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DEVELOPING DEPRIVATION MEASURES FOR NORTHERN IRELAND*

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Abstract: This paper outlines the development of a measure of "multiple deprivation" for Northern Ireland at small area level. To best construct such a measure, it is essential to have a clear conceptual model and translate this into a series of measures using the best data at hand. Thus, each dimension is measured independently using the best indicators available to generate a score or domain measure for each aspect of deprivation. These domain scores are then combined, with explicit weighting, to generate a multiple deprivation measure which is an aggregate of the component domains. The availability of new data has allowed these domains to be described with more precision, and in a more robust and consistent way than has been possible before. It is the hope of the researchers that as data quality and sources improve, so will the estimation procedures, as the multiple deprivation measure is reviewed and developed over time.

Keywords: multiple deprivation, domain score, poverty.
JEL Classification: I310, I320.

1. INTRODUCTION

The need for information about the geographical distribution of relative deprivation in Northern Ireland has long been recognised. In response, each of the last three Censuses of Population in 1971, 1981 and 1991 has been examined to produce information on deprivation. The result of the 1991 analysis was the construction of a series of deprivation measures (Robson, 1994). These measures have been used by a

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wide variety of programmes and projects to most effectively target social and economic deprivation.

However, advances in the collection and use of other data sources, such as administrative data, have allowed analysis of deprivation at small area level in the inter-censal period. Such advances have also released the analysis from using proxy indicators from the Census in favour of using direct measures of deprivation, such as low income. In addition, recent work has developed the conceptualisation of multiple deprivation and its component parts, and this has been built into the construction of the new Northern Ireland Measures of Deprivation.[1]

2. POVERTY AND MULTIPLE DEPRIVATION

> "*We must first know what poverty is before we can identify where and when it is occurring or attempt to measure it; and before we can begin to do anything to alleviate it*" (Alcock, p.57).

In his 1979 account of *Poverty in the United Kingdom*, Townsend sets out the case for defining poverty in terms of relative deprivation. Thus his definition is:

> "*Individuals, families and groups can be said to be in poverty if they lack the resources to obtain the types of diet, participate in the activities and have the living conditions and amenities which are customary, or at least widely encouraged or approved in the societies to which they belong*".[2]

Although "poverty" and "deprivation" have often been used interchangeably, many have argued that a clear distinction should be made between them. It could be argued that the condition of poverty means not having enough financial resources to meet needs. Deprivation, on the other hand, refers to unmet need, which is caused by a lack of resources of all kinds, not just financial. In similar vein, Atkinson (1998) notes that in recent debates on "Social Europe", the terms poverty and social exclusion have been used on occasions interchangeably, but defines poverty as a "*lack of money or material possessions*".[3] Townsend himself concurs. In his article "Deprivation", Townsend argues that

> "*people can be said to be **deprived** if they lack the types of diet, clothing, housing, household facilities and fuel and environmental, educational, working and social conditions, activities and facilities which are customary* …" (our emphasis).

People are in poverty if they lack the resources to escape deprivation.[4]

In his 1987 article, Townsend elaborates distinctions between social and material deprivation. The former – which he acknowledges as more difficult to measure – provides "*a useful means of generalising the condition of those who do not or*

cannot enter into ordinary forms of family or other relationships". In this he is anticipating some aspects of what one might now call "social exclusion". The more easily measured material deprivation relates to diet, health, clothing, housing, household facilities, environment and work.[5] Townsend also lays down the foundation for articulating multiple deprivation as an accumulation of single deprivations – a concept which is developed further in the design of the new Northern Ireland Measures of Deprivation.

Though Townsend's work mainly (although not entirely) referred to individuals experiencing deprivation – single or multiple – the arguments can, in modified form, extend to area-based measures. However, unavailability of data inevitably causes some of the sophistication of his original concept to be lost. At an area level, it is very difficult to measure the percentage of the population experiencing one, two or more deprivations. It is possible to look at single deprivations at an area level and state that a certain proportion of the population experiences that deprivation, or a proportion experiences some other form of deprivation etc. and, at an area level, describe the combination of single deprivations as area level multiple deprivation. This approach thus conceptualises multiple deprivation as a composite of different dimensions or domains of deprivation. It does, however, say little of the *individual* experience of *multiple* deprivation.

