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## Crime Concentration in Ireland in 2012: A Location Quotient Approach

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### Abstract

The aim of this paper is to investigate spatial patterns of crime in Ireland to develop a better theoretical understanding of the role of geography and opportunity, as well as enabling practical crime prevention solutions that are tailored to specific places. The analysis uses crime data sourced from the Central Statistics Office to analyse crime concentration for a range of crime categories using alternative measures of concentration. The findings of this paper indicate that crime concentrates in particular places in Ireland. The findings may be utilised by An Garda Síochana (Irish police force) to enable practical crime prevention solutions that are tailored to specific places. Particularly, the concentrations of certain sub categories of crime may require a rearrangement of current resources, as well as the deployment of additional resources to worst affected areas.

**Key words:** Crime concentration, crime rates, location quotient, Ireland.

### Introduction

Crime concentration refers to geographical regions with higher levels of crime relative to larger geographical units, usually nations. Research within the economics of crime and spatial criminology find evidence of high concentrations of crime in particular places (Brantingham and Brantingham, 1993, 1998; Melo et al 2015; Eck and Weisburd, 2015). Additionally, the literature suggests that this concentration varies across different crime types. This paper examines crime concentration in Ireland in 2012 across different categories of crime including property crimes, person crimes and crimes against society. Melo et al (2015) question the appropriateness of aggregating crime types when the underlying spatial pattern is of interest. As such, the study analyses the concentration of sub categories of crime across Ireland to ascertain whether concentration changes at a more detailed level.

The analysis uses crime data sourced from the Central Statistics Office to analyse crime concentration. Crime concentration is examined for a range of crime categories using alternative measures of concentration – crime counts, crime rates and location quotients (LQs). Crime counts measure the absolute number of crimes committed in an area during a specified period of time while crime rates measure the ratio of crimes in a region to the population of that region; expressed per 10,000 of population. Crime counts and crime rates are common measures of crime concentration. However, the adoption of location quotients in the criminological literature has been sparse and to my knowledge no studies have been conducted in Ireland on measuring crime concentration using this measure. The location quotient is a measure of concentration which measures how concentrated a particular region is compared to a larger geographical region, usually the nation. Location quotients have been used extensively in economics literature to measure the concentration of a particular industry (Feldman & Florida, 1994) cluster (Delgado, Porter, & Stern, 2014; Porter, 2003), occupation (Cover,

Jones, & Watson, 2011) or socio-demographic group (Morrill, 2016; Simpson & Finney, 2009) in particular regions. However, its adoption into criminological measurement has been both sparse and generally quite recent. The aim of this paper is to investigate spatial patterns of crime in Ireland to develop a better theoretical understanding of the role of geography and opportunity, as well as enabling practical crime prevention solutions that are tailored to specific places.

The next section provides a review of the relevant literature on crime concentration and crime mapping, followed by an outline of the data and methodology used in this study, as well as a detailed analysis of crime concentration across different crime types using three measures of concentration – counts, rates and LQs. Furthermore, a visual representation of different categories and subcategories of crime in Ireland is presented using mapping techniques. Finally, the findings and potential policy implications of the research are discussed.

## **Literature Review**

Crime mapping has been of interest since at least the beginning of the 19th century with the pioneering work of Guerry (1833) and Quetelet (1842) in France, Plint (1851) and Mayhew (1862) in the United Kingdom and Halpern et al. (1934) and Shaw and McKay (1942) in the United States.

André-Michel Guerry and Adolphe Quetelet are credited with establishing the study of ‘moral statistics’ which later became the foundation for modern social science and criminology. Guerry (1833) provided the first systematic analysis of comprehensive data on crime, suicide, and other social variables in France. Guerry used tables and maps to analyse patterns of crime and suicide and found that while criminal activities remain constant over time, they differed systematically across regions, age groups and types of crime. Similarly, Quetelet (1842) made extensive use of statistical techniques to gain insights into the relationships between crime and other social factors. Quetelet placed social factors, not moral or evil, as the key determinants of crime and found strong relationships between age and crime, as well as gender and crime. Other influential factors he found included climate, poverty, education, and alcohol consumption.

Plint (1851) and Mayhew (1862) conducted similar studies in England which indicated variations in patterns of crimes in different cities, towns and villages. Mayhew (1862) identified areas in London known as ‘rookeries’ which exhibited high levels of criminal residence and consequently persistent high levels of crime over time. Shaw and McKay (1942) developed social disorganisation theory which analyses environmental correlates of crime, namely, spatial variations in crime rates and neighbourhood ecological characteristics. A major conclusion was that poverty or deprivation was most closely related to the geography of crime (Ackerman, 1998). Research in this vein argues that crime is transmitted through frequent interactions with criminal traditions which are developed and strengthened over time in disorganised areas of a region. As such, geographical context of human behaviour is very important when examining the underlying determinants of criminal activities.

Brantingham and Brantingham (1993) first introduced the location quotient into criminological research, but its adoption into criminological measurement has been both sparse and generally quite recent. The works of Rengert (1996) and Hirschfield and Bowers (1997) are the only ones found that used the location quotient to study crime during the 1990s, with Andresen (2007),

McCord and Ratcliffe (2007), Ratcliffe and Rengert (2008), and Robinson (2008) more recently also using the location quotient in crime analysis.

In Ireland, no such studies have been conducted analysing the concentration of crime. The Central Statistics Office is responsible for publishing official recorded crime statistics. These crime statistics are based on administrative data provided by An Garda Síochana from their Police Using Leading Systems Effectively (PULSE) system. The Central Statistics Office (2014) provide a broad overview of the trends in recorded and detected offences across the 16 top level offence groups of the Irish Crime Classification System (ICCS) up to the end of 2012. The report highlights crime counts and crime rates across various crimes but overlooks the LQ as a potential measure for crime concentration.

The next section outlines the data and methodologies used to carry out the analysis of crime concentrations in Ireland. The section includes a discussion on the potential limitations of the data employed, as well as the strengths and weaknesses of various measures of concentration utilised in the study.

### **Data and Methodology**

This paper uses Irish crime data sourced from the Central Statistics Office. The Central Statistics Office provides a detailed set of crime categories based on administrative data provided by An Garda Síochana from their PULSE system. The crime categories are based on the Irish Crime Classification System (ICCS). Analyses of individual criminal events and of individual person, building or street victimization studies are currently of great interest (Clarke, 1980, 1992), but for practical purposes individual criminal events must be aggregated in order to assess patterns and devise methods for addressing them (Brantingham and Brantingham, 1998).

The Central Statistics Office Annual Crime Statistics provide data for six Garda Síochana regions, which comprise of 28 Garda Síochana Divisions. A list of An Garda Síochana Divisions is provided below.

Figure 1: An Garda Síochána regions and divisions in Ireland



Source: An Garda Síochána (2017).

**Dublin Metropolitan Region:** Eastern DMR, North Central DMR, Northern DMR, South Central DMR, Southern DMR and Western DMR.

**Eastern:** Kildare, Laois/Offaly, Meath, Westmeath and Wicklow.

**Northern:** Cavan/Monaghan, Donegal, Louth and Sligo/Leitrim.

**North Eastern:** Kilkenny/Carlow, Tipperary, Waterford and Wexford.

**Southern:** Cork City, Cork North, Cork West, Kerry and Limerick.

**Western:** Clare, Galway, Mayo and Roscommon/Longford.

Data at Garda Síochána Division level is very detailed and relates to specific crime categories. However, it is only available at a broad spatial scale. Larger counties are broken down into smaller divisions, for example, Dublin is broken down into five Garda Síochána Divisions - DMR Eastern, DMR North Central, Northern DMR, South Central DMR, Southern DMR and Western DMR while Cork County is broken down into three Garda Síochána divisions - Cork City, Cork North and Cork West. Alternatively, smaller counties are aggregated into a single Garda division, for example, Laois and Offaly make up a single Garda Síochána division.

This paper analyses crime concentration across a range of crime categories using alternative measures of concentration. Firstly, crime levels are analysed using actual crime counts. Actual

crime counts provide information on all reported crimes by Garda Síochána division. Crime counts are used to assess the locations of ‘hot spots’, assess police work loads and estimate future resource needs. Using actual crime counts, however, as a measure of concentration has some drawbacks. Analysing crime concentration by actual crime counts does not take into account the population or population density of the region being studied and thus may provide misleading results. For example, 1,000 recorded burglary crimes have different implications in a region with 100,000 people compared to a region with a population of 1,000,000 inhabitants.

To overcome some of the potential pitfalls associated with analysing crime concentration by actual crime counts, the crime rate is also utilised as a measure of concentration. The crime rate measures total crime rate per 10,000 of population. Using crime rates as a measure of concentration provides advantages over using the absolute number of crime i.e. crime counts. Utilising crime rates allows for an assessment of trends discounted for changing conditions (such as population growth). Brantingham and Brantingham (1998) note that crime rates are particularly useful in planning prevention campaigns and in assessing the impact of changing social conditions of the risk of crime.

Generally, limitations of crime data in Ireland should be considered before attempting to analyse the concentration levels of crime. Firstly, the recorded counts of crime events often represent an underestimation of actual crime counts. The reasoning for this is that some crimes tend not to be reported to police while counting and recording rules typically record only the most serious offense in any complex criminal transaction. Furthermore, evidence suggests that differences exist between reported crimes and recorded crimes in Ireland. The Central Statistics Office (2015) estimated 20% of crime reported to An Garda Síochána in 2011 via their Command Aided Dispatch (CAD) equipped divisions does not appear to be captured on the PULSE system. These CAD divisions accounted for approximately half of all recorded crime in Ireland.

Secondly, actual crime data may be incorrectly categorised or re-categorised which may distort the findings of particular concentration studies. In Ireland, an estimated 3% of incidents were incorrectly classified to the wrong crime category while a further 4% of cases had insufficient information to determine the correct classification. Some 7% of incidents classified to Attention and Complaints (a non-crime category on PULSE) should have been classified as a crime, generally as either fraud or assault. The equivalent figures for Property Lost and non-crime Domestic Disputes were 4% and 7% respectively (Central Statistics Office, 2015).

Thirdly, timelessness issues with recording crimes have been identified as a potential drawback to using crime data for analytical purposes. The length of time between reporting a crime and the recording of the crime on the PULSE system could be associated with data errors such as the accidental exclusion of crime data and misspecifications of crime data. The Central Statistics Office (2015) analysed all criminal offences created on PULSE in 2012 (269,194 records) and found that 6.7% of offences were created more than one week after the reported date.

Finally, evidence suggests crime data in Ireland is often incorrectly labelled “detected” or “invalidated”. The Central Statistics Office (2015, p.24) found that 35% of the offences without a charge or summons sheet attached were incorrectly designated as detected, based on current Garda Síochána detection rules. This has the effect of reducing the overall number of detected crimes from 138,807 to approximately 116,500 cases, or a drop of 16%. Furthermore, the

Central Statistics Office concluded that 23.1% of invalidated incidents were invalidated incorrectly. These limitations must be considered when analysing criminal activities in Ireland.

The limitations of the data point to evidence of crime being underreported, incorrect status applied to particular cases and problems associated with length of time between reporting and recording of particular crimes. However, these issues are systematic and patterns of variance are unlikely to be present across regions. As such, studies analysing the concentration of crimes using recorded crime data can be considered representative of the actual levels of crime concentration in Ireland.

This paper uses location quotients (LQ) as an alternative measure of crime concentration in Ireland. The LQ is a popular measure of concentration amongst economic geographers, particularly with regards to the concentration of employment (Porter, 2003; Delgado et al 2014). However, the measure has been rarely applied to measure concentrations of crime. The location quotient is measured by comparing the concentration of a particular industry, cluster, demographic group or occupation in a particular region compared to the national average.

The LQ is measured by:

$$LQ_{i,n} = \frac{E_{i,n}}{E_{t,n}} = \frac{\sum E_{i,n}}{\sum_{n=1} E_{t,n}}$$

where: n is small area under observation, N = total areas,  $E_i$  = employment in industry  $E_t$  = total employment in all industries. Following accepted economic theory, an  $LQ > 1$  indicates that an area has proportionately more workers than the larger comparison area employed in a specific industry sector. A region with a  $LQ > 1.25$  is considered to be over represented in a particular industry compared to the national average while an  $LQ < 1$  indicates that the region is underrepresented compared to the national average.

For this paper the LQ has been adapted in order to provide a measure for crime concentration in Ireland. The model below shows the formulae for calculating the LQ in criminological form:

$$LQC_{i_n} = \frac{C_{i_n}}{C_{t_n}} \bigg/ \frac{\sum_{n=1}^N C_{i_n}}{\sum_{n=1}^N C_{t_n}} \quad \text{Brantingham and Brantingham (1998)}$$

Where: n= small area under observation, N= total of all areas,  $C_i$ = crime count (local area),  $C_t$ = total crime count.

An example is now presented to illustrate how calculations are made using the LQ. In 2012, Northern DMR had the highest concentration of robberies measure by LQ in Ireland with a LQ of 2.15, over double the national average. In 2012, there were 437 robberies recorded in Northern DMR out of 17,595 crimes in total in the region. In Ireland, the total number of robberies recorded in 2012 was 2,818 with 243,968 crimes recorded in total. Thus, the LQ is calculated as:

$$\frac{\left(\frac{437}{17,595}\right)}{\left(\frac{2,818}{243,968}\right)} = 2.15$$

Thus, the LQ is given as the ratio of the concentration of particular crimes relative to total crimes in a particular region compared to the concentration of the particular crime to total crimes in the country. The classification outlined by Miller *et al.* (1991) is used in this paper for interpreting the location quotient of crime: much underrepresented areas,  $0 \leq LQ \leq 0.70$ ; moderately underrepresented areas,  $0.70 < LQ \leq 0.90$ ; average represented areas,  $0.90 < LQ \leq 1.10$ ; moderately overrepresented areas,  $1.10 < LQ \leq 1.30$ ; and very overrepresented areas,  $LQ > 1.30$ . These classifications are used in the legend classifications below. Miller et al (1991) provide a more substantial classification than standard economic theory with five classifications used instead of the standard three.

While the LQ offers significant advantages it should be noted that certain limitations exist when utilising the measure for analysing crime concentration. Similar to other measures the LQ is dependent on the level of aggregation used and crime classification schemes. Brantingham and Brantingham (1998) assert that limits are introduced when crimes are divided into property/violent clusters, specific criminal code violations or index crime categories. Similarly, Melo et al (2015) question the usefulness of using broad categories of crime when the underlying spatial effects are of interest.

This paper seeks to overcome this issue by firstly analysing crime concentration across three broad categories of crime i.e. crimes against the person, property crimes and crimes against society, and, secondly, analysing trends in narrow categories of crime to ascertain which specific crimes are different from the general trends, or within a category such person crimes, which types of person crimes are different from a restricted comparison to crime against the person trends.

Furthermore, LQ measures of crime concentration are restricted by the boundaries selected to carry out analysis. As such, particular concentrations of crime may potentially be hidden if the level of aggregation selected is overly broad or narrow. For example, the concentration of a particular type of crime e.g. theft and related offences is likely to vary depending on whether the level of aggregation is the local unit, city, police force, county or NUTS 3 regions (territorial units for statistics – EU classification). Furthermore, certain concentrations of crime may be best captured across borders which will not be detected using LQ, although the visual representation presented in this paper may provide some evidence of cross border patterns of crime concentration.

Despite these limitations, the LQ approach offers a unique, underutilised and potentially advantageous approach to measuring concentrations of crime with the potential to provide

contrasting evidence of the spatial concentration of crime which up until now has been overlooked

### Counts, Rates and LQ's of Crime in Ireland

Table 1 below highlights the top ranked Garda Síochána regions for person crimes according to number of crime counts, rate of crime of the region and concentration of crime in a region as measured by the location quotient. The composition of person crimes is made up of (i) Attempts or Threats to murder and Related Offences (ii) Dangerous or Negligible Acts (iii) Homicide (iv) Kidnapping and Related Offences and (v) Sexual Offences.

Table 1: Top ranked Irish Garda Síochána regions for person crimes in 2012

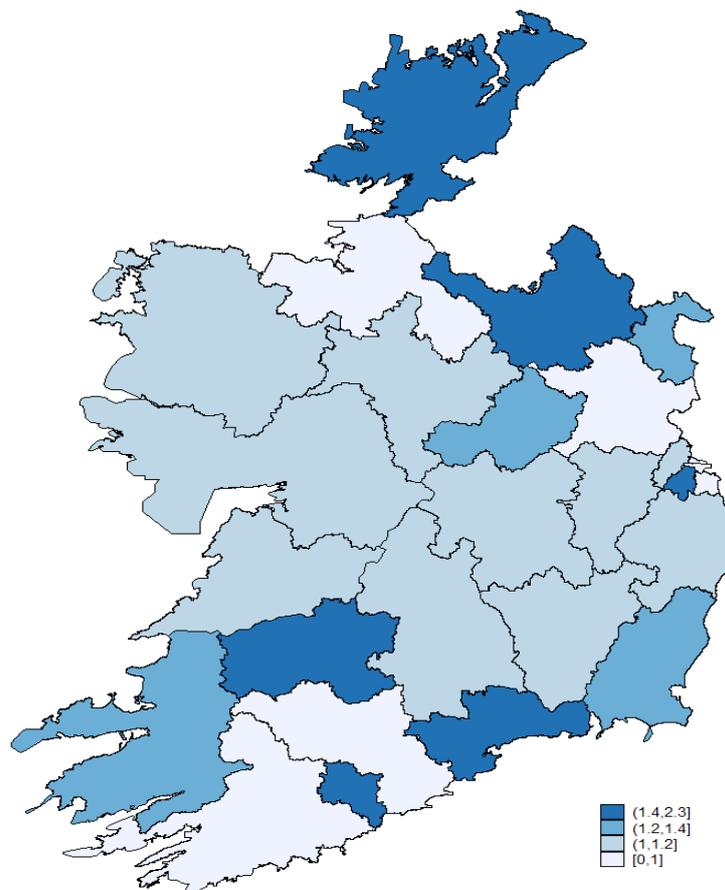
Rank	Garda Region	Count	Garda Region	Rate	Garda Region	LQ
1	Western DMR	1736	North Central DMR	2.30	Donegal	2.02
2	Cork City	1614	South Central DMR	1.98	Cavan/Monaghan	1.82
3	Northern DMR	1550	Waterford	1.57	Cork West	1.58
4	Limerick	1419	Cavan/Monaghan	1.56	Kerry	1.49
5	Galway	1289	Donegal	1.49	Roscommon/Longford	1.46
6	South Central DMR	1230	Cork City	1.41	Mayo	1.44
7	Donegal	1197	Limerick	1.41	Cork North	1.37
8	Southern DMR	1106	Louth	1.30	Tipperary	1.33
9	Kildare	1061	Kerry	1.24	Sligo/Leitrim	1.26
10	Cavan/Monaghan	1040	Westmeath	1.24	Clare	1.26
11	North Central DMR	1003	Wexford	1.21	Laois/Offaly	1.24
12	Waterford	930	Western DMR	1.16	Galway	1.23
13	Wexford	884	Kilkenny/Carlow	1.14	Wexford	1.22
14	Kerry	875	Laois/Offaly	1.12	Waterford	1.17
15	Laois/Offaly	848	Wicklow	1.12	Westmeath	1.15

Western DMR and Cork City have the highest recorded crime counts against the person in 2012 with 1,736 and 1,614 crimes respectively (column 3). Generally, one would expect high rates of recorded crime in these regions given the size of their large urban populations. Columns

4 and 5 show the highest ranked regions by crime rates i.e. crimes per 10,000 of population. Measures of crime rates provide an alternate view of crime concentration compared to crime counts as they take into account population considerations on the levels of crime. Utilising crime rates, North Central DMR has the highest recorded incidence of crime against the person with 2.3 crimes per 10,000 recorded in 2012, while South Central DMR recorded 1.98 crimes per 10,000 population.

Columns 6 and 7 show the highest ranked regions by crime against the person as measured by the location quotient (LQ). Again, this measure provides a different picture of crime concentration. The LQ is neither a rate nor a percentage, but rather is a relative measure. Regions with high concentrations of person crimes measured by the LQ are those in which crimes against the person makes up a much higher share of total crime than is typical of the national pattern generally. Regions with high crime rates will not necessarily have high LQs while regions with low crime rates may produce high concentrations of crime when measured by the LQ, as the crime may make up an unequal share of total crimes in that region. For example, in 2012, Donegal had the highest concentration of crimes against persons as measured by the LQ. Donegal's location quotient was 2.08 which indicates the region had 108% greater concentration in person crimes in comparison to the national average. Concentration of person crimes measured by crime rates are mapped in Figure 2.

Figure 2: Person crime Rate in Ireland in 2012

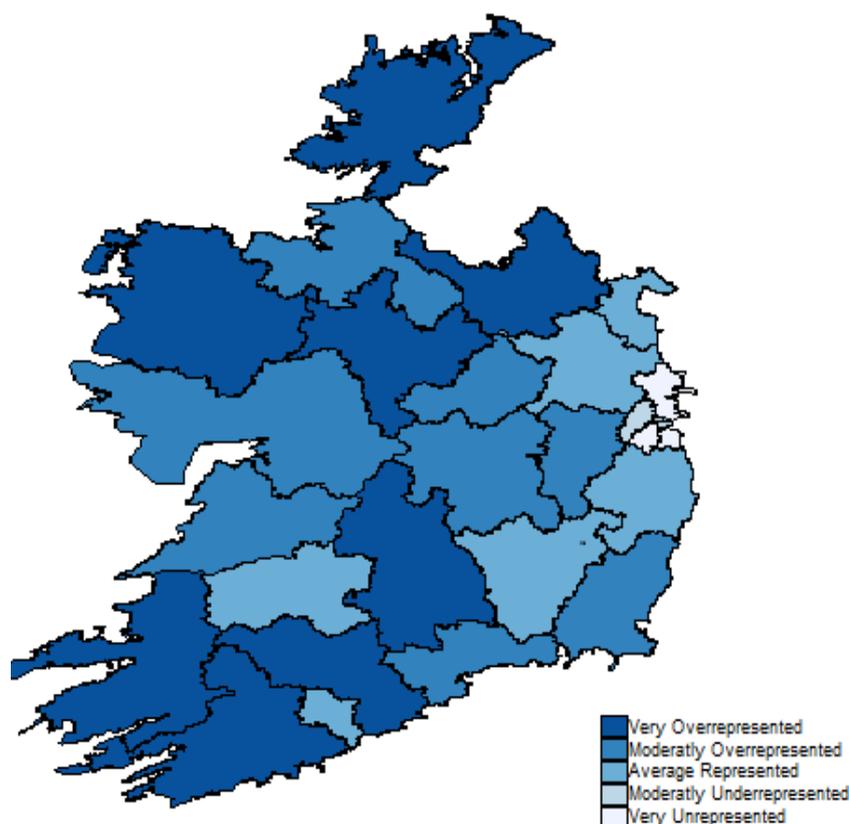


Source: Central Statistics Office (2015)

North Central DMR has the highest recorded incidence of crime against the person with 2.3 crimes per 10,000 recorded in 2012 while South Central DMR recorded 1.98 crimes per 10,000 population. These areas are represented by the darkest shade on the map.

Figure 3 highlights the concentration of person crimes as measured by the location quotient. It is clear that Figure 2 and Figure 3 present stark differences in geographic pattern

Figure 3: Crime against the Person measured by LQ in Ireland in 2012



Source: Central Statistics Office (2015).

Figure 2 and Figure 3 present clear evidence that crimes against the person concentrate in particular places. However, the choice of measurement is important with stark differences evident between results of concentration measured by crime rates and LQs. These results are not surprising given that the scales of each measure are different. Cahill (2005) uses similar measures of crime concentration to analyse spatial patterns of crime in Nashville, USA. The findings suggest significant differences in the concentration of crime measured by crime rates compared to concentration measured by LQs.

Figure 3 shows a high concentration of person crimes in both the North West and South West of Ireland in 2012. Donegal (2.02) is very overrepresented in person crimes measured by the LQ. However, the region only ranks ninth overall when measured by crime rates per 10,000. Similarly, West Cork and Kerry are very overrepresented for concentration of crimes against person measured by LQs although these regions are considered much underrepresented as measured by crime rates. Thus, while crime rates for person crimes in these regions are low

relative to the national average, these regions are overrepresented for person crimes relative to total crime in the region.

North Central DMR and South Central DMR, the top two ranked regions by crime rates per 10,000 are shown to be moderately underrepresented when measured by the LQ. Thus, while these regions have high rates of person crimes, compared to the country as a whole, person crimes make up a smaller percentage of overall crime in the region. As such, North Central DMR and South Central DMR have disproportionately high rates of property crimes, thus reducing the LQ of crime against the person.

Table 2 shows the top ranked Garda Síochána regions for property crimes in Ireland in 2012. Table 2 ranks regions by number of crime counts, rates of crime per 10,000 of population and the concentration of crime as measured by the LQ. The composition of property crimes is made up of (i) Burglary and related Offences (ii) Damage to Property or Environment (iii) Fraud (iv) Robbery (v) Theft and Related Offences.

Table 2: Top ranked Garda Síochána regions by property crimes in 2012

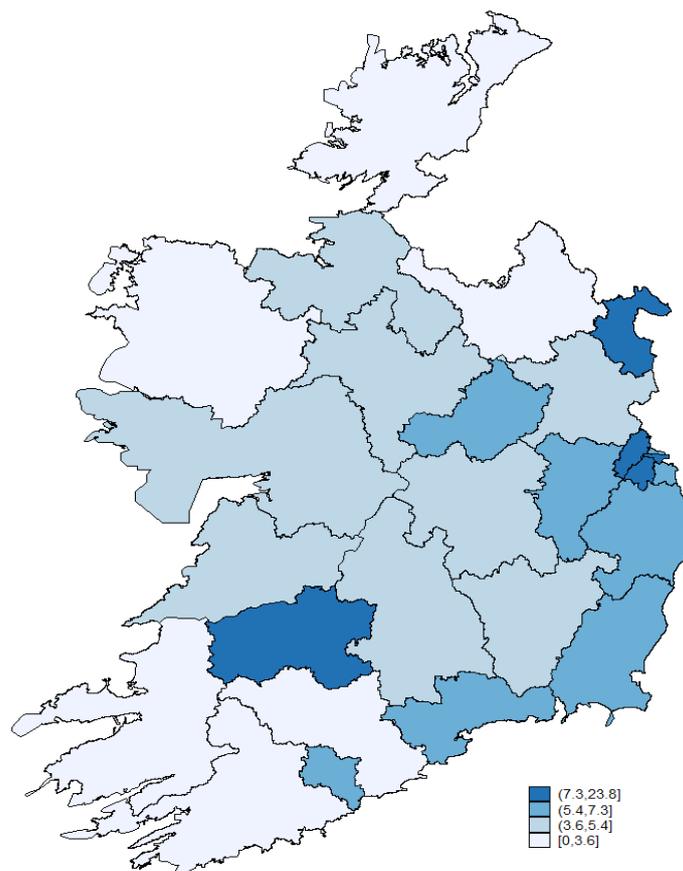
Rank	Garda Region	Count	Garda Region	Rate	Garda Region	LQ
1	Western DMR	14404	North Central DMR	23.86	Eastern DMR	1.21
2	South Central DMR	13468	South Central DMR	21.73	Kildare	1.18
3	Northern DMR	12032	Western DMR	9.58	South Central DMR	1.17
4	North Central DMR	10405	Southern DMR	7.67	Northern DMR	1.15
5	Southern DMR	9178	Louth	7.58	Meath	1.14
6	Limerick	7628	Limerick	7.56	Southern DMR	1.12
7	Eastern DMR	6882	Northern DMR	7.29	Western DMR	1.12
8	Cork City	6638	Eastern DMR	7.25	Louth	1.08
9	Kildare	6250	Waterford	6.94	Wicklow	1.04
10	Galway	4830	Wicklow	6.75	Wexford	1.04
11	Louth	4738	State	6.33	Roscommon/Longford	1.00
12	Wicklow	4622	Kildare	5.95	Limerick	0.99
13	Meath	4492	Cork City	5.80	Laois/Offaly	0.98
14	Waterford	4131	Wexford	5.67	Westmeath	0.95
15	Wexford	4123	Westmeath	5.61	Waterford	0.95

Dublin Metropolitan area has a high concentration of property crimes according to the actual count of crime incidents with the top 5 ranked regions by crime count all located in the region. Western DMR has the highest recorded number of property crimes in 2012 with 14,404 incidents recorded in the region followed by South Central DMR with 13,468.

Unsurprisingly, given the large concentration of property crimes by actual crime count, a similar picture appears in crimes per 10,000 of population. North Central DMR is the highest ranked region in terms of crimes per 10,000 with a rate of 23.86 per 10,000 while South Central DMR had a property crimes rate of 21.73 per 10,000 of population. A similar picture emerges when considering concentration of property crimes as measured by LQs. Again, the top ranked region in Ireland and five out of the top seven located in the greater Dublin Metropolitan area being the Eastern DMR having the highest concentration of property crime measured by LQ in 2012.

Figure 4 shows the crime rates per 10,000 against property in Ireland in 2012. Property crimes as measured by crimes per 10,000 are concentrated mostly along the East coast of the country with further concentration in Limerick and Cork City. In contrast, regions along the West coast of Ireland are the most underrepresented for property crimes in 2012 with Kerry (2.60), Donegal (2.90) and Mayo (3.54) ranked in the bottom five regions for property crimes per 10,000 in 2012.

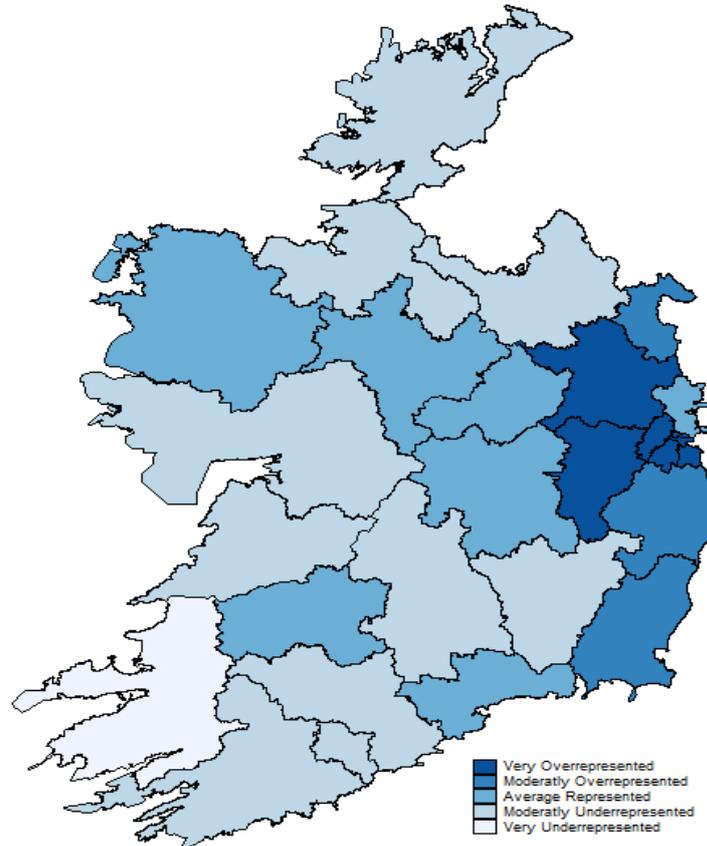
Figure 4: Crime rate against property in Ireland in 2012



Source: Central Statistics Office (2015)

Figure 5 below shows the concentration of property crimes as measured by the LQ. A similar picture emerges for the concentration of property crimes across measurements of LQs and crime rates per 10,000.

Figure 5: Property crimes measured by LQ in Ireland in 2012



Source: Central Statistics Office (2015)

An interesting finding occurs when comparing crime concentration measured by LQ across person crimes and property crimes. An inverse relationship is evident between the concentration of person crimes and property crimes measured by the LQ. Regions within Dublin Metropolitan Region (DMR) are highly concentrated in property crimes measured by the LQ. However, these same regions are found to be least concentrated in person crimes as measured by the LQ. Similarly, Donegal and Cork West are found to be very overrepresented in person crimes as measured by the LQ. However, these regions are much underrepresented for property crimes. These findings suggest that overrepresentation of crimes in one crime category in a region leads to underrepresentation of alternative crime categories in the same region.

Furthermore, LQ tends to provide evidence of high levels of concentration across much of the country, particularly for person crimes. Obviously, this is not an ideal scenario when conducting mapping exercises as crime concentration implies that crime is concentrated in specific places *not* most places, particularly when results differ significantly from results of concentration patterns given by crime counts and crime rates.

Melo et al (2015) provides a possible explanation for these results by questioning the appropriateness of aggregating crime types when the underlying spatial pattern is of interest. Aggregating crimes into broad categories may result in underlying spatial concentrations being hidden. As such, this study analyses the concentration of sub categories of crime across Ireland to ascertain whether concentration change is more evident at a more detailed level. Table 3 shows the concentration of sub categories of crime in Ireland in 2012 measure by the LQ. Highly concentrated area i.e.  $LQ > 1.3$  are highlighted in bold.

Table 1 and 2 provided evidence of crime concentration at a broad level of aggregation. Table 3 shows measures of crime concentration in Ireland by subcategory of crime measured by LQ in 2012. An alternative picture of crime concentration is shown highlighting the underlying spatial concentrations of crimes at a more disaggregated level.

Table 3: Measure of Crime Concentration in Ireland by Subcategory of Crime and by Garda Division – 2012

Garda Region/Division	Crimes Against Person					Property crimes				
	Attempts or Threats to murder and related offences	Dangerous or Negligible Acts	Homicide	Kidnapping and Related Offences	Sexual Offences	Burglary and related Offences	Damage to Property or Environment	Fraud	Robbery	Theft and Related Offences
Eastern DMR	0.60	0.69	0.00	0.26	0.68	<b>1.41</b>	1.07	1.16	1.04	1.22
North Central DMR	0.58	0.37	0.67	0.94	0.37	0.46	0.67	0.99	<b>1.85</b>	1.19
Northern DMR	0.76	0.88	0.89	0.99	0.89	1.07	1.10	1.23	<b>2.15</b>	1.16
South Central DMR	0.70	0.42	0.81	1.55	0.44	0.72	0.70	1.25	<b>1.71</b>	<b>1.51</b>
Southern DMR	0.68	0.78	0.91	1.27	0.99	<b>1.50</b>	1.22	0.88	<b>1.67</b>	0.95
Western DMR	0.66	0.84	0.72	<b>1.38</b>	0.85	0.90	1.25	1.26	<b>1.41</b>	1.12
Kildare	1.12	1.06	<b>2.11</b>	<b>1.96</b>	1.03	<b>1.69</b>	1.11	0.92	0.88	1.06
Laois/Offaly	1.27	1.17	1.00	0.79	<b>1.44</b>	1.31	1.07	0.78	0.43	0.86
Meath	1.01	1.13	0.00	0.75	1.04	<b>1.61</b>	0.97	0.99	0.65	1.07
Westmeath	1.07	<b>1.39</b>	0.69	0.00	0.75	1.06	1.02	1.29	0.42	0.88
Wicklow	1.09	0.71	0.00	1.01	0.97	1.38	1.02	1.04	0.55	0.95
Cavan/Monaghan	<b>1.77</b>	<b>2.05</b>	<b>2.38</b>	0.00	1.22	0.79	0.90	1.06	0.30	0.69
Donegal	<b>2.14</b>	<b>1.85</b>	1.15	0.91	<b>1.96</b>	0.70	1.03	0.96	0.44	0.58
Louth	1.05	0.82	1.28	1.02	<b>1.55</b>	<b>1.37</b>	1.25	1.28	1.16	0.89
Sligo/Leitrim	1.29	1.24	0.89	0.71	1.22	0.99	1.15	1.08	0.40	0.77
Kilkenny/Carlow	0.96	<b>1.34</b>	<b>1.75</b>	0.35	0.88	1.27	0.80	0.73	0.58	0.82
Tipperary	1.19	<b>1.53</b>	<b>2.26</b>	<b>4.05</b>	<b>1.37</b>	1.10	0.89	0.87	0.53	0.80
Waterford	1.27	1.06	1.29	0.68	0.98	0.92	1.07	0.71	0.99	0.93
Wexford	1.13	1.40	<b>1.41</b>	0.75	1.18	<b>1.39</b>	1.11	0.89	0.18	0.93
Cork City	1.18	0.99	1.15	0.18	0.87	0.56	1.00	0.67	0.65	0.85
Cork North	1.17	1.67	<b>1.30</b>	0.00	<b>1.60</b>	0.68	0.87	0.83	0.09	0.77
Cork West	<b>1.48</b>	1.81	0.87	0.00	<b>1.48</b>	0.75	0.89	0.95	0.07	0.71
Kerry	<b>1.41</b>	1.67	<b>2.90</b>	0.46	<b>1.30</b>	0.54	0.65	0.68	0.26	0.56
Limerick	1.04	0.86	0.48	<b>1.73</b>	<b>1.40</b>	0.82	1.21	0.58	0.67	1.00
Clare	1.20	<b>1.31</b>	0.77	1.23	<b>1.58</b>	0.79	0.95	0.78	0.38	0.80
Galway	1.24	1.25	0.65	0.78	1.11	0.90	0.87	1.12	0.25	0.81
Mayo	<b>1.55</b>	<b>1.34</b>	<b>1.47</b>	0.00	1.03	0.99	1.05	1.01	0.26	0.86
Roscommon/Longford	<b>1.38</b>	<b>1.51</b>	<b>1.87</b>	<b>1.49</b>	<b>1.73</b>	<b>1.41</b>	0.95	<b>1.46</b>	0.13	0.86

Table 3 demonstrates property crimes and person crimes are driven by concentrations of particular subcategories of crime. Donegal has the highest concentration of person crimes in Ireland in 2012 as measured by the LQ. However, closer examination of the underlying spatial concentrations indicate that this figure is driven by two subcategories of crime i.e. Attempts or Threats to Murder and Related Offences (2.14) and Dangerous or Negligible Acts (1.85). Similarly, while the Dublin Metropolitan Region is highly concentrated in property crimes in general, only robberies and burglaries could be considered overrepresented in the region relative to the rest of the country.

Table 3 provides evidence of the inverse relationship between property and person crimes. The LQs of property crimes were intrinsically different from the LQs of person crimes. Regions with high LQs for person crimes such as Donegal, Cavan, Kildare and Kerry are found to exhibit low LQs across all subcategories of property crimes. Likewise, regions with high LQs across several subcategories of property crimes such as regions within Dublin Metropolitan Region show relatively low LQs for person crimes. Zhang and Peterson (2007) present similar findings when analysing crime concentrations in Omaha, Nebraska.

While LQs are a useful tool for measuring spatial concentrations of crime, caution should be exercised when interpreting extremely low and extremely high values of LQ. For example, Table 3 shows that homicides are highly concentrated in 8 regions across Ireland in 2012. When interpreting these results, it should be noted that regions with extremely low crimes counts tend to overstate the concentration levels of crime. This is particularly relevant for homicides as crime counts tend to be very low and as such, small variations in crime counts may result in LQs being overestimated. Cahill (2005) addressed this issue by just including observations with certain amount of incidents. However, Zhang and Peterson (2007) note that eliminating the outliers from the dataset may affect the statistical power and produce misleading results.

## **Discussion and Conclusion**

Researchers within the fields of criminology, sociology and economics have been interested in analysing the concentrations of crime across space. Many studies have been conducted, particularly in the United States which have focused on crime concentration using various methodologies. However, until now, no such studies have been conducted in Ireland. This paper addresses the gap in the current literature by analysing crime concentration in Ireland using three different measures of concentration – crime counts, crime rates and location quotients. Moreover, concentration was analysed for two categories – person crimes and property crimes – as well as sub categories of these crimes.

Similar to previous studies, the findings of this paper suggests that crime concentrates in particular places in Ireland. Moreover, the choice of measurement is important when analysing spatial concentrations of crime. While crime counts and crime rates have been used by the Central Statistics Office (2014) when reporting on concentrations of crime, the LQ method utilised in this paper presents an alternative measurement of crime and provides contrasting evidence of spatial concentration of crime in Ireland which up until now has been overlooked.

The findings of this paper may be utilised by An Garda Síochána to allow for practical crime prevention solutions tailored to specific places. Particularly, the concentrations of certain sub categories of crime, highlighted in Table 3, may require a rearrangement of current resources as well as the deployment of additional resources to worst affected areas. Regions with high

concentrations of crime may require specialised policing strategies and allocation whilst diversified regions may require alternative policing strategies.

In line with the current literature, future research on crime in Ireland needs to focus on the particular determinants of crime in Ireland, the associated costs of these crimes to the economy and society in general, as well as effective preventative strategies which may be carried out in order to make the best use of scarce resources.

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