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Measuring Crime Dispersion

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INTRODUCTION

The policy implications of crime problems which are confined to only a few geographical regions differ from those which are spread across the State. Each year, the New South Wales (NSW) Bureau of Crime Statistics and Research publishes data on the numbers and rates of recorded criminal incidents in NSW in its annual crime statistics report.[1] In addition to a brief comparative regional analysis, the report features a discussion of trends in recorded crime in NSW for major offence categories over the most recent two-year period.

When upward trends are detected in the recorded incidence of serious criminal offences, the report attracts considerable attention from the media. The headlines of such crime news stories usually engender fear and concern in wide sections of the community, regardless of the actual level of crime, or crime increase, in any particular geographical area. However, the concern in some regions may be unwarranted. An upward trend for the State as a whole does not indicate that all regions are equally affected, nor that all residents of NSW have the same risk of crime victimisation.

Given the significant public interest in crime rate increases, useful measurement of the extent of crime across different regions of NSW is critical. Existing measures generally either compare crime rates within regions over time, in order to identify a worsening or improvement in the level of crime, or rank regions by crime rate in a specific time period, in order to compare the relative safety of one community with another in relation to the risk of victimisation. Such comparisons, however, provide no information about the relative contribution made by particular geographical areas to the observed aggregate change in the State crime rate or to the current level of crime in NSW.

The purpose of this bulletin is to present some measures recently developed by the NSW Bureau of Crime Statistics and Research to describe the dispersion, or spread, of crime across regions. The value of such measures is that policy makers can determine whether crime prevention and policing activity for individual offences should be targeted at a limited number of identifiable regions, or aimed more broadly across the whole State. The methods which will be presented below include graphical methods and summary indices for measuring dispersion in both (1) increases in crime rates from one time period to another, and (2) crime rates for a single time period. For illustration purposes, NSW Local Government Area (LGA) data from 1995 and 1996 are used.

Table 1: NSW Recorded Crime Statistics 1996: selected offence categories

Offence category	*Total incidents 1996*	*Absolute increase 1995 to 1996*	*Percentage increase 1995 to 1996*
Robbery with a weapon not a firearm	1,872	407	27.8%
Sexual assault	2,802	530	23.3%
Assault	47,944	8,812	22.5%
Break and enter—dwelling	74,132	12,796	20.9%
Steal from motor vehicle	63,490	7,594	13.6%
Steal from dwelling	28,251	2,861	11.3%
Malicious damage to property	78,301	6,484	9.0%
Robbery without a weapon	4,897	379	8.4%
Break and enter—non-dwelling	43,232	2,839	7.0%
Motor vehicle theft	49,019	1,926	4.1%

RECORDED CRIME IN NSW

Table 1 shows information about changes in the number of crime incidents for the ten major offence categories which recorded a statistically significant upward trend between January 1995 and December 1996.[2] The offences in the table are ordered from highest to lowest in terms of the percentage increase in the number of recorded criminal incidents between 1995 and 1996, as shown in the final column of the table.

Other than several qualitative differences between offence categories, such as the seriousness of the offence, the impact on victims and the wider impact on the

community, the offences differ in quantitative terms. We will consider these differences in terms of four measurable characteristics, namely absolute frequency, absolute increase, percentage increase and geographical dispersion.

Firstly, the offence categories differ in terms of incidence, that is, in terms of the frequency with which they occur in a particular time period. The second column of Table 1 shows the number of recorded incidents for each offence category in 1996. It can be seen that, in 1996, high frequency offences include *malicious damage to property* (78,301 recorded incidents), *break and enter – dwelling* (74,132 incidents) and *steal from motor vehicle* (63,490 incidents).

Secondly, the offence categories differ in the level of increase in the number of recorded incidents between one year and the next. The third column in Table 1 details the absolute increase in the volume of offences between 1995 and 1996 for each offence category. Not surprisingly, the highly prevalent offences in 1996 also showed the largest absolute increases between 1995 and 1996 in terms of the number of incidents recorded: increases of 6,484, 12,796 and 7,594 incidents, respectively, for the categories *malicious damage to property, break and enter – dwelling* and *steal from motor vehicle*. In addition to these offences, the *assault* offence category showed a large increase in the number of recorded offences (an increase of 8,812 incidents between 1995 and 1996).

The third measurable difference when reporting on changes in recorded crime between 1995 and 1996 is the percentage increase, whereby the number of additional incidents recorded in 1996, compared with 1995, is calculated as a percentage of the total number of incidents in 1995. The percentage increase in the number of recorded incidents in 1996, compared with 1995, is shown in the final column of Table 1. The four offence categories which had the largest percentage increases over the two-year period are: *robbery with a weapon not a firearm* (27.8%), *sexual assault* (23.3%), *assault* (22.5%) and *break and enter – dwelling* (20.9%). These are the four offence categories which will be used to illustrate the analyses in this paper.

What Table 1 does not show, however, is that the offence categories differ in their coverage or geographical **dispersion**. It will be shown, below, that the 27.8 per cent increase in the rate of *robbery with a weapon not a firearm* between 1995 and 1996 was actually effected by less than 20 per cent of LGAs in NSW, while the 22.5 per cent increase in the rate of *assault* over the same period was effected by rate changes in almost 70 per cent of the State. Thus, as in the example just described, the dispersion of a percentage increase in crime can be used to describe the extent to which an increased crime rate between two time periods is confined to only a few geographical areas or, alternatively, is widespread across the State. In addition, dispersion may be examined cross-sectionally to determine the geographical extent of a specific crime problem in NSW at one particular point in time. These two approaches will be described in the sections which follow.

MEASURING CRIME DISPERSION: RATE CHANGE BETWEEN TWO TIME PERIODS

Table 1 showed the percentage increases between 1995 and 1996 in NSW crime rates for those offence categories which exhibited a statistically significant upward trend over the two-year period.[3] As was noted above, it is of interest to determine, particularly for offence categories with sizeable increases in the number of recorded criminal incidents, whether the increase in the State rate has resulted from a fairly uniform increase across many geographical areas, or whether the increase is due to excessive crime growth in only a few areas. The policy implications for reducing crime would be quite different in each instance. In order to make this determination, a graphical procedure will firstly be used, followed by the calculation of a numerical index. For the graphical procedure, the points on the graph for each offence category are determined by the method which follows.

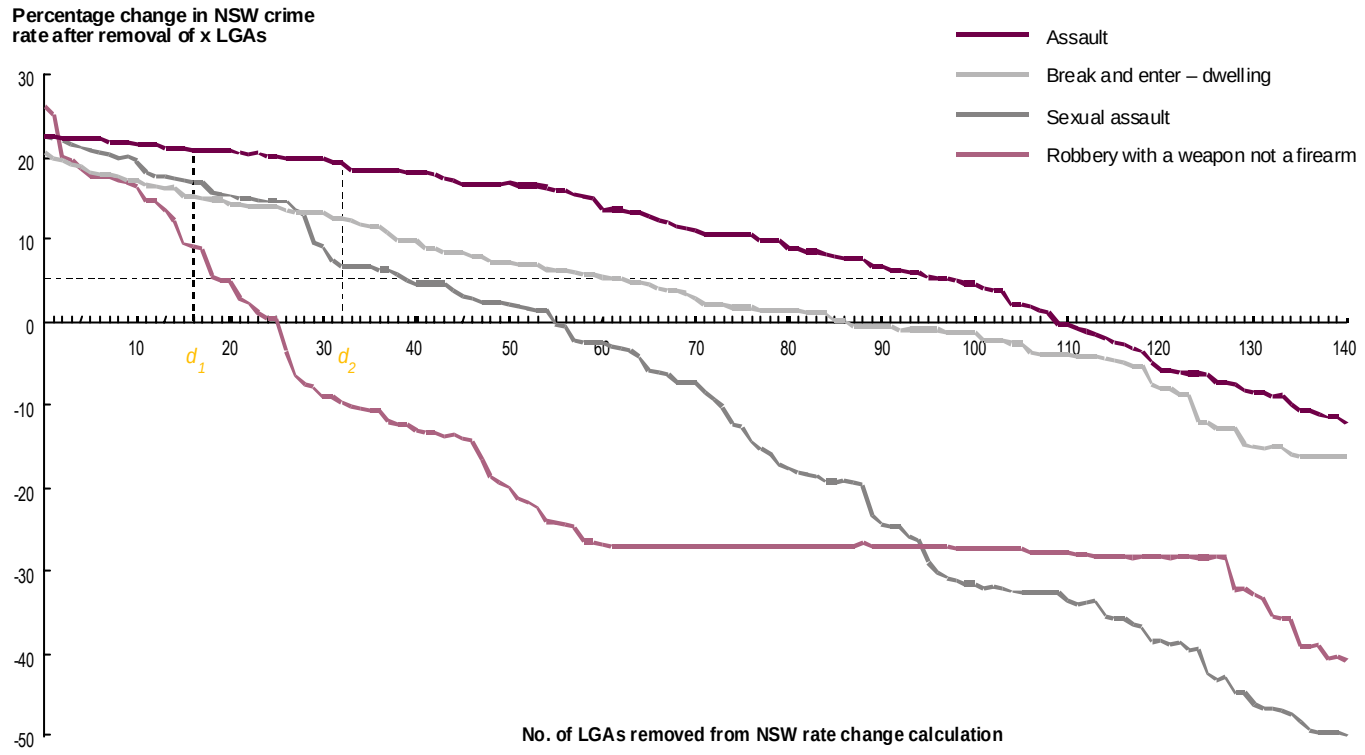
Firstly, for each category of interest, the absolute rate change over a two-year period (here, between 1995 and 1996) is calculated for each geographical area. In the present instance, the rate change was calculated for each of 160 LGAs.[4] The rate change for an LGA is calculated simply by subtracting the 1995 rate of recorded criminal incidents per 100,000 population from the 1996 rate. Secondly, LGAs are rank ordered from highest to lowest on the basis of this calculation.

The next step is to exclude the highest ranking LGA (that is, the LGA with the largest increase in rate for the specified offence) from the rate calculations for the State, and then to recalculate the percentage increase in the 'State' rate as if the 'State' now consisted only of the remaining LGAs. The same calculations are then made with the two highest ranking LGAs excluded. The procedure continues, with an additional LGA being removed from the calculations at each step.

Initially for each offence category, therefore, the single top ranking LGA in terms of the change in the total number of incidents per 100,000 resident population, over the time period of interest, is effectively 'removed' from the State's calculations. A new 1995-96 NSW percentage change in the recorded crime rate for the specified offence is then calculated from the total number of incidents recorded in 1995 and 1996 in the remaining 159 LGAs. Then, the *two* top ranking LGAs (in terms of rate change between 1995 and 1996) are removed, and an adjusted NSW percentage rate change is calculated for the remaining 158 LGAs, and so on. In general, the incidents in 1995 and 1996 for *n* LGAs are removed from the State total and a new percentage change calculation is made for the remaining (160-*n*) LGAs at that point. The recalculation proceeds until only one LGA (that with the lowest rate change) remains in calculating the so-called 'State' rate.

The series of calculations just described is carried out for each offence category of interest. A graph is then constructed for each offence category, plotting on the horizontal axis (*x*-axis) the number of LGAs removed from the calculation, against the recalculated percentage change in the 'State' rate after removal of the specified number of LGAs. That is, the value on the vertical axis (*y*-axis)

Figure 1: Dispersion of percentage change in NSW crime rate, 1995 to



corresponds to the percentage change in the crime rate for the group of remaining LGAs. By plotting several offence categories on the same chart, the relative dispersion of offences can be compared.

If the removal of only a small number of LGAs has a marked effect on the change in the State rate for a particular offence category, then it may be said that the increase in recorded crime in NSW between the two time periods is confined to only a few regions, and is not evenly distributed across the State. If this is found to be the case, then persons resident in the majority of LGAs need not be unduly concerned about an increase in their individual risk of becoming a victim of this offence. On the other hand, where the recalculated State percentage rate change decreases slowly as each successive LGA is removed (the removal of a small number of LGAs having little effect on the change in the State rate), then the distribution of the increase in crime for that offence category is widespread.

