

# THE METHODOLOGY OF THE POLICE-REPORTED CRIME SEVERITY INDEX

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## ABSTRACT

Statistics Canada has developed a new measure of police-reported crime, the Police-reported Crime Severity Index (PRCSI). Extensive development has endeavoured to ensure it is methodologically sound, easily understandable, and robust with respect to changes in crime. The methodology of the index is examined, including the overall index structure, the linkage procedure for updating the weights and how the weights are calculated. The performance of the index is examined using real and simulated changes in crime volume and sentencing patterns. In conclusion, the index is compared to other current measures of crime.

KEY WORDS: Crime Measurement, Seriousness of Crime, Volume Index.

## RÉSUMÉ

Statistique Canada a développé un nouvel instrument de mesure des crimes déclarés par la police. Il s'agit de l'Indice de gravité de la criminalité déclarée par la police (IGCDP). Son développement a suscité de vastes recherches qui visaient à garantir sa pertinence (sur le plan méthodologique), son accessibilité (sur le plan de la compréhension) et sa robustesse (en ce qui concerne l'évolution de la criminalité). Cette présentation s'intéresse à la méthodologie rattachée à l'Indice, ce qui comprend la structure globale de l'Indice, la procédure de mise à jour des poids par couplage et la technique permettant de calculer ces poids. On tente également, dans le cadre de ce texte, de mesurer l'efficacité de l'Indice en utilisant des données réelles et simulées pour étudier la variation du volume des crimes et les tendances dans l'application des peines. En guise de conclusion, l'indice est comparé aux autres mesures courantes de la criminalité.

MOTS CLÉS: Importance du crime; indice de volume; mesure de la criminalité.

## 1. INTRODUCTION

Historically, Statistics Canada has published information on crimes in Canada from two perspectives: police-reported crime from the Uniform Crime Reporting Survey (UCR) and victim-reported crime from the General Social Survey (GSS) Victimization Cycle (Statistics Canada, 2005). Both have their relative strengths and weaknesses but what they both share is that for the purpose of calculating overall rates, all crimes are treated equally, *i.e.* counted as one. A detailed explanation on the limitations associated with crime measurement can be found in a recent Statistics Canada publication regarding new developments with the UCR (Wallace *et al.*, 2009). Other notable drawbacks for the GSS include sampling error, telescoping, limited crime types, infrequent data collection (every five years), *etc.* In the case of the crime rate from the UCR, it is important to note that although it is a census, incidents not reported to the police are not in scope.

Statistics Canada has developed a third measure of crime, called the Police-reported Crime Severity Index (PRCSI). This measure is more closely related to the traditional UCR crime rates than the victimization rates from the GSS but addresses the issue of equal treatment of crimes. From the UCR data, an overall crime rate is calculated by summing up the number of crimes and dividing by the population. While this is a useful measure of crime volume with a lengthy time series, it is not an effective tool for measuring change in the severity of crimes being committed.

The PRCSI is essentially a weighted volume measure of crime, where the weights are measures of the relative severity of each type of offence. Thus, if a crime that is very serious in nature (*i.e.*, homicide, robbery, *etc.*) experiences a change in volume, the impact on the PRCSI will be more significant than the impact on the crime rate. Conversely, large fluctuations in less serious crimes (such as mischief, minor theft, disturbing the peace) will have a smaller impact on the PRCSI than they do on the crime rate.

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## 2. STRUCTURE OF THE INDEX

### 2.1 Overall Structure

As mentioned previously, the PRCSI is considered to be a volume index, in that it is principally intended to measure changes in volume over time, as opposed to something like the Consumer Price Index (CPI), which is intended to measure price changes over time (Statistics Canada, 2008). Whereas the traditional crime rate is simply the sum of the number of offences taking place in a year divided by the population (Statistics Canada, 2003), the PRCSI adds to this notion by weighting each of the offences by a measure of relative severity and then dividing by the population. For the purposes of calculating the overall crime rate, for example, one incident of murder is equivalent to one incident of disturbing the peace. In the PRCSI, however, murder has a weight of over 7000 while disturbing the peace has a weight of just nine.

