: First, the addition of the inmate population adds significantly to the overall degree of poverty. The computations for 1997 indicate that the intensity of poverty is between 9% and 15% percent higher with the inclusion of the inmate population.[22]

Second, the effect is stronger in the nineties than in the eighties. As would be anticipated, the much lower rate of incarceration in the earlier period yields a smaller addition to the measured poverty intensity. But, as pointed out in the introduction to the paper, this increase should not be attributed simply to the 'war on drugs' or higher rates of criminal activity—crime fell in the nineties. It is primarily the higher rate of sentencing in the later years that generates the elevated incarceration levels.

Third, the impact of including the incarcerated population on the overall poverty intensity is robust regardless of which version of the poverty line is chosen. Each of the three poverty lines yields a substantive increase in the measured poverty intensity. The main difference throughout the results is that the increase is highest for the official poverty line definition.[23] The greater sensitivity of the statistic based on the official poverty index is due to the fact that it yields the lowest degree of poverty of the three statistics for the non-incarcerated population. The addition of a completely impoverished sub-population therefore is relatively more significant in that context.

Fourth, the element in the Sen index that is most strongly responsible for increasing the poverty statistic is the poverty gap component, not the increase in the rate of incar-

[22]The percentage difference in the Sen index in 1997: $\frac{0.08467-0.07760}{0.07760} \simeq 9\%$ based on the 1/2 median income as the poverty line and the OECD equivalent income scale; $\frac{0.08596-0.07760}{0.07760} \simeq 9\%$ based on the 1/2 median income as the poverty line and the squared rule equivalent income scale; and $\frac{0.05638-0.04921}{0.04921} \simeq 15\%$ based on the official poverty thresholds.

[23]See Footnote 22.

ceration, nor the degree of inequality among the inmate population. This is because the earnings of prisoners are almost uniformly very far below (about 80%–90% below) the poverty line, however defined. In contrast, for the non-institutionalized population, the distribution of poverty gap ratios for the non-institutionalized poor are spread throughout the range from 0 to 1. This finding becomes more stark in view of the fact that the earnings data we have used for prisoners are gross figures, prior to any payments made to victims, for costs of prison services, or to families or for child support. The data from the Criminal Justice Institute for 1997 indicate that the actual net earnings, after such payments, may be as low as one half of the gross payments that we have used in our computations. Accordingly, the numbers that we report are certainly a lower bound on the true effect of including the prison population.

Fifth, in the context of international comparisons, the rate of incarceration over the period of 1980–2000 has been significantly higher in the US than in western Europe. In Figure 1 we present rates for several economies for the year 2000.[24] The highest rate in this western Europe group is Portugal, with 127 incarcerations per 100,000 population, compared with the US which has 702 per 100,000. Additionally, the rate of change has been greater in the U.S. where, from 1980 to 2000, the total number of the incarcerated has increased fourfold. Consequently, were we to perform this study for virtually any western European economy we would find the results much less striking.[25] This is important when it comes to comparing poverty on a country-by-country basis. For, when a common construction of the poverty line is adopted—for example one half of median income, we know that the US invariably exhibits much more poverty than European economies (*e.g.* Osberg and Xu, 2000). Our findings underscore how much greater that difference may be when the analysis is conducted on a more representative sample of the population.

[24]See Elkins and Olagundoye (2001).

[25]While the UK experienced a major increase in the rate of incarceration between 1993 and 1998 the level remains low, so that total poverty in the UK would show just a minor increase in comparison with that registered in the U.S. as a result of expanding the defined population.

[Please place Figure 1 about here]

5 Sensitivity Analysis

The fact that we have to work with prison earnings data that have some limitations raises the obvious issue of whether our findings are robust enough to present an accurate portrait of aggregate poverty. For example, as indicated, we have used the gross earnings for prisoners, rather than their net-of-restitution-payments earnings. In addition, we have had to assume that jailed inmates earn the same as those in state and federal prisons. In the third instance we have no information on the distribution of earnings within each state prison/jail system. Each of these shortcomings leads to a possible underestimate of the impact of including the incarcerated population on the poverty intensity statistic. Consider each of the above issues in turn.

The key to the robustness of our results lies in the behavior of the poverty gap component of the Sen index. In this context let us suppose that we had an estimate of net earnings for inmates in every year (which we have not, net figures are published only for 1997). Since net earnings for 1997 are at most half of gross earnings the poverty gap would increase to reflect this. The use of gross earnings yields a poverty gap of 0.91599, based on the 1/2 median income as the poverty line and the OECD equivalent scale, for that year. Therefore a halving of gross earnings which gives the average net income would increase that gap to about 0.96.[26] Using this estimate in equation (15) yields an increase in value from 0.0862 to 0.0867—a remarkably small increase in view of a fifty percent reduction in earnings. However, the result can be explained simply: the poverty gap measure is measured in relation to the poverty line. When inmate earnings are so far below this line to begin with, further—even dramatic—reductions in earnings make

[26]The poverty gap of about 0.92 indicates the average gross earnings of the inmates is about 8% of the poverty line. If the average net earnings is about the half of the average gross earnings, it is about 4% of the poverty line. This will generate a poverty gap of about 0.96.

little difference, because the point of reference is not zero, which is close by, but the poverty line which is far distant.

The same reasoning applies to the second possible source of bias—the assumption that jail inmates get the same earnings as prison inmates. This assumption will not affect the poverty rate because the earnings of the incarcerated population are all well below the poverty line. While it may have some impact on the poverty gap, this impact will be relatively small given the extremely low levels of all inmate incomes discussed above.

Finally, in relation to the Gini component, let us suppose that we knew the distribution of earnings for inmates and that the result of this knowledge led to a Gini coefficient of the same order of magnitude as for the non-incarcerated population. For example if, in Table 8 Panel A, we had a Gini coefficient for the I population equal to the Gini coefficient for the N population, the overall effect on the Sen intensity index again shows up at the fourth decimal place. The reason for the small impact is that the weight associated with the within-group Gini index is the weight-adjusted proportion of poverty deprivation [see equation (14)], which remains very small even in the late nineties.

To conclude, even though the data on inmate earnings is imperfect, given that their earnings are very far below the poverty line, the Sen intensity index is very robust to the assumptions underlying the these earnings data.

Several further issues warrant mention. The first pertains to the treatment of juveniles. Our data exclude the vast majority of juveniles in custody. These are individuals 18 years of age or below who are housed, for the most part, outside of the state and federal prison/jail system. The *BJS Sourcebook* indicates that there were approximately 110,000 such custodial cases in 1999 and the proportion held in the prison system is about 5% of this. Were we to treat all detained juveniles as separate single-person households, the effect would be to increase the measured poverty intensity. The decision

to omit this part of the criminal population is purely age-based. It is well-known that older juveniles have the highest rate of crime commitment (Imai and Krishna, 2001). However, our focus is not on the frequency of behavior among specific demographic groups, but rather on the poverty that attends their neutralization.

The sensitivity of the results to the definition of income is also examined. While the official poverty lines were developed with a view to being compatible with a measure of disposable income rather than gross income, the latter is frequently used in poverty studies. Accordingly we have re-estimated our statistics for each year to see how a different income definition could influence our conclusions. The use of this definition yields virtually identical effects: including the incarcerated population increases each estimate of poverty intensity by a percentage that is similar to that obtained when disposable income is used. This similar increase materializes even though the values for the poverty intensity statistics themselves take on slightly different values—elevated for the two cases where a relative threshold is used, and reduced for the case where the official (absolute) version of the poverty threshold is used.

Lastly, we relaxed our assumption that none of the cost of sheltering prisoners represents an in-kind income transfer, by assigning each inmate an in-kind allowance of $10 per day. We have found that when the cost of sheltering prisoners is added to the earnings, the poverty rate for the incarcerated remains the same, the poverty gap is reduced, and the inequality of the poverty also falls. Given all of these, a smaller decline in the increment to the poverty intensity index is still attributable to including the incarcerated.