In development of our measures of deprivation for Northern Ireland, we try to articulate this conceptualisation in a clear and meaningful way. Thus, each dimension is measured independently using the best indicators available to generate a score or domain measure for each aspect of deprivation. These domain scores are then combined, with explicit weighting, to generate a multiple deprivation measure which is an aggregate of the component domains. As will be discussed, the availability of new data has allowed these domains to be described with more precision, and in a more robust and consistent way than has been possible before.

The approach allows the separate measurement of different dimensions of deprivation, such as housing deprivation, education deprivation and health deprivation. There is a question as to whether there should be an additional domain for low income, or one that measures the lack of socially perceived necessities (Gordon *et al.*, 2000), such as adequate diet, consumer durables, ability to afford social activities and so on. To follow Townsend, within a multiple deprivation measure only the deprivations flowing from a low income would be included; low income itself would not be a component, but socially perceived necessities would. However, as there are no readily available small area data on the lack of socially perceived necessities, low income is an important indicator for these aspects of material deprivation. Moreover, there are arguments that measures of consumption are themselves problematic, as lack of certain items may be by choice rather than inability to pay for them. Therefore, it is appropriate to measure low income itself rather than the possession of certain items.

We recognise income deprivation in its own right but would not argue that it should be the only measure of area deprivation. Many dimensions of deprivation are measured more directly than before. The other dimensions of deprivation contribute crucial further information about an area. However, low income remains a central component of the definition of multiple deprivation for the Northern Ireland Measures of Deprivation. As Townsend writes:

> "*while people experiencing some forms of deprivation may not all have low income, people experiencing multiple or single but very severe forms of deprivation are in almost every instance likely to have very little income and little or no other resources*".[6]

Multiple deprivation is not some separate form of deprivation. It is simply a combination of more specific forms of deprivation, which themselves can be more or less directly measurable. It is an empirical question whether combinations of these different forms of deprivation are more than the sum of their parts; they are not simply additive but interact and may have *more* impact, if found in certain combinations.

This perspective accommodates the reality of varying combinations of deprivation and disadvantage in different types of areas, which has been a persistent finding on the geographical distribution of different forms of deprivation and disadvantage since the pioneering work of Richard Webber in Liverpool in the 1970s (Webber, 1975). However, it does raise questions about the addition of items to form a measure of "multiple deprivation". Moreover, if multiple deprivation cannot be *directly* quantified, then there are problems in technically validating any overall Multiple Deprivation Measure, as "validation" requires something against which the Multiple Deprivation Measure can itself be measured. If this is correct, then the question of how components in the overall Multiple Deprivation Measure might be weighted rightly becomes a central question.

Measuring different aspects of deprivation and combining these into an overall Multiple Deprivation Measure raises a number of questions about the links between different forms of deprivation at the individual, household and area level. Firstly, how far do individuals and families experiencing deprivation in fact cluster together geographically, and how far are other individuals and families who are *not* experiencing deprivation affected by the overall level of deprivation in their area? Though much of the data collected may, in the final analysis, be based on individual or household levels of deprivation, the results in any composite measure are likely to be presented in the form of an aggregate score for that area. However, this may combine deprivations experienced by many *different* groups within that area.

3. MEASURING MULTIPLE DEPRIVATION IN NORTHERN IRELAND

This brief debate on poverty and deprivation has underlined the importance of the financial component in any overall measurement of deprivation. This theme runs through our approach to multiple deprivation and the basis for weighting the components in any overall multiple deprivation measure.

The debate also confirms the idea of separate "domains" of deprivation, which any individual or household may experience singly or in combination. The intention has been to find ways of assessing the major forms of deprivation to create a robust deprivation measure for each domain – that is, for income, unemployment, education etc. separately.

This approach implies rather more items in total than in earlier overall measures of deprivation. It also requires "domain specific" items (and not what often happens when, for example, "educational deprivation" is measured by a mix of education, social and economic factors in combination). It also requires procedures for combining items *within* any Domain Deprivation Measure according to clear rules.

During the process of developing measures of deprivation for Northern Ireland, extensive consultations were carried out with a range of potential users of the measures, from both the voluntary sector and statutory sector.