Where the weights come from and how they should be determined were both sources of much debate. Several options were examined by the original working group<sup>6</sup> including (but not limited to): public opinion, financial cost of crime, maximum criminal code penalties and courts sentencing data. The latter was retained in the end for a variety of reasons. Courts data is: (1) representative nationally; (2) part of the regular Statistics Canada ongoing collection; (3) objective; and (4) collected using the same coding structure as the microdata version of the UCR (also called the UCR2). As a result, the sentencing data from Canadian criminal courts represent an objective way of measuring relative severity of crimes. At this point, it is worth mentioning the differences between the two versions of the UCR, namely the UCR1 (aggregate version) and the UCR2 (microdata version). The UCR1 has been in operation since 1962 and collects monthly totals of crime counts using the UCR1 coding structure. The UCR2 collects detailed microdata on each criminal incident, including information on victims, accused and the actual incident itself. The UCR2 also uses a more detailed coding structure that can be mapped unidirectionally to UCR1 codes.

Regarding the courts data, there were some issues involving the use of the youth component. Some members of the working group argued that since youths are sentenced under different provisions from adults, that the two sources of data were not compatible. For example, when an adult is convicted of first-degree murder, the result is a life sentence with no possibility of parole for 25 years. For youths, the maximum penalty is 10 years. Similarly, youths are in general less likely to be incarcerated than are adults in general. A study was undertaken to examine the correlation of youth sentences versus adult sentences. When excluding some rare offences with minimal courts data (and concurrently that had almost no impact on the PRCSI due to low volume), a simple linear model can be fitted between youth and adult data. For this model (and depending on which rare crimes are excluded), the coefficient of determination was found to be between 0.80 and 0.90, indicating a strong linear relationship between the data. As a result, it was decided to include youth data for two reasons: (1) many of the crimes are committed by youths, thus the omission of youth data would be inconsistent with respect to the transparency of the index; and (2) it is the *relative* weight that is important and since youth and adult data have a strong linear relationship, the addition of youth data would have little impact on the relative weights (although in general, the weights would all be lower).

### 2.2 The PRCSI Formula and the UCR2 Counts

The PRCSI is calculated by multiplying the number of offences by the weight for that offence, summing them up and then dividing by the population. This is standardized by dividing by the baseline data (namely the weighted sum for Canada for the base year) and multiplying by 100. The equation is given in (2.1).

$$PRCSI_{t/b} = \frac{\sum_{i=all\_offences} q_{i,t} w_i / pop_t}{\sum_{i=all\_offences} q_{i,b} w_i / pop_b} * 100 \quad (2.1)$$

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<sup>6</sup> The original Crime Severity Index working group consisted of provincial and federal justice stakeholders, including members of the Liaison Officers Committee, police officers, academics, criminologists, analysts from the Canadian Centre for Justice Statistics (CCJS) and a Statistics Canada methodologist.

The way this equation reads is: The Police-reported Crime Severity Index for time period t (given base year b) is equal to the weighted sum of all offences in time period t divided by the weighted sum of all offences in time period b, multiplied by 100. The population figures are also included to standardize the PRCSI, since crime volume is directly dependent on population.

This results in an index more or less centred around 100 that can be calculated for any geography or time period. However, one of the inputs for the PRCSI is the UCR2 counts at the respondent (police service) level. As of 2009, almost every police service in Canada was reporting to the UCR2 version of the survey. However, the farther back in time one goes, the lower this percentage is. In fact, in 1998 (the initial year for which index data was created), UCR2 coverage was approximately 50% while the remaining 50% was covered by the UCR1. The challenge, then, was to create UCR2 data for all respondents going back to 1998 using their UCR1 data. Fortunately, there is much overlap between the two surveys; in fact, approximately 80% of crime volume falls into categories that map exactly one-to-one between the UCR1 and UCR2 code sets. The remaining 20% therefore had to be imputed, although it is important to remember that very well established control totals exist at the UCR1 level. Although this is referred to as imputation, the procedure probably more closely resembles benchmarking. For respondents who were providing data in UCR2 format, their distribution was calculated and their UCR2 counts were benchmarked to the UCR1 totals. This was done to ensure that there would be no revisions to the historical counts of incidents, since UCR1 data is only revised one year back, while UCR2 data represents essentially a continuous database. For UCR1 respondents, a donor distribution was determined based on similar respondents. A modelling exercise showed that the most significant predictors of the UCR2 code for an incident were population-related variables. Amongst these, the municipal/non-municipal status of a police force was chosen as it was of high quality and captured the main factor, that being the size of the population being policed. Thus, any municipal police force<sup>7</sup> on UCR1 was imputed using the UCR2 data from all municipal police forces in the country. Original attempts were made using a size/population variable as part of the imputation class, but due to the relatively rare nature of certain crimes, this would often lead to nonsensical and unstable results.

### **2.3 Courts Sentencing Weights**

While the crime counts were fairly straightforward to calculate, the creation of the weights was less so. To begin with, there were questions as to what exactly should go into the calculation of the weights. Should only incarceration data be used? There was debate regarding whether other information should also be incorporated, such as conditional sentences, fines and probation. Two of the main goals of the index are for it to be objective and easily understandable. To include the other sentencing information, models would need to be built to equate levels of incarceration with fines, probation and conditional sentences. Because these other measures vary across jurisdictions and offence types, many models would be required which would result in violating these two primary objectives. In consultation with the working group, it was determined that using only the incarceration data would provide the best objective measure of relative severity. In the final model, the weights are calculated by multiplying the incarceration rate for an offence by the average sentence length for the same offence for those people who were sent to prison. Essentially, the weights represent, on average, how long a person would be sentenced to prison given that they were found guilty (convicted) of an offence. It is worth noting that to calculate the weights, the most recent five years of courts sentencing data available were used. This provides stability in the weights, especially when dealing with relatively rare crimes, which can have few, if any, convictions in a given year. Details of how often the weights are updated are found in Section 2.6.

### **2.4 Outlier Detection**

During the calculation of the PRCSI weights, some sentences for specific cases appeared to be outliers. An investigation took place to determine what the causes of these outliers were and what treatment they should receive. It is worth noting that the courts program at Statistics Canada processes approximately six million court appearance records per year. When rolled up to the charge level, the number of records used to calculate the weights (over five years) for the PRCSI still include some five million records. When examining outliers (by violation code<sup>8</sup>), some unique cases were discovered, such as one sentence for impaired operation of a vehicle resulting in an incarceration of 25 years. Clearly, such a sentence is unlikely and further investigation showed that between the start and end of the court case, the Canadian Criminal Code was revised. The person in question was actually sentenced for a homicide, but due to the changing

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<sup>7</sup> A Municipal force essentially refers to a community that has its own police force and does not contract out its policing responsibilities to large multi-jurisdictional forces, as is the case with many jurisdictions being served by the Royal Canadian Mounted Police (RCMP).

<sup>8</sup> A violation code is a 4-digit code that categorizes criminal offences into about 150 categories.

criminal code, the data made it appear as if it was another offence. The sheer volume of records that are received makes it impossible to follow up with every questionable sentence and thus it is believed that the majority of the outliers in the courts data are due to data quality issues as opposed to unique but valid cases. Regardless of the reason, courts sentencing data has proven to be very consistent with few issues such as that above.

In the end, several options were investigated for outlier detection. To begin with, sentencing data is in no way distributed normally. In addition to being multi-modal (*i.e.*, sentences are often 30 days, 60 days, etc.), the distribution is also highly skewed, with the vast majority of sentences being less than a year or two, going up to a maximum of 25 years (for homicide and others). By calculating a mean and standard deviation from this distribution (medians are frequently unstable for sentencing data), the end result would be only finding outliers with very high values, thus biasing the results downward, particularly for the more serious offences. A trimmed mean option was also investigated. Although the end result was consistent, tens of thousands of records were deemed to be outliers, most of which were valid. The final outlier detection method involved a simple logarithmic transformation which made the data follow a more normal distribution. The next step was to remove any extreme outliers, that is data points that were more than three standard deviations away from the transformed mean. When the outlier detection was ultimately performed, the final method resulted in a mere 1,400 (<0.03%) of sentences being removed as outliers.

## 2.5 Proxy Weights

There was not sufficient data to calculate a weight for every violation. Some crimes are very rare and other offences are very new (the criminal code is constantly being updated with new legislation). As a result, even though the police can arrest someone for a crime, there is no guarantee that Statistics Canada will have courts sentencing data on it anytime soon. The need thus existed to calculate proxy weights for such offences. As one of the objectives of the PRCSI is to remove as much as possible the element of subjectivity, this was not a straightforward task. There were several cases where it was obvious what should be used as a proxy weight, but what was needed was a consistent algorithm. The algorithm that performed best was one that followed the coding structure of the UCR2, in conjunction with the Canadian Criminal Code. Each violation in the UCR2 is defined by a 4-digit code, roughly generated from the structure of the criminal code. For example, all violations starting with a “1” refer to “Violations against the person”. Those starting with a “2” are “Violations against property” and so on. Within this coding structure, offences are grouped further, such that all offences involving a homicide start with “11” and all assaults start with “14”. That being said, an infanticide (code 1150) carries a maximum penalty of 5 years, while first-degree murder (1110) carries a maximum penalty of life in prison. Clearly, one would not be a good proxy for the other. Further examination of the data revealed that combining similarities in the coding with the criminal code maximum penalties performed well. As a result, similar offences with similar consequences are grouped together. The final algorithm basically allows for any violation with insufficient courts data to be approximated by similar offences with the same (or most similar) maximum penalty. Finally, it is worth noting that only about 1% of the final PRCSI comes from violations with proxy weights, and the vast majority of this is because of drug violations, which the police break down by drug type at a more detailed level than the courts. Thus, a combined weight is used for trafficking heroin, cocaine, crystal meth, *etc.*, while the policing data has individual violations for these drug types.

There was one exception in the calculation of the weights that should be mentioned. It is noteworthy because of the extenuating circumstances that surround it. The violation in question is motor vehicle theft (MVT). In the UCR2, there are two types of MVT, namely MVT over \$5000 and MVT under \$5000. These violations have existed in the UCR2 for many years. However, there is no specific criminal code section for MVT; they are merely specific cases of theft over \$5000 and theft under \$5000. However, there is currently legislation in progress that would see the creation of a new criminal code section for MVT. Additionally, police respondents and subject matter experts felt that MVT under \$5000 was more like MVT over \$5000 than it was like non-MVT theft under \$5000. As a result, a study was undertaken to examine the characteristics of sentencing for MVT. Since courts data contains no information on the presence of a vehicle in a theft, a record linkage exercise was undertaken linking policing and courts data together for incidents of theft. The policing data, which includes information about the presence of a vehicle, was added to the courts information. The courts sentencing data was then examined and four type of theft were compared: theft under \$5000 with and without a vehicle, and theft over \$5000 with and without a vehicle. As expected, theft over \$5000 was associated with significantly longer sentences than theft under \$5000. This expectation comes from the fact that theft over \$5000 carries a longer maximum penalty in the criminal code. Additionally, when looking at MVT under \$5000 versus non-MVT under \$5000, the presence of a vehicle resulted in a significantly longer sentence. However, this sentence was also significantly lower than theft over \$5000, regardless of whether or not a vehicle was involved. In conclusion, the results did not support the

hypothesis that MVT under \$5000 was equivalent to MVT over \$5000. However, it also did not support the notion that MVT under \$5000 was similar to non-MVT under \$5000. In the end, a combined weight was created for all MVTs which represented the distribution of incidents over and under \$5000. The split between over and under is about 55%-45% respectively, and this is true in the courts data and the policing data, across all provinces and historically over the past 10 years. This final solution was a compromise between the requirements of the police to not have different weights for different MVTs, the conclusion of the record linkage activity and the results displayed by the data themselves.

## 2.6 Linkage Procedure

Obviously, there is a need for the PRC SI weights to be updated periodically and once again, there was some debate over how often this should be done. A well-established index, the CPI, updates its basket every four years (Statistics Canada, 1995). In the case of the PRC SI, five years seemed most appropriate, especially considering that this is the window used for calculating the weights. However, the possibility of updating the weights on an annual basis was also examined. The performance with an annual update versus one every five years was very similar at the national level. Another factor in the decision was the interpretation of a change in the value for the index. When an annual weight change is incorporated, every change in the PRC SI is a combination of a change in severity and a change in crime volume. Since changing volume should be the driver, it was more important to minimize the “noise” from the changing weights. Thus, the final decision was made to update the weights every five years, which would minimize the impact of the weight changes and lessen the workload on production staff while allowing for periodic updates due to changing sentencing practices and new offences.

Of note, the final updating strategy incorporated is referred to as a backwards-linking chain index. Essentially, in the linkage year, denoted LY in (2.2) and (2.3), the index is calculated with the old weights and the new weights (using the same crime counts). This ratio is defined as the linkage factor and it is applied to every value for the PRC SI that occurs after the linkage. Other formulae for calculating the index across different geographies and multiple linkage factors can be found in the official specifications for the index. (Babyak, 2008)

$$CI_{t/b,p} = \frac{\sum_{i=all\_offences} q_{i,t,p} w_{2i} / pop_{t,p}}{\sum_{i=all\_offences} q_{i,b} w_{1i} / pop_b} * LF_{LY} * 100 \quad (2.2)$$

$$LF_{LY} = \frac{\sum_{i=all\_offences} q_{i,LY} w_{1i}}{\sum_{i=all\_offences} q_{i,LY} w_{2i}} \quad (2.3)$$

## 3. PERFORMANCE OF THE INDEX

### 3.1. Comparisons across Jurisdictions

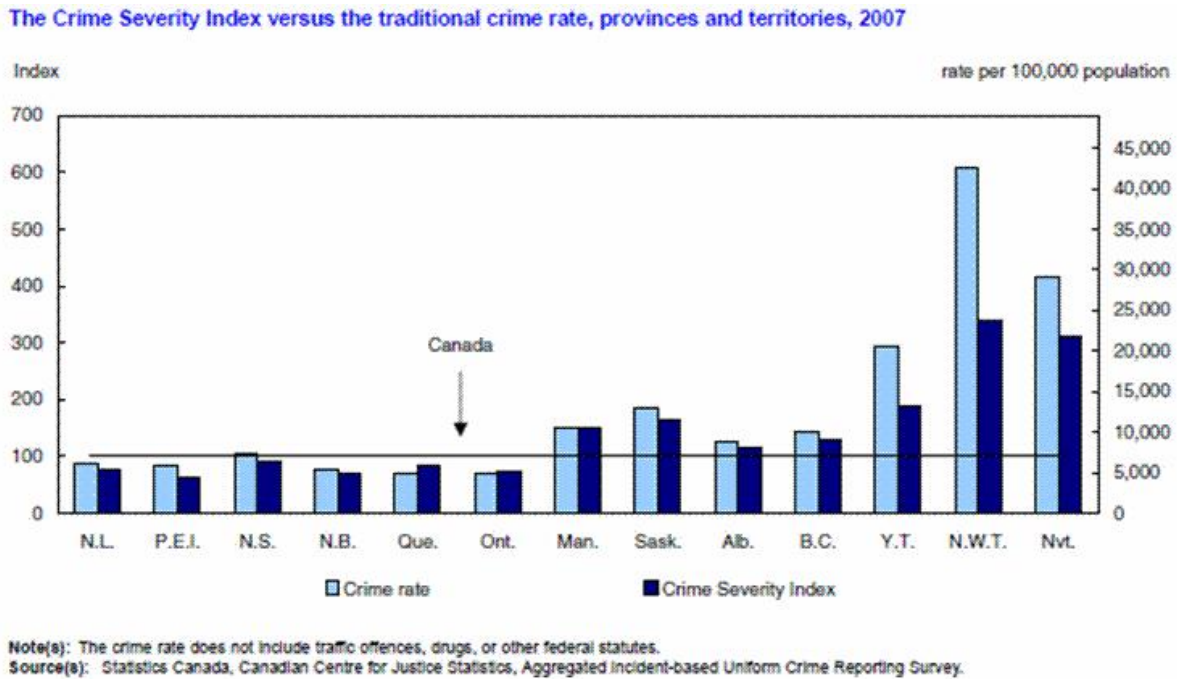
Early versions of the PRC SI showed that the index performed in the manner expected, that is to say that changes in serious crimes (break and enter, robbery, *etc.*) tended to be the driver of the index as opposed to minor offences (mischief, disturbing the peace, *etc.*) as was the case for the crime rate.

However, there were several other suppositions that had been made about the performance of the index that needed to be verified. There exist reporting differences between police services that tended to influence the crime rate in such a way as to make comparisons suspect. For example, in the province of British Columbia, marijuana possession can be dealt with via a municipal / provincial bylaw. Similarly, incidents of mischief in Calgary can be handled with a municipal bylaw. In both cases, these are significant volume offences that will not be submitted to the UCR for the cities in question. For the PRC SI, these offences both carry relatively low weights and as such, are not as influential.

Similar results are also seen at provincial levels. Despite the media attention it receives, the violent crime in Ontario and Quebec have never seemed to surface in the crime rates, with these two provinces consistently reporting crime rates among the lowest in Canada. When the severity of crime is included, both provinces approach the national average and while still in the bottom half, they no longer are the lowest. This is more intuitive and it can be shown that while the overall volume of crime in these provinces is the lowest, they tend to have more than their fair share of the more serious

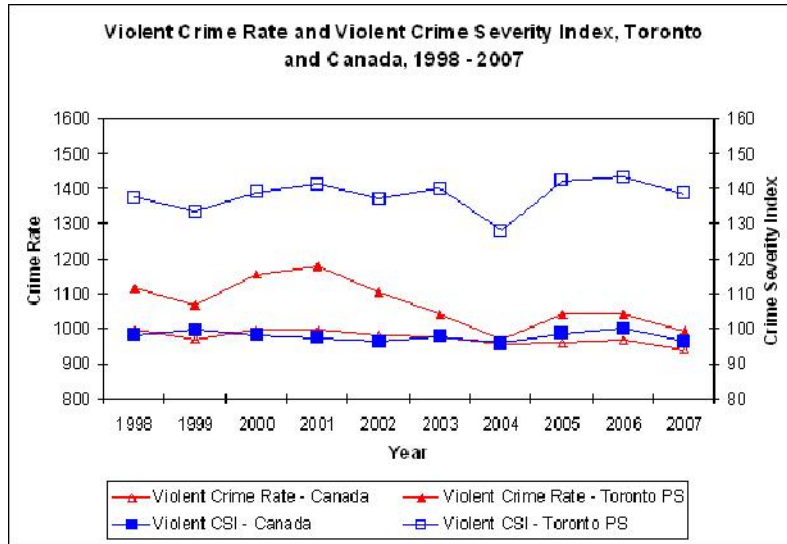
violent and property crimes. Additionally, the territories are routinely excluded from provincial comparisons due to their extremely high crime rates. However, the vast majority of crimes in the territories are minor in nature (breach of probation, disturbing the peace, *etc.*) and when crime severity is incorporated, the territories are brought back towards the national average, as can be seen in Figure 1.

Figure 1: PRCSI by Province / Territory, 2007



Other recent media attention has focused on violent crime in Toronto. However, when comparing the violent crime rate for the Toronto Police Service and Canada, while Toronto is marginally higher for most years between 1998 and 2007, the difference is quite small. When crime severity is taken into account, however, it can be seen that the violent PRCSI for Toronto is about 40% higher than the national numbers for the same time period. (Figure 2). The index correctly demonstrates that while Toronto’s violent crime rate is relatively “average”, their mix of crimes tends towards the more serious, which coincides with public perception.

Figure 2: Violent Crime Rate and PRCSI for Toronto and Canada, 1998-2007

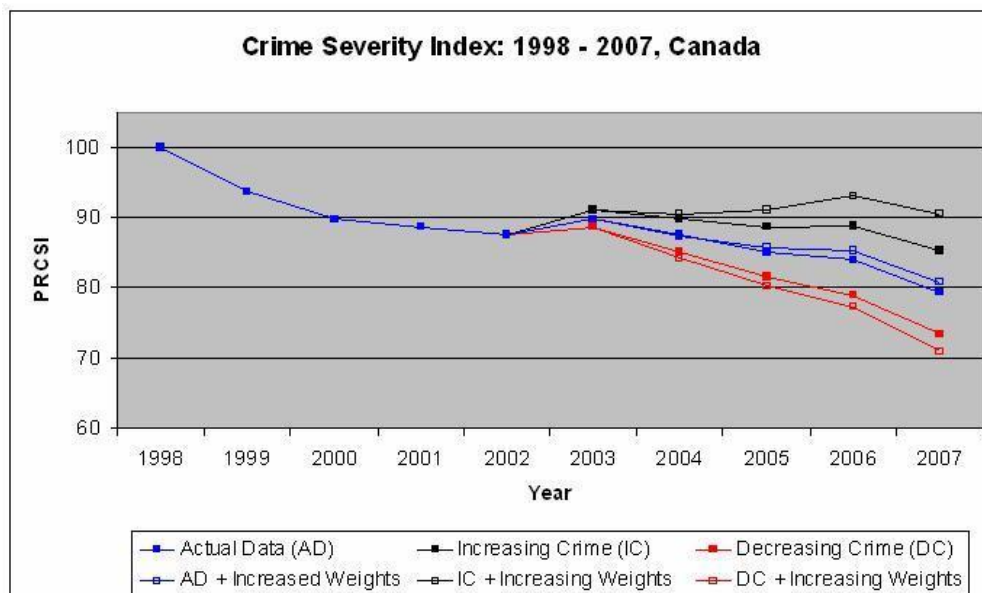


### 3.2 Legislative Changes

Another issue put forth by the working group and by the Chief Statistician was the effect that legislative changes could have on the index. For example, there is currently legislation in progress that would see a mandatory minimum sentence handed down for crimes committed with handguns. To analyze this possibility, a simulation was devised that would combine increases in the weights for certain crimes along with different scenarios for volume changes in these same crimes. To magnify the effect, weights for robbery, homicide, assault and weapons offences were doubled, although in reality, such an increase is highly improbable.

As can be seen in Figure 3, it is not the weight changes that are driving the index. In fact, the index performs exactly as anticipated. When a weight change is introduced in the simulation starting in 2003, three scenarios are projected: (1) actual data from 2003 – 2007 with and without increased weights (designated AD); (2) steadily increasing handgun crime (IC); and (3) steadily decreasing handgun crime (DC). Figure 3 shows the values for the PRCSI under these scenarios. While there are differences due to the weight change, the overall trend is most dependent on changes in the volume of crime.

Figure 3: Police-reported Crime Severity Index under a variety of Scenarios



### 3.3 Other Performance Issues

When the original publication for the PRC SI was about to be released, there were a few police respondents with abnormally high values for the index. After some investigation, it was determined that the likely culprit was inconsistent population mapping for some very small respondents. As a result, it was necessary to determine parameters that would indicate at what level a PRC SI value was unfit for publication. After some analysis, the decision was made to set 1000 people as the minimum population for publishing and to add a warning to any PRC SI based on a population of less than 5000. The 1000 figure was selected as the preliminary cut off since the worst offenders for unstable PRC SIs fell below this number. The 5000 figure was selected after examining the remaining PRC SI outliers. It is worth noting that the data required for a user to calculate the PRC SI for these small respondents is still available and that the decision to suppress these values in the publication was not for reasons of confidentiality.

## 4. CONCLUSION

In developing the PRC SI, Statistics Canada took every reasonable precaution to ensure that it was objective, easy to understand and methodologically sound. While the actual calculation for the index is fairly straightforward, there are numerous behind-the-scenes steps that take place before the final value for the index can be published. After ensuring that all of these steps contributed to a robust and useful indicator of crime, the question still to be answered is whether or not the PRC SI can be seen as a replacement for the other current measures of crime. The index is robust with respect to changes in legislation. The index can contend with reporting differences between police services. The weights are quite stable over time but allow for the addition of new crimes. However, the PRC SI is still a police-reported measure and does not include any crime that goes unreported, unlike the victimization cycle of the GSS. Additionally, the traditional crime rate has a longer time series and is a reliable workload indicator. As a result, although it presents a meaningful and important measure of crime, the PRC SI should be seen as one of several complementary measures that together, allow us to analyze the picture of crime in Canada.

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