6 Conclusions

Our objective has been to explore the effect of the increasing rate of incarceration upon the intensity of poverty in the U.S. Sentencing has increased dramatically since the early

eighties, when it was at a historic low. Two challenges presented themselves. The first was to develop a poverty statistic which envelopes the various dimensions of poverty, and which at the same time is decomposable. The second was to obtain reliable data on inmate earnings.

In contrast to most thinking about inequality and poverty—extremes lead to criminal behavior, our attention has been directed towards the poverty that accompanies incarceration. That is, the higher rate of incarceration should be reflected in the measurement of aggregate poverty. The expenditures associated with incapacitating criminals should not be viewed as fiscal transfers to those individuals. These expenditures are the societal costs that accompany the necessary rehabilitation and neutralization of those who commit crime. Society at large suffers when crime is committed and also in the subsequent phase. But in addition to bearing the monetary costs, society suffers in experiencing a higher degree of poverty. Our focus has been on the degree to which poverty has been understated in the eighties and nineties as a result of omitting the incarcerated population. The central finding is that, in the late nineties, the Sen poverty intensity statistic is between 9% and 15% higher when we include the incarcerated population over and above the non-institutionalized population. The growth in sentencing has meant that this effect is stronger in the late nineties than in the eighties. As a corollary, we should distinguish between the effects of economic expansions on the one hand (which Freeman and others have shown generally lead to a reduction in poverty), and on the other hand the belief that the amount of poverty in the whole population has actually decreased in the nineties expansion. It has, but at a higher overall real level.

The computations are robust to imperfections in the data. While the more precise data collection is clearly desirable for both administration and social policy making purposes, we have attempted to make the best use of the existing data and been deliberately conservative in our computational approach. The sensitivity analysis indicates that our results underestimate, but only by a small order, the true state of poverty intensity.

Nonetheless, since, in the period 1997-2002, the incarcerated population increased by a further two hundred thousand individuals, the magnitude of the phenomenon that we have examined has grown correspondingly.

We have not examined the dynamic interaction between poverty and imprisonment in this paper, but this research indicates that it is clearly an issue to be pursued. There is a well-developed literature on the interaction between time spent incarcerated and subsequent labor-market activity. This literature is reviewed in an illuminating survey by Western, Kling and Weiman (2001). From the standpoint of our results, it is evidently possible that the increase in recent rates of incarceration could have profound long-term impacts on the poverty rate. In the first instance this could come about because inmates are typically incarcerated early in their life-cycle, at a time when they should be accumulating human capital in the form of on-the-job experience. Second, the fact that rates have increased so much for specific demographic groups means that there is scope for what may be termed agglomeration effects. Young inner-city Blacks and Hispanics in particular have experienced much steeper increases in incarceration rates than whites. The return, upon release, to an environment in which there is a higher population of individuals with a prison record may reduce the crime-deterring effects of stigma, and deter potential employers from operating in these areas. Third, time in prison may exacerbate pre-existing pathologies:

> "In addition, behaviours that are adaptive for survival in prison are unlikely to be consistent with work routines outside. These effects may be especially large in the recent period as support has declined for training, drug treatment and health care." (Western, Kling and Weiman. 2001)

Many researchers have pointed to the likelihood that those who are incarcerated come disproportionately from a group who fare worse in the labor market than the general population, regardless of their prison history. Such 'self-selection' creates difficulties

for causal inference and therefore for policy. However, what is crucial in recent prison history is that the growth in incarceration rates has been primarily a policy decision. Crime rates are down in the nineties, in some areas and for some crime types, quite substantially. Consequently, the quadrupling of the incarcerated population during the last two decades is certainly not the manifestation of the quadrupling of a population suffering from pathologies who would do poorly in the labor market. This is an area with considerable scope for exploration.

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Appendix A: Income Measurement

A.1 The incarcerated in prisons

Earnings data for inmates from the *Criminal Justice Institute (CJI)* are available for every year corresponding to the *Luxembourg Income Survey*, with the exception of 1979. To deal with this gap we estimated inmate earnings for 1981 and deflated them using the CPI to bring them back to 1979. Furthermore, the *Bureau of Justice Statistics* yields a count on the total number of inmates for each year, and we assumed that the distribution by state of 1979 inmates was the same as the distribution in 1981—which is available from the *CJI Yearbook*.

Each Yearbook contains information at the state level on the earnings of a sample of prisoners who are engaged in various work programs—for example, on a prison farm, a prison industry setting, in a prison run by the private sector, or simply classified as doing 'other work'. In addition, or as an alternative, prisoners are assigned to educational and vocational training.

Earnings and work-program participation data are also provided in the *CJI Yearbook* for the inmates of the federal prison system. Such inmates form a small part of the total of all inmates—about 10% of the state prison population.

Unfortunately no earnings data are available for the jail population. The jail population tends to be about half of the size of the state prison population. Jail inmates are generally awaiting trial, serving short terms—usually less than one year, or awaiting transfer to the prison system following sentencing. While work programs are less well developed here, we have assumed that such inmates earn the same amount as inmates in the state system.

Holes in the data are relatively few. A small number of states do not pay their inmates for the work performed—for example, Arkansas, Florida, Georgia, Mississippi and Texas for much of the time span. In cases where states do pay their workers but

where the data are not reported, we have used information for adjoining sample years to attribute an estimate. There tend to be no more than a handful of such states in any given year.

The earnings data are survey-based and do not include data for all institutions in any given state: earnings are generally reported for a sample of inmates assigned to work programs, not all inmates in the state, because not all institutions in the state answer the survey, and even those that do frequently leave gaps. The earnings data that appeared most complete on a nation-wide basis were those defining earnings of inmates, and number of inmates, involved in prison industry—as opposed, for example, to farm work. We therefore chose the earnings estimate based on this work program as being representative of an inmate's earnings.

Finally we note that these earnings are all so low that the issue of using a before- or after-tax measure is irrelevant.

A.2 The incarcerated in jails

The jail population is taken as of Dec 31 in each year. But not every jail inmate is incarcerated for a full year—some are released on bail, some serve a short sentence in jail, others go on to serve a sentence in the prison system. Our treatment of jail detainees is based upon information in the Bureau of Justice Statistics' *Sourcebook*, sections 5 and 6.

When a defendant first enters the detainee system s/he generally gains access to a pretrial hearing within a matter of days. A decision is then made regarding bail or continued detention. More than half of those charged are held, and for a considerable period of time, before a decision is reached. The mean time between arrest and decision (sentencing or release) is one year for state courts trying felons. Consequently we know that the vast majority of those in jail whose case has not been completed have been there for a considerable period of time. We also know that, of those who are charged

with a crime, about 90% are found guilty. This is true of both the federal and the state systems.

On the sentencing side, about one quarter of those sentenced serve their sentence in jail—for an average period of 6 months. Slightly less than half are sentenced to prison and almost one third are placed on probation. In view of the high rate of 'guilty' rulings, long waiting periods and sentences, it is safe to conclude that at least one half of detainees in jail suffer severe poverty for one year—similar to inmates who are serving time in the prison system. This is the assumption we make in our estimations, and we attribute to this proportion of jail detainees the same earnings as we observe for prisoners, even though earnings and training programs are less well-developed within the jail system.

A.3 The non-incarcerated

The variable for the after-tax family income is DPI or disposable personal income in the *Luxembourg Income Study* data. The gross disposable income is defined as the sum of gross wage and salary income, farm self-employment income, non-farm self-employment income, cash property income, cash sickness insurance benefits, accident pay, disability pay, social retirement benefit, child or family allowance, unemployment compensation, maternity allowance, military/veteran/war benefits, other social insurance, mean-tested cash benefit, all near cash benefits, private pensions, public sector pensions, alimony or child support received, other regular private income, and other cash income. The net disposable income equals the gross disposable income minus mandatory contributions for self-employed, income taxes, and mandatory employee contributions.[27]

[27]See http://www.lisproject.org/techdoc/variabdef.htm for more details.

Appendix B: The Between-group Gini Index

The between-group Gini index of poverty gap ratios, G^B. G^B is computed as the Gini index, where the individual poverty gap ratios are replaced with the subgroup average poverty gap ratios. Generally, if $I^N \leq I^I$, then

$$G^B = 1 - \left[\left(\frac{Q^N I^N}{Q^N I^N + Q^I I^I} \right) \left(\frac{Q^N}{Q} \right) + \left(\frac{2Q^N I^N + Q^I I^I}{Q^N I^N + Q^I I^I} \right) \left(\frac{Q^I}{Q} \right) \right]. \tag{17}$$

As shown in Figure 2, the between-group Lorenz curve is given by the solid dotted line. The between-group Gini index is defined as the ratio of Area A to the sum of Areas A, $B1$ and $B2$, that is

$$G^B = \frac{A}{A + B1 + B2} = 1 - 2(B1 + B2). \tag{18}$$

Note that the horizontal distance between the origin 0 and point a is $\frac{Q^N}{Q}$ and that between point a and 1 on the horizontal axis is $\frac{Q^I}{Q}$. In other words, these two line segments on the horizontal axis represent the proportion of the non-institutionalized population and that of the institutionalized population, respectively. The vertical distance between the origin 0 and point b is $\frac{Q^N I^N}{Q^N I^N + Q^I I^I}$ and that between point b and 1 on the vertical axis is $\frac{Q^I I^I}{Q^N I^N + Q^I I^I}$. Areas $B1$ and $B2$ are measured by

$$\left(\frac{Q^N I^N}{Q^N I^N + Q^I I^I} \right) \left(\frac{Q^N}{2Q} \right) \tag{19}$$

and

$$\left(\frac{Q^N I^N}{Q^N I^N + Q^I I^I} + 1 \right) \left(\frac{Q^I}{2Q} \right), \tag{20}$$

respectively. Substituting expressions (19) and (20) into equation (18) gives equation (17). However, if $I^I \leq I^N$, then

$$G^B = 1 - \left[\left(\frac{Q^I I^I}{Q^N I^N + Q^I I^I} \right) \left(\frac{Q^I}{Q} \right) + \left(\frac{2Q^I I^I + Q^N I^N}{Q^N I^N + Q^I I^I} \right) \left(\frac{Q^N}{Q} \right) \right]. \tag{21}$$

Table 1: Family and Individual Poverty Rates (%) in the United States

Author(s)	Freeman	Hines et al.	Dickens-Ellwood	Osberg-Xu	Osberg
Income Unit	Family	Family	Family	Individual OECD Scale	Individual Square Root Rule
Poverty Line	Official	Official	Official	Half-Median	Half-Median
1959	18.5				
1969	9.7				
1974				14.6	
1979	9.2		10.4	15.5	
1982	12.2				
1986				18.0	
1989	10.3	12.8			
1991				17.7	
1992	11.9	14.8			
1994				18.3	18.5
1997					16.8
1999	9.3	11.8	10.9		

Table 2: State and Federal Correctional Populations

Year	Probation mil.	Jail mil.	Prison mil.	Parole mil.	Total mil.	US pop mil.	Inmates per 1000 violent crimes	Inmates per 1000 crimes
1980	1.12	0.18	0.32	0.22	1.84	227.2	227	23
1982	1.36	0.21	0.40	0.22	2.19	231.7	291	30
1984	1.74	0.23	0.45	0.27	2.69	235.8	337	36
1986	2.11	0.27	0.53	0.33	3.24	240.1	338	38
1988	2.36	0.34	0.61	0.41	3.71	244.5	373	42
1990	2.67	0.40	0.74	0.53	4.35	249.5	392	49
1992	2.81	0.44	0.85	0.66	4.76	255.0	423	57
1994	2.98	0.48	0.99	0.69	5.14	260.3	513	68
1996	3.16	0.51	1.13	0.68	5.48	265.2	644	80
1998	3.67	0.58	1.22	0.70	6.13	270.2	813	100
1999	3.77	0.60	1.28	0.71	6.32	272.7	862	106
2000	3.84	0.62	1.31	0.73	6.47			

Source: Bureau of Justice Statistics. *Probation*: court-ordered community supervision of convicted offenders by a probationary agency. *Prison*: numbers confined to a State or Federal facility for more than 1 year as of Dec 31. *Jail*: numbers confined in a local jail while pending trial, awaiting sentencing or serving a sentence usually less than 1 year. *Parole*: community supervision after a period of incarceration. *Inmates per 1000 (violent) crimes*: based on Federal Bureau of Investigation's 'Uniform Crime Reporting Program' data.

Table 3: Federal Prison Population and Sentencing

	Total Sentenced and Unsentenced Population	Sentenced Population		
		Total	Drug Offences	
			Number	%
1970	21,266	20,686	3,384	16.3
1972	22,090	20,729	3,523	16.9
1974	23,690	21,769	6,203	28.4
1976	27,033	24,135	6,425	26.6
1978	27,674	23,501	5,981	25.4
1980	24,252	19,023	4,749	24.9
1982	28,133	20,938	5,518	26.3
1984	32,317	27,622	8,152	29.5
1986	40,505	31,831	12,119	38.1
1988	43,401	34,680	15,526	44.8
1990	57,331	47,847	25,037	52.3
1992	70,346	61,026	36,349	59.6
1994	85,290	76,186	46,743	61.4
1996	94,215	83,515	50,754	60.8
1998	106,536	95,522	56,291	58.9

Source: Department of Justice, Bureau of Justice Statistics, Sourcebook.

Table 4: Poverty in US in 1979

Group (1)	**Rate** (2)	**Weight for** (2)	**Gap** (3)	**Weight for** for (3)	**Gini Index** (4)	**Weight for** for (4)	**Sen Index** (5)
	Panel A: Based on 1/2 Median Income as Poverty Line and OECD Scale						
N	0.15906	0.99828	0.33489	0.98927	0.40793	0.96111	0.07500
I	1.00000	0.00172	0.90474	0.01073	0.04810	0.00031	0.94826
Total	0.16051	1.00000	0.34100	1.00000	0.41000	1.00000	0.07717
	Between-group Gini Index 0.01774				R Term 0.00018		
	Panel B: Based on 1/2 Median Income as Poverty Line and Square Root Rule						
N	0.15547	0.99828	0.32762	0.98905	0.41235	0.96063	0.07194
I	0.99766	0.00172	0.87562	0.01095	0.06374	0.00031	0.92926
Total	0.15692	1.00000	0.33362	1.00000	0.41419	1.00000	0.07403
	Between-group Gini Index 0.01779				R Term 0.00027		
	Panel C: Based on the Official Poverty Thresholds						
N	0.11698	0.99828	0.33039	0.98547	0.42532	0.94790	0.05509
I	1.00000	0.00172	0.88798	0.01453	0.05763	0.00055	0.93915
Total	0.11851	1.00000	0.33849	1.00000	0.42719	1.00000	0.05725
	Between-group Gini Index 0.02359				R Term 0.00040		

Note: The poverty line is $ 4,338.10 based on the 1/2 median income and the OECD scale. The poverty line is $ 3,261.11 based on the 1/2 median income and the square root rule. The US official poverty thresholds in 1979 are $3,689 for the family of one person, $ 4,725 for two, $ 5,784 for three, $ 7,412 for four, $ 8,775 for five, $ 9,914 for six, and $ 12,280 for seven and more.

Table 5: Poverty in US in 1986

Group (1)	**Rate** (2)	**Weight for** (2)	**Gap** (3)	**Weight for** for (3)	**Gini Index** (4)	**Weight for** for (4)	**Sen Index** (5)
	Panel A: Based on 1/2 Median Income as Poverty Line and OECD Scale						
N	0.17911	0.99717	0.35359	0.98440	0.36589	0.94694	0.08650
I	1.00000	0.00283	0.88236	0.01560	0.05941	0.00059	0.93478
Total	0.18143	1.00000	0.36184	1.00000	0.36931	1.00000	0.08990
	Between-group Gini Index 0.02245				R Term 0.00036		
	Panel B: Based on 1/2 Median Income as Poverty Line and Square Root Rule						
N	0.17981	0.99717	0.34904	0.98446	0.37550	0.94819	0.08633
I	1.00000	0.00283	0.84539	0.01554	0.08149	0.00057	0.91428
Total	0.18213	1.00000	0.35676	1.00000	0.37814	1.00000	0.08955
	Between-group Gini Index 0.02129				R Term 0.00076		
	Panel C: Based on the Official Poverty Thresholds						
N	0.13237	0.99717	0.33482	0.97900	0.39166	0.92802	0.06168
I	1.00000	0.00283	0.85759	0.02100	0.07399	0.00109	0.92105
Total	0.13483	1.00000	0.34579	1.00000	0.39546	1.00000	0.06506
	Between-group Gini Index 0.03108				R Term 0.00084		

Note: The poverty line is $ 6,745.00 based on the 1/2 median income and the OECD scale. The poverty line is $ 5,132.35 based on the 1/2 median income and the square root rule. The US official poverty thresholds in 1986 are $ 5,572 for the family of one person, $ 7,138 for two, $ 8,737 for three, $ 11,203 for four, $ 13,529 for five, $ 14,986 for six, $ 17,409 for seven, $ 18,791 for eight, and $ 22,497 for nine and more.

Table 6: Poverty in US in 1991

Group (1)	**Rate** (2)	**Weight for** (2)	**Gap** (3)	**Weight for** for (3)	**Gini Index** (4)	**Weight for** for (4)	**Sen Index** (5)
	Panel A: Based on 1/2 Median Income as Poverty Line and OECD Scale						
N	0.17934	0.99592	0.34346	0.97337	0.39453	0.92305	0.08590
I	1.00000	0.00408	0.88930	0.02234	0.04677	0.00125	0.93089
Total	0.18269	1.00000	0.35565	1.00000	0.39810	1.00000	0.09084
	Between-group Gini Index 0.03352				R Term 0.00036		
	Panel B: Based on 1/2 Median Income as Poverty Line and Square Root Rule						
N	0.17749	0.99592	0.34600	0.97743	0.39025	0.92470	0.08538
I	1.00000	0.00408	0.85471	0.02257	0.06387	0.00122	0.90930
Total	0.18085	1.00000	0.35748	1.00000	0.39292	1.00000	0.09005
	Between-group Gini Index 0.03139				R Term 0.00598		
	Panel C: Based on the Official Poverty Thresholds						
N	0.13257	0.99592	0.33860	0.97002	0.40289	0.89872	0.06297
I	1.00000	0.00408	0.86902	0.02998	0.05663	0.00220	0.91824
Total	0.13611	1.00000	0.35450	1.00000	0.40648	1.00000	0.06786
	Between-group Gini Index 0.04352				R Term 0.00075		

Note: The poverty line is $ 8,201.55 based on the 1/2 median income and the OECD scale. The poverty line is $ 6,248.96 based on the 1/2 median income and the square root rule. The US official poverty thresholds in 1991 are $ 6,932 for the family of one person, $ 8,865 for two, $ 10,860 for three, $ 13,924 for four, $ 16,456 for five, $ 18,587 for six, $ 21,058 for seven, $ 23,605 for eight, and $ 27,942 for nine and more.

Table 7: Poverty in US in 1994

Group (1)	**Rate** (2)	**Weight for** (2)	**Gap** (3)	**Weight for** for (3)	**Gini Index** (4)	**Weight for** for (4)	**Sen Index** (5)
	Panel A: Based on 1/2 Median Income as Poverty Line and OECD Scale						
N	0.18518	0.99536	0.36027	0.97544	0.39383	0.91739	0.09299
I	1.00000	0.00464	0.90547	0.02456	0.04683	0.00146	0.94787
Total	0.18965	1.00000	0.37366	1.00000	0.39674	1.00000	0.09862
	Between-group Gini Index 0.03495				R Term 0.00042		
	Panel B: Based on 1/2 Median Income as Poverty Line and Square Root Rule						
N	0.18306	0.99536	0.36022	0.97516	0.39489	0.91826	0.09199
I	1.00000	0.00464	0.87645	0.02484	0.06323	0.00145	0.93187
Total	0.18686	1.00000	0.37304	1.00000	0.39694	1.00000	0.09737
	Between-group Gini Index 0.03351				R Term 0.00072		
	Panel C: Based on the Official Poverty Thresholds						
N	0.14210	0.99536	0.36015	0.96823	0.39980	0.89559	0.07164
I	1.00000	0.00464	0.89033	0.03177	0.05525	0.00238	0.93953
Total	0.14608	1.00000	0.37699	1.00000	0.40225	1.00000	0.07722
	Between-group Gini Index 0.04326				R Term 0.00080		

Note: The poverty line is $ 8,755.50 based on the 1/2 median income and the OECD scale. The poverty line is $ 6,699.12 based on the 1/2 median income and the square root rule. The US official poverty thresholds in 1994 are $ 7,547 for the family of one person, $ 9,661 for two, $ 11,821 for three, $ 15,141 for four, $ 17,900 for five, $ 20,235 for six, $ 22,923 for seven, $ 25,472 for eight, and $ 30,300 for nine and more.

Table 8: Poverty in US in 1997

Group (1)	**Rate** (2)	**Weight for** (2)	**Gap** (3)	**Weight for** for (3)	**Gini Index** (4)	**Weight for** for (4)	**Sen Index** (5)
	Panel A: Based on 1/2 Median Income as Poverty Line and OECD Scale						
N	0.16813	0.99424	0.33287	0.96670	0.40990	0.88299	0.07890
I	1.00000	0.00576	0.91599	0.03330	0.03163	0.00288	0.94496
Total	0.17292	1.00000	0.35229	1.00000	0.41563	1.00000	0.08623
	Between-group Gini Index 0.05329				R Term 0.00031		
	Panel B: Based on 1/2 Median Income as Poverty Line and Square Root Rule						
N	0.16667	0.99424	0.32887	0.96642	0.41571	0.88340	0.07760
I	1.00000	0.00576	0.88934	0.03358	0.04291	0.00288	0.92750
Total	0.17146	1.00000	0.34770	1.00000	0.42018	1.00000	0.08467
	Between-group Gini Index 0.05232				R Term 0.00050		
	Panel C: Based on the Official Poverty Thresholds						
N	0.10264	0.99424	0.33913	0.94658	0.41391	0.82408	0.04921
I	1.00000	0.00576	0.89340	0.05342	0.04115	0.00691	0.93017
Total	0.10780	1.00000	0.36873	1.00000	0.41834	1.00000	0.05638
	Between-group Gini Index 0.07601				R Term 0.00096		

Note: The poverty line is $ 1,0382.75 based on the 1/2 median income and the OECD scale. The poverty line is $ 7,882.50 based on the 1/2 median income and the square root rule. The US official poverty thresholds in 1997 are $ 8,183 for the family of one person, $ 10,473 for two, $ 12,802 for three, $ 16,400 for four, $ 19,380 for five, $ 21,886 for six, $ 24,802 for seven, $ 27,593 for eight, and $ 32,566 for nine and more.

Figure 1: Number of Prisoners per 100,000 Population for Selected Countries in 2000

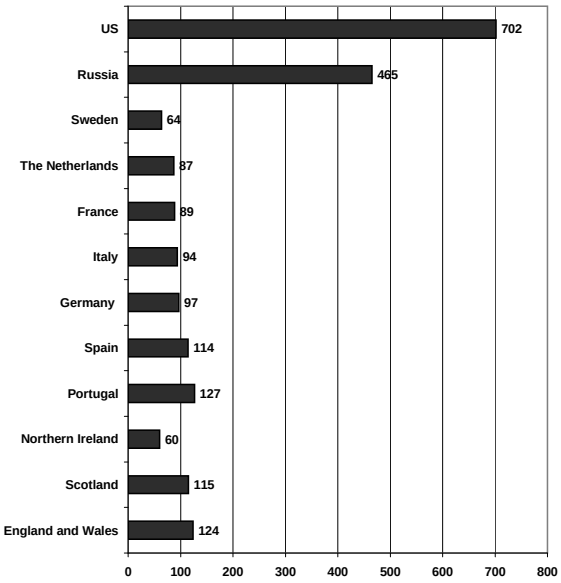

Figure 2: Between-Group Gini Index of Poverty Gap Ratios