During this consultation process, the need for indicators to capture the deprivation experienced by people living in rural areas was raised. Several features of the Measures of Deprivation address these concerns. Firstly, all indicators included in the Measures of Deprivation had to be applicable to the whole of Northern Ireland, so that fair scores and comparisons between areas could be made. This means that all of the indicators in the Measures of Deprivation are applicable to both rural and urban areas. High rates of unemployment, for example, can occur in principle in both rural and urban wards, and would then be captured by the rate of people claiming the relevant benefits. Secondly, indicators which have different "meanings" depending on their location have not been included. Thus, car ownership, which has previously been used as a proxy for low income, has not been included, as in some areas people might choose to make other financial sacrifices because they need a car to get to work if there is limited public transport. Low income itself is measured directly in the Income Domain by the inclusion of counts of people claiming benefits. It is also appreciated that "rural" areas do not necessarily share all the same characteristics, and that these differences will be revealed in the ward scores and ranks. This is, of course, also true of the differences between and within "urban" areas.

Many people expressed concern during the consultation process that the Measures of Deprivation should take some account of the toll the Troubles have taken on the lives of people living in Northern Ireland. Suggestions were made as to how

particular aspects of this might be measured. However, very few sources of Northern Ireland wide data are available which are specifically related to the Troubles. Some other suggested indicators included unemployment counts, a measure of mental health and poor access to services. Indicators which measure each of these have been included in the Measures of Deprivation. However, these indicators do not measure a causal link between the Troubles and, for example, high unemployment. Each indicator measures a deprivation in its own right and not in relation to the Troubles, as it is not possible to distinguish in the Measures of Deprivation between a person who is unemployed as a direct result of the Troubles, and a person who is unemployed because of low economic growth in an area. Similarly, it is difficult to quantify the effect of segregated housing or schooling on the individuals living in an area. The strength of the Measures of Deprivation is that by combining many indicators into domains of deprivation, which are in turn combined to create a Multiple Deprivation Measure, wards which face a number of problems, however complex the causality, will be identified, and the consequences of the Troubles will be incorporated.[7]

The question of deprivation experienced by women was raised by many people during the consultations. It is undoubtedly the case that many aspects of deprivation are gendered. One of the strengths of the Measures of Deprivation is that they do address some aspects of deprivation which affect women. The Income Domain, for example, has a measure of Income Support which is paid to lone parents, the overwhelming majority of whom are women. The relatively disadvantaged position of older women (and older people in general) is captured by the inclusion of Income Support in the Income Domain, and of Attendance Allowance in the Health Domain, as women will be disproportionately represented in these groups. However, there is still a data deficit in this area. This means that for example, the Employment Domain does not capture women who are involuntarily out of work, unless they are registered as unemployed in their own right, participant in the New Deal for Lone Parents or are claiming Incapacity Benefit or Severe Disablement Allowance. It is hoped that future versions of the Measures of Deprivation will continue to make progress in this regard.

It is important to capture deprivation experienced by people whatever their ethnicity and regardless of any religious affiliation. The Measures of Deprivation are constructed in such a way that the indicators measure deprivation across all such categories. They measure inequality between small areas which provides important information about the spatial distribution of deprivation.

It can still be argued that certain groups experience additional types of deprivation that cannot as yet be measured in a more "direct" way. An example is the additional types of deprivation experienced by some people from ethnic minorities or some people with a religious affiliation. It would be desirable to include measures of racism, discrimination and cultural isolation if they were available. In the absence of these measures, it would be inappropriate to treat membership of an ethnic community or religious group as a deprivation in itself. Ethnic and religious groups

are not homogenous and many of the deprivations disproportionately experienced by some members will have been captured in the relevant domains.

During the consultation, there was discussion about particular socially excluded groups such as rough sleepers, travellers and young people aged 16 and 17 who are not in education or employment and are excluded from the benefits system. Unfortunately, indicators for these groups have been difficult to obtain or, where available, turn out to be very small. They will each be discussed in the relevant domains.

4. THE GEOGRAPHICAL SCALE OF THE MEASURES OF DEPRIVATION

An ideal measure of area deprivation would be able to quantify deprivation at the level of "neighbourhoods", or small areas with a homogeneity of characteristics and a standard population size. Such a measure would be able to offer to policy makers and funding programmes a robust method of describing the geographic distribution of deprivation to define areas for targeted intervention.

This raises several issues for a potential multiple deprivation measure: firstly, the possible availability of data and population estimates for small areas; secondly, the problem of the variation in population size between areas; thirdly, the heterogeneity of areas.