Figure 1 plots the relative contribution of LGAs to the percentage NSW rate change for the four offence categories in Table 1 which showed the largest percentage increases in crime rates between 1995 and 1996. There are four lines in Figure 1, one for each of the offence categories *assault, robbery with a weapon not a firearm*, *break and enter – dwelling* and *sexual assault*. For each offence type, the corresponding line on the graph follows the progressive change to the NSW percentage rate increase for that offence category as the top ranking LGAs are successively removed. It will be seen from Figure 1 that the patterns exhibited by each offence category are quite different.

Consider, firstly, the plot of the dispersion of the percentage change from 1995 to 1996 in the NSW rate of *assault*, the uppermost line on the graph. The total percentage increase in NSW for this offence (based on 160 LGAs) was 22.5 per cent, from 38,020 recorded incidents in 1995 to 46,591 incidents in 1996. The percentage increase of 22.5 per cent is plotted on the zero point of the *x*-axis. The next point on the graph corresponds to the percentage increase in NSW after removing the number of *assaults* in 1995 and 1996 (1,183 and 1,479, respectively) recorded in the single LGA which had the largest *assault* rate increase during this period. Without this LGA included in the calculation, the percentage increase for NSW is still 22.5 per cent. The second point on the line indicates the resultant NSW percentage increase after removing the two highest ranking LGAs from the calculation – the NSW rate is now 22.4 per cent. After removing three LGAs, the change becomes 22.3 per cent; after four, it is 22.2 per cent, and so on. Details of the calculation of the first five co-ordinates for the *assault* graph are shown in Table 2 below.[5]

It is evident from Table 2 and Figure 1 that as more LGAs are removed from the cumulative count of *assault* incidents, the percentage increase in NSW drops away, but only very slowly. For example, consider the percentage NSW increases in *assault* in Figure 1 which correspond to the points d_1 and d_2, the first and second deciles in the data set (corresponding to the removal of 10% and 20% of the LGAs respectively, that is, to the removal of 16 and 32 LGAs). The overall NSW crime rate increase at point d_1 is 21.0 per cent and at point d_2 is 19.6 per cent. That is, after removing 10 per cent of LGAs, the overall *assault* rate drops by only 1.5 percentage points; after removing another 10 per cent of LGAs, it reduces by just another 1.4 percentage points.

Table 2: Sample calculations for Figure 1 - Assault

No. of LGAs removed up to and including this point (value on x-axis)	*Number of recorded incidents in LGAs:*				*Percentage change 1995 to 1996 for remaining LGAs (value on y-axis)*
	remaining in the calculation 1996 (1)	*being removed at this point 1996* (2)	*remaining in the calculation 1995* (3)	*being removed at this point 1995* (4)	$\frac{(1)-(3)}{(3)} \times 100$
0	46,591	-	38,020	-	22.5
1	45,112	1,479	36,837	1,183	22.5
2	44,822	290	36,617	220	22.4
3	44,444	378	36,351	266	22.3
4	42,143	2,301	34,491	1,860	22.2
5	42,103	40	34,473	18	22.1

Most importantly, by considering the point at which the offence curve crosses the horizontal axis, one can determine the number of LGAs which would have to be removed from the calculation in order to achieve stability (zero change) in the rate of *assault* between 1995 and 1996. The point at which the *assault* graph crosses the *x*-axis is after the removal of 107 LGAs, or after two-thirds of all NSW LGAs have been removed. This suggests that the offence category of *assault*, when considered in terms of the relative contribution of LGAs to the NSW rate change, may be considered a Statewide problem, or one with a **high** dispersion factor.

On the other hand, consider the plot corresponding to the offence category *robbery with a weapon not a firearm*. Its line on the graph has the steepest slope, indicating that the percentage increase drops more quickly for this offence than for any other offence, as successive LGAs are removed from the State rate calculation. The overall percentage increase in NSW between 1995 and 1996 for this offence was 27.8 per cent (and is plotted on the zero point of the *x*-axis). Progressively removing one, two, three and four LGAs, respectively, results in NSW rate increases of 26.0, 25.0, 19.8 and 19.5 per cent. Thus, after the removal of only the four top-ranking LGAs, the NSW rate for *robbery with a weapon not a firearm*, while starting from more than five percentage points higher than that for the *assault* category, drops below the point to which the *assault* rate dropped after the removal of 32 LGAs. Sample calculations for the first five points graphed for the *robbery* offence category are shown below in Table 3.

The dispersion pattern is obviously very different for the offence categories of *assault* and *robbery with a weapon not a firearm*. In particular, the large increase in the crime rate between 1995 and 1996 is much less widespread for the offence category *robbery with a weapon not a firearm* than for *assault*. After the removal of only 25 LGAs (less than one-sixth of all LGAs), the State ceases to show an increase in the crime rate for *robbery*. At the first two decile points, the percentage NSW rate change falls off very rapidly – down to 9.3 per cent at d_1, and to -9.8 per cent at d_2. That is, after removing only the top one-fifth of LGAs (at d_2) from the calculation of the State rate, NSW shows an improvement in the rate of *robbery with a weapon not a firearm* – the overall rate fell, rather than rose, by almost 10 per cent between 1995 and 1996 for the remaining 128 LGAs in NSW.

Figure 1 also plots the percentage change in the NSW crime rate for the other two offence categories which showed an overall percentage increase greater than 20 per cent between 1995

Table 3: Sample calculations for Figure 1 - Robbery with a weapon not a firearm

No. of LGAs removed up to and including this point (value on x-axis)	*Number of recorded incidents in LGAs:*				*Percentage change 1995 to 1996 for remaining LGAs (value on y-axis)*
	remaining in the calculation 1996 (1)	*being removed at this point 1996* (2)	*remaining in the calculation 1995* (3)	*being removed at this point 1995* (4)	$\frac{(1)-(3)}{(3)} \times 100$
0	1,870	-	1,463	-	27.8
1	1,711	159	1,358	105	26.0
2	1,522	189	1,218	140	25.0
3	1,387	135	1,158	60	19.8
4	1,384	3	1,158	0	19.5
5	1,373	11	1,157	1	18.7

and 1996. The offence category *break and enter – dwelling* showed an overall increase in the total number of incidents between 1995 and 1996 of 20.9 per cent. The plot of the declining State percentage increase, as NSW LGAs are progressively removed for this offence category, follows a pattern somewhere between that of the *assault* and *robbery* categories. At the two decile points marked on the graph, d_1 and d_2, the percentage change for *break and enter – dwelling* in NSW drops to 15.2 per cent and 12.5 per cent, respectively. In order to observe no change in the NSW rate, a total of 85 LGAs need to be removed from the calculation (a little over half of all LGAs in NSW).

For *sexual assault*, the decline in the State percentage increase as LGAs are progressively removed is more gradual than for the *robbery with a weapon not a firearm* category, but less so than that of *assault*. Compared with *break and enter – dwelling,* the decrease is more gradual within the first decile of ranked LGAs, but more rapid thereafter. For example, for *sexual assault* compared with *break and enter – dwelling,* the percentage increase at d_1 is higher, being 17.2 per cent compared with 15.2 per cent, but at d_2 is lower, being 6.8 per cent compared with 12.5 per cent. For the *sexual assault* offence category, the *x*-axis is crossed after 53 LGAs (one-third of the total) have been omitted from the calculation of the State rate.

It should be noted here that it is not necessarily the same geographical areas which have been removed at each point for each offence category being compared (although often geographical areas with high rates of crime for one offence category also exhibit high rates for others). The contribution of any one particular LGA to the overall crime rate in NSW for all types of crime has not been measured by the method described above.[6] The method applied here simply compares the residual crime rate for an offence category after the highest ranking LGAs *specific* to that category have been removed.

In addition to the above graphical technique for comparing crime dispersion across offence categories, it is useful to calculate a numerical measure or index of dispersion for each category. The information which has been presented graphically in Figure 1 is therefore summarised numerically using the Offence Dispersion Index (ODI), which allows a straightforward comparison of dispersion across offences.

Table 4: Offence Dispersion Index (ODI)
Rate change, 1995 to 1996, NSW: selected offence categories

Offence category	*ODI*
Assault	0.67
Break and enter – dwelling	0.53
Sexual assault	0.33
Robbery with a weapon not a firearm	0.16

The ODI for a particular offence category is calculated by simply determining the proportion of LGAs which are excluded from the NSW rate calculation before a steady state situation (a zero percentage change in crime rate) between years is reached. That is, the value of the ODI for a particular offence category is equal to the proportion of LGAs which have been removed from the plot at the point of intersection with the x-axis. This index ranges from zero to one, with a low index indicating an offence category with rate increases confined to only a few geographical areas (because only a small proportion of the LGAs need to be removed to achieve a no-change situation for the State). An index closer to unity suggests that the annual increase has affected a substantial proportion of LGAs in the State. Table 4 presents dispersion indices for the offence categories plotted in Figure 1.

The dispersion indices for these offences range from 0.16 for *robbery with a weapon not a firearm* up to 0.67 for the *assault* category. The ODI of 0.16 for *robbery with a weapon not a firearm* means that the percentage increase in the NSW rate for this offence category is accounted for by only 16 per cent or 25 LGAs, while the ODI of 0.67 for *assault* corresponds to an increased number of recorded offences between 1995 and 1996 in a total of 67 per cent or 107 LGAs. The smaller index for *robbery* compared with *assault* suggests that strategies to reduce the *robbery* rate could be restricted to fewer geographical areas than strategies to reduce the rate of *assault.*

In the calculations above, offence categories with a large NSW percentage increase were selected for analysis. Each offence plot in Figure 1, therefore, commences at approximately the same point on the vertical axis. Following the plots down to the *x*-axis, it was noted that different offence categories follow a different slope pattern. Clearly, the first offence category to cross the *x*-axis, the *robbery* category, has, in general, the steepest slope as LGAs are progressively omitted from the calculations, indicating that the removal of high ranking LGAs has the largest effect on the NSW rate calculation for this category. It is further suggested that when comparing offence categories, besides looking at the point at which the *x*-axis is crossed, one could also compare the slopes at different points on the graph.

For example, the slope for the *sexual assault* graph within the first decile (up to the point d_1 on the *x*-axis) is substantially less than in the second decile (a drop of 6.1 percentage points in the first decile, compared with 10.4 percentage points in the second). This suggests that the 10 per cent of LGAs with the highest rank exert relatively less influence on the crime rate increase than the next 10 per cent of LGAs for this offence category. For the other offence categories, the contributions of LGAs within the two top deciles is more similar. Such a comparison may be done on any chosen segments of the graph.

In addition, one could choose to look, not at the point at which a zero change in the State crime rate is reached (that is, where the *x*-axis is crossed), but rather at a point which is considered to be a tolerable increase, say five per cent. A horizontal line representing a five per cent increase has been marked on Figure 1. By considering, for each

offence category, the number of LGAs which have been removed to achieve a five per cent increase, an alternative ODI (ODI_5) can be calculated and the dispersion of the offences again compared. In this case, the five per cent cut-off points for the offences are in the same order as the *x*-axis cut-offs (namely 20, 39, 62 and 96 LGAs, respectively, for the offences of *robbery with a weapon not a firearm*, *sexual assault, break and enter – dwelling* and *assault,* giving values for ODI_5 of 0.13, 0.24, 0.39 and 0.60, respectively).

Some further points should be noted about this measure of dispersion. The first is that it is not related to the size of the percentage increase in the crime rate for the entire State between the two time periods of interest. This fact is clearly demonstrated in Figure 1 by comparing the lines for *assault* and *robbery with a weapon not a firearm*. For both these offence types the percentage increase from 1995 to 1996 was similar (22.5% for one, 23.3% for the other); hence, the lines for these two offence types start at approximately the same point on the *y*-axis. However, the fact that these lines then diverge, indicating different patterns of dispersion, clearly shows that the degree of dispersion of an increase in crime does not depend on the size of the Statewide percentage increase in crime.

The second point to note is that, while there is no direct relationship between the amount of dispersion and the total amount of crime in a region, it cannot be said that the amount of dispersion is totally unrelated to the amount of crime. For example, suppose that for a specified offence category there were fewer incidents than there were regions in the State. It would be impossible for such an offence to be very widely dispersed because there would simply not be enough incidents to be distributed among all of the regions. It follows that offence categories with a low volume of incidents would probably be less likely to be widely dispersed than would offence categories with a large volume of incidents.

Finally, it should be noted that the basis chosen for the ranking procedure at the outset can be modified. In the example described above, the initial ordering of geographical areas was based on the absolute rate increase. The ordering could also be based on calculations such as the magnitude of the change in the volume of incidents, or on the percentage rate change.

MEASURING CRIME DISPERSION: RATE IN A SINGLE TIME PERIOD

The analysis above considered dispersion differences between offence categories based on the change in the crime rate over time. It is useful to know how widely a change in the crime rate over time has been experienced, but it is also of interest to know the relative distribution of offences across LGAs at a particular point in time. Therefore, a second type of crime dispersion indicator is that of the contribution of crime incidents in LGAs to the current NSW rate. Several simple measures for enumerating the spread or dispersion of a given set of numbers at a given point in time are readily available, for example, standard deviation, range, and so on. However, an alternative procedure for comparing offence categories on the relative dispersion of crime incidents, which is again based on a simple graphical procedure, is suggested here.

Offence categories will, therefore, again be contrasted on a simple measure of crime dispersion, but one which references only the crime rate in a single time period, rather than one which references the change in crime rates between one period and the next. Before the index is developed, the differences in dispersion between offence categories will be illustrated graphically using two procedures.

As before, the level of disaggregation used is the LGA. Firstly, for a specified offence category, the LGAs are ranked from highest to lowest on the total number of recorded crime incidents for the time period of interest. In addition a State total is calculated, being the total number of recorded crime incidents of the specified offence type, summed across all of the LGAs. The top ranking LGA is then removed and the total number of recorded crime incidents for the set of remaining LGAs is calculated as a proportion of the State total. Then the top two ranking LGAs are removed and the same calculation carried out, again with the total number of recorded crime incidents for the remaining LGAs being calculated as a proportion of the State total. As before, the procedure continues until all LGAs have been removed. The results are plotted in a graph with the number of LGAs removed on the *x*-axis and the proportion of total recorded crime incidents in the remaining LGAs on the *y*-axis. The same procedure is followed for each offence category.

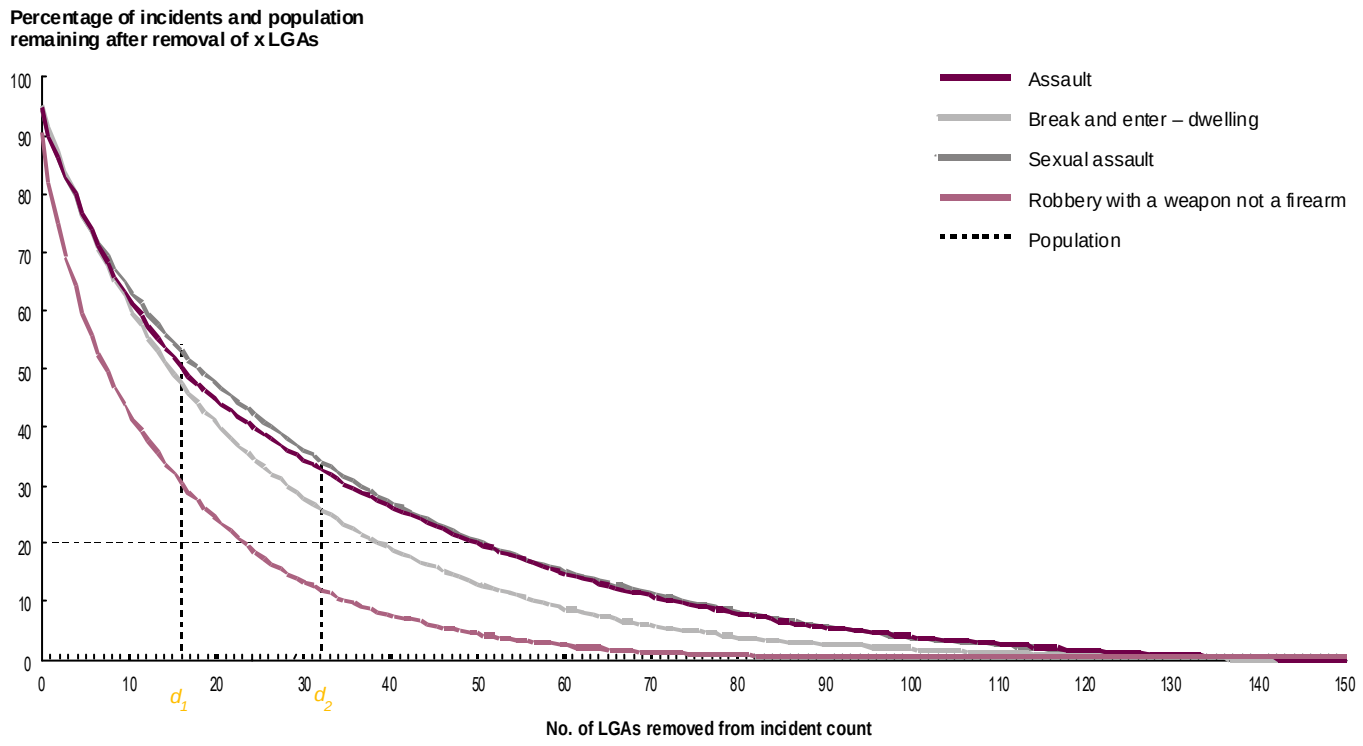
A similar procedure is also carried out on the basis of resident population rather than recorded crime incidents. In this case, after the removal of the top ranking LGAs, the calculation is the population of the remaining LGAs as a proportion of the total NSW population.[7]

All of the resulting lines, one for each offence category and one for the population, are then plotted onto a single graph. It should be noted, of course, that the particular LGAs removed at each step of the process may differ between the lines drawn on the graph, because the top ranking LGA in terms of population may not be the same as the top ranking LGA, say, for *assault*. Similarly the top ranking LGA in terms of *assault* may be different from the top ranking LGA for *robbery with a weapon not a firearm* or any other specified offence.

Following the method detailed above, Figure 2 plots the relative contribution of LGAs to the NSW rate in 1996 for the same four offence categories which were considered in Figure 1. For each offence category, the corresponding line plots the percentage of NSW crime incidents which remain after top ranking LGAs have been removed.

The patterns exhibited by each offence category are, again, somewhat different from each other. The offence lines closest to the population line indicate the more widely dispersed offence categories, that is, those categories concentrated in a pattern which most closely approximates the spread of the population in NSW. In Figure 2, the *sexual assault* category approximates the population line most closely, followed by *assault*. This suggests that, in 1996, these offences were more widely spread

Figure 2: Relative distribution of NSW crime incidents & population, 1996



across NSW than the other two categories considered. *Break and enter – dwelling* is the next most dispersed offence, followed by *robbery with a weapon not a firearm*, which is again the offence category having high rates confined to fewer geographical areas.

Again, the ranking of offences shown in the figure using this dispersion criterion does not simply reflect the relative volume of offences in NSW, as listed in Table 1. As before, a measure of dispersion can be calculated. For example, consider the decile points d_1 and d_2, which correspond to the points at which the top 10 per cent and 20 per cent of LGAs have been removed for each offence category, and for the population. After removing the first 10 per cent of LGAs (i.e. 16 LGAs) based on population rank, 58 per cent of the total NSW population remains. For the *sexual assault* category at d_1, 56 per cent of offences remain after the top decile of LGAs, with respect to the volume of incidents, is removed. The corresponding percentages at d_1 for the categories of *assault*, *break and enter – dwelling* and *robbery with a weapon not a firearm* are, respectively, 54 per cent, 51 per cent and 33 per cent. The corresponding percentages for the four offence categories at d_2, the second decile are, respectively, 37 per cent, 35 per cent, 29 per cent and 14 per cent. At the second decile, 37 per cent of the NSW population remains in the calculation. Clearly, the spread for *robbery with a weapon not a firearm* in 1996 approximates the population spread in NSW less closely than do those of the other three offence categories.

Alternatively, different points of intersection may be considered. For example, consider the number of LGAs which would need to be removed in order to remove 80 per cent of the population or 80 per cent of the total number of recorded criminal incidents for a particular offence category in NSW. These points on the graph correspond to a remainder of 20 per cent of the population or 20 per cent of the volume of incidents, and thus have a y-value of 20 per cent. In Figure 2, a horizontal line at 20 per cent on the y-axis has been drawn to enable the x-values of these points to be noted. Thus, 20 per cent of the total population of NSW remains after the removal of 55 LGAs. The numbers of LGAs that need to be removed to leave only 20 per cent of incidents for each offence category are: 54 for *sexual assault* and *assault*, 42 for *break and enter – dwelling*, and 25 for *robbery with a weapon not a firearm*. Again, the pattern for *robbery with a weapon not a firearm* indicates a higher level of concentration than do the patterns for the three other offences.

In order to enumerate the differences between offence categories which are illustrated in Figure 2, a method commonly used by economists to measure disparity in the distribution of income and wealth, the Lorenz curve and associated Gini index, may also be applied.[8] A Lorenz curve will be drawn for each of the four offence categories considered above based on the number of crime incidents by LGA in 1996.

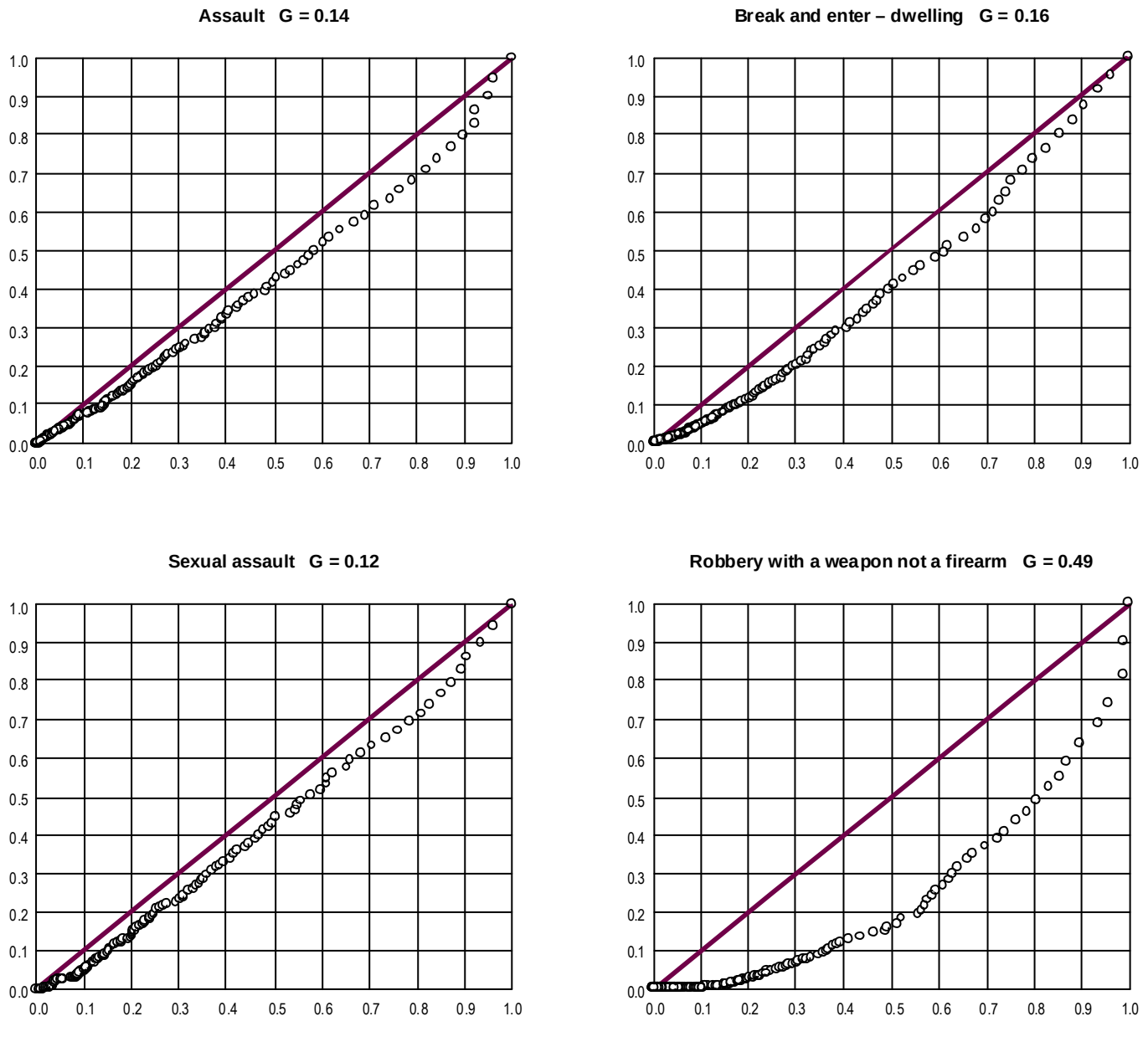
The points on the Lorenz curve for the incidence of recorded crime for each offence category in a particular year are calculated as follows. Firstly, for a specified offence category, the LGAs are ranked from lowest to highest on the total number of recorded crime incidents for the time period of interest. Note that this contrasts with the ranking of LGAs in both Figures 1 and 2, which were based

on a highest to lowest ranking. As with the calculations for Figure 2, a State total is also calculated, representing the total number of recorded crime incidents of the specified offence type, summed across all of the LGAs.

The calculation of the points on each of the Lorenz curves in Figure 3 involves the progressive addition (rather than the removal of LGAs, as in Figures 1 and 2) of LGAs at each step. That is, at the first step in calculating the points to be graphed on the curve, the total number of recorded criminal incidents for the specified offence category in the **lowest** ranking LGA is calculated as a proportion of the State total. This is the value which is plotted against the *y*-axis. The corresponding point along the *x*-axis is the proportion of the State population in this same LGA. At the next step, the two lowest ranking LGAs are included, and the same calculation carried out. That is, the total number of recorded crime incidents for the two lowest ranking LGAs is calculated as a proportion of the State total, and plotted against the proportion of the State's total population resident in these two LGAs. The procedure continues until all of the LGAs have been incorporated into the calculation.

Consider the method used to calculate the Lorenz curve for the offence category *assault*. In 1996, the LGA which had the smallest number of recorded *assault* incidents, and therefore ranked lowest among the 160 LGAs used in the calculation, recorded just six incidents of *assault*. Altogether there were 46,591 incidents in 1996 recorded in NSW. Hence, this lowest ranked LGA accounts for 6/46,591 or 0.01 per cent of the total number of *assault* incidents in NSW. This LGA has a population of 3,060 which is 0.05 per cent of the total NSW population. Hence, this LGA accounts for 0.01 per cent of total *assaults* and

Figure 3: Lorenz curves and Gini indices (G) for selected offences, 1996



0.05 per cent of the total NSW population. The first point plotted on the Lorenz curve for *assault* is therefore 0.01 per cent on the *y*-axis against 0.05 per cent on the *x*-axis.

The LGA ranked second lowest in the number of *assault* incidents in 1996 recorded seven *assaults*, and had a population of 3,650. Together these two lowest ranking LGAs account for 0.03 per cent of total *assaults* and 0.11 per cent the of total population in NSW. Hence the next point plotted in the Lorenz graph for *assault* is 0.03 per cent on the *y*-axis against 0.11 per cent on the *x*-axis.

The same procedure is followed for each offence category. Figure 3 details the Lorenz curves plotted for each of the four offence categories considered in this bulletin.

Each point on a Lorenz curve therefore represents the cumulative proportion of crime accounted for by a particular group of LGAs (on the *y*-axis) plotted against the cumulative proportion of population accounted for by these same LGAs (on the *x*-axis). The point furthest left represents these cumulative proportions for one LGA only (the lowest ranked in terms of the number of offences). The next point along to the right represents these cumulative proportions for two LGAs (the two lowest ranked), and so on. The point at the far right is always at the 100 per cent point on both axes because all LGAs are included in the calculation for this point and hence all of the State's crime and all of the State's population is accounted for by this point.

If the amount of crime is distributed across regions in exactly the same proportions as is the resident population, then the crime rate (being equal to the number of offences per population) is exactly the same for each region. Such a situation is reflected by the diagonal line in the Lorenz graph. If, on the other hand, there is variation across regions in the crime rate (and hence in the amount of crime relative to the population), then the line departs from the diagonal. Note that the consequence of ranking the LGAs from lowest to highest is that such a line always falls below the diagonal.[9]

On each graph, the Lorenz curve for the offence category is compared with the diagonal line which corresponds to a match between incidents and population for each LGA – that is, equivalent crime rates across all geographical areas. The closer the curve is to the diagonal line, the more uniform the distribution of crime (that is, the more widely dispersed the crime). A large area between the line and the Lorenz curve means that crimes are more concentrated in particular areas. The Lorenz curves in Figure 3 confirm the distributions noted in the section above, with the *robbery* category showing the least similarity to the population spread. That is, in Figure 3, *robbery with a weapon not a firearm* has the most bowed shape, while the other offence categories follow the diagonal more closely.

The Gini index associated with each Lorenz curve is a numerical index of the relationship between the actual dispersion or spread of crime across LGAs at a particular point in time, and the spread which would exist if crime rates across the State were equal. In the case of data measured on a continuous scale, such as income, the Gini index is calculated as the ratio of two areas: the area between the Lorenz curve and the diagonal line, and the total area below the diagonal. In the present application, however, because we are using a distinct number of LGAs, we can calculate, for each LGA, the 'distance' (that is, the difference in the *y*-values) between the point on the diagonal line and that on the curve. We then sum these values across the set of 160 LGAs in NSW, and express this as a proportion of the sum of the distances from the zero point on the *y*-axis up to the diagonal (that is, the sum of the *y*-values for the diagonal line).[10]

The value of the Gini index described above represents the disparity between the observed distribution of crime across geographical regions of NSW, and the distribution which would exist in a situation of homogeneity, where the crime rate is equal in all regions of NSW (or widely dispersed). The Gini index can range from zero to one, with values closer to zero indicating wide dispersion, and those closer to one indicating a greater concentration of recorded crime incidents in particular geographical areas, or a higher degree of 'inequality' with respect to the crime rate.

Table 5: Gini index of 1996 rate: selected offence categories

Offence category	*Gini index*
Assault	0.14
Break and enter – dwelling	0.16
Sexual assault	0.12
Robbery with a weapon not a firearm	0.49

The values of the Gini index for the offence categories analysed in this paper are shown in Table 5. The calculated indices confirm the distributional differences between offence categories which were noted in the above section. The categories *sexual assault, assault* and *break and enter – dwelling* follow a dispersion pattern which reflects the LGA population, while *robbery with a weapon not a firearm* is concentrated in a smaller selection of LGAs in NSW in 1996. That is, the Gini index of 0.49 for the offence *robbery with a weapon not a firearm*, compared with Gini indices which range between 0.12 and 0.16 for the other three offence categories, suggests a more uniform (more widely dispersed) pattern of crime for the offences *sexual assault*, *assault* and *break and enter – dwelling* than for *robbery*.[11]

In this section, therefore, we have developed two graphical representations and an associated numerical index which allows us to describe the dispersion of crime across NSW at a particular point in time for selected offence categories. As with measures of dispersion in changes in the crime rate, additional information about the dispersion of crime in a particular time period enhances the information already available to policy makers who wish to determine whether policing activity and crime prevention should be targeted at a small number of specific geographical areas or more widely across the State.

CONCLUSION

While annual crime rate levels and changes in crime rates are routinely analysed in NSW, the measurement of dispersion or the spread of crime by offence category has not been previously undertaken. By considering the changes in crime rates for a selection of offences between 1995 and 1996, and the relative crime rates across LGAs in NSW in 1996 for these same offences, this bulletin has developed graphical procedures and associated numerical indices which describe crime dispersion, including a demonstration of how the Lorenz curve and Gini index can be applied to crime data.

The methods presented above can be applied to any set of offence categories at any level of disaggregation. Local Government Area was chosen as a compromise between choosing areas large enough to show meaningful rate changes, yet small enough to allow differences in dispersion to emerge. For police, the analysis may be better performed at area command level to enable the relative effect of a change in crime rate in a specific region of NSW to be calculated. Further, as was noted earlier, ranking on alternative measures may be done prior to the application of the graphing procedure, or any appropriate combination of offence categories selected for comparison.

The methods described in this bulletin are thus a useful starting point for developing a measure of dispersion which can be tailored to the needs of individual users. These simple methods lend themselves to further refinement and to the development and calculation of alternative measures of dispersion.

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NOTES

1 The two most recent published reports in this series are: Chilvers, M. 1998, *NSW Recorded Crime Statistics 1997,* NSW Bureau of Crime Statistics and Research, Sydney; and NSW Bureau of Crime Statistics and Research 1997, *NSW Recorded Crime Statistics 1996,* NSW Bureau of Crime Statistics and Research, Sydney.

2 Although an 11th category, *fraud*, was shown to have an upward trend in the *NSW Recorded Crime Statistics 1996* publication, this offence category has been excluded from the present analysis because it is one which depends on police detection rather than on reporting to police.

3 Because the same population estimates were used for the calculation of both the 1995 and 1996 crime rates, the percentage increases in crime rates are identical to the percentage increases in the number of recorded criminal incidents shown in Table 1. However, if different population estimates are used in the rate calculation, rate changes will be similar, though not identical, to changes in the number of recorded incidents.

4 Crime rates in areas with small population, and comparisons of recorded crime rates across such areas, may be unreliable. There are, in fact, 179 LGAs in NSW, but 19 of these had populations of less than 3,000 in 1996. The analyses reported here are based on the 160 LGAs with populations of 3,000 or more. For the purposes of illustration, NSW is deemed to consist of just these 160 LGAs when dispersion across the State is being considered.

5 Note that the resultant percentage change in Table 2 is referred to as a 'rate' change, but no measure of population has been included in the calculation. This is because recorded crime statistics for both 1995 and 1996 were based on the same population estimate. If the estimate of population differed between the two time periods, there would be an additional step in the calculation – namely, the calculation of a rate for the remaining NSW residents. This has not been illustrated.

6 While the method described here deals with specific offence categories in turn, it could be adapted to examine the contribution of particular LGAs to the overall crime rate. Such an adaptation would require combining crime rates across categories prior to ranking (for example, by summation of total incidents across a number of offences). With such an approach, however, caution should be exercised, as a simple aggregation of offence categories may not always be meaningful.

7 As before, LGAs having resident populations less than 3,000 are excluded from the analysis. The calculation of total recorded criminal incidents and total NSW population are therefore based on 160 rather than the complete set of 179 NSW LGAs.

8 See, for example: Lee, W.-C. 1996 'Analysis of Seasonal Data Using the Lorenz Curve and the Associated Gini Index', *International Journal of Epidemiology*, vol. 25, no.2, pp.426-434; and Tziafetas, G.N. 1989 'A Formula for the Gini Coefficient and its Decomposition', *Biometrical Journal*, vol. 31, no. 8, pp.961-967.

9 Because the regions are ranked from lowest to highest in the amount of crime, there is relatively less crime than population in the lower ranking LGAs and hence the values on the *y*-axis fall below the corresponding values on the diagonal.

10 The formula for calculating the Gini index for a discrete distribution is given on page 964 of Tziafetas (1989), referenced in footnote 8.

11 Note that a value close to one for the Gini index indicates a narrow offence dispersion. This contrasts with the Offence Dispersion Index, developed earlier in the bulletin, for which a value close to unity indicated a wide offence dispersion. This is because the ODI is a direct measure of *dispersion*, while the Gini index is, traditionally, a measure of *inequality*. Clearly, a high level of crime dispersion is synonymous with a low level of 'inequality' across regions.

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