The availability of data for small areas in the inter-censal period had been considerably advanced by the increasing accessibility of benefits and other data at a sub-LGD level. In addition, in close collaboration with NISRA, we have developed a new methodology for estimating populations at small area level.

In order to compare concentrations of deprivation between areas, it is necessary to calculate rates so as to standardise for differences in the size of the population. Although wards vary in size, the problem of varying sizes is inherently much greater for LGDs. This raises the problem of the heterogeneity or homogeneity of an area, in terms of the intensity of deprivation. Rates for large areas, such as a whole city, may mask a great variation within it. This means that because of the heterogeneity within LGDs, as well as the variations in population size, comparisons of the intensity of deprivation at the LGD level are problematic. The ward level thus presents the most robust small area option for the Multiple Deprivation Measure. In addition, the ED level Economic Deprivation Measure helps to pick up "pockets" of deprivation. Administrative boundaries in Northern Ireland have changed significantly since 1991; a review of local government boundaries in 1992 increased the number of wards from 566 to 582 and involved changes to most ward boundaries. The twenty-six LGDs were largely unchanged. Prospective users expressed particular interest in sub-ward (i.e. ED) level analysis. The EDs were functional units created to assist field work in the 1991 Census and nest within the 1991 wards, but do not nest within

the new 1992 wards. This analysis therefore used the ward and ED boundaries in place at the time of the 1991 Census.

Because of the availability of small area data, and the techniques we employed to harness other data sets, it was possible to construct the Multiple Deprivation Measure at ward level. The measures of deprivation are based on the 1984 ward geography which was in place at the time of the 1991 Census.

One of the disadvantages of using the geographical unit of wards is that smaller pockets of deprivation can be masked. An ED level multiple deprivation measure, however, poses considerable challenges: the availability and robustness of non-census indicators at this level and the construction of sub-ward population estimates. It was possible to produce ED level population estimates for 1999, and because of the large number of cases in the data in the Employment and Income Domains, these were constructed at ED level and were combined to form a measure of Economic Deprivation. This was not possible for any other domains. However, the Economic Deprivation ED level Measure presents detailed information about the main drivers of deprivation in a dynamic and updateable form.

5. DOMAINS AND INDICATORS

It follows from the conceptualisation of multiple deprivation we have articulated that the new Northern Ireland Measures of Deprivation should comprise indicators which are first combined to form domains of deprivation. This process produces a score for each of the domains – a domain deprivation measure – which can be ranked across Northern Ireland to give a relative picture of each dimension of deprivation. The domain deprivation measures were combined into an overall Multiple Deprivation Measure.

5.1 Domains

The domains in the Multiple Deprivation Measure are Income Deprivation, Employment Deprivation, Health Deprivation and Disability, Education, Skills and Training Deprivation, Geographical Access to Services, Housing Stress, and Social Environment. The domains were each presented as a separate Domain Deprivation Measure, as each domain reflects a particular aspect of deprivation. Thus, the Employment Domain captures exclusion from the world of work and conditions of work – *not* the low income that may flow from it – and the Income Domain can be used apart from the Multiple Deprivation Measure to examine low income alone. Similarly, the Education Domain does not include markers of income deprivation such as "children in receipt of free school meals", as children living in low income families are measured within the Income Domain. This approach avoids the need to make any judgments about the complex links between different types of deprivation (for example the links between poor health and unemployment), and enables clear

decisions to be made about the contribution that each domain should make to the overall Multiple Deprivation Measure.

While the domains represent distinct dimensions of deprivation, it is perfectly possible, indeed likely, that the same person could be captured in more than one domain. So, for example, if someone was claiming Income Support and was in poor health, they would be captured in both the Income and Health Domains. This is entirely appropriate because one individual can experience more than one type of deprivation at any given time.

The domains each represent a type of deprivation that is measured as directly as possible, rather than comprising a set of "vulnerable groups" (i.e. groups of people at risk of deprivation), as discussed above.

5.2 Indicators

Each Domain Deprivation Measure contains a number of indicators. The criteria for these indicators were that they should be:

- "domain specific" and appropriate for the purpose (as direct as possible a measure for that form of deprivation);
- measuring major features of that deprivation (not conditions only experienced by a very small number of people or areas);
- up-to-date;
- capable of being updated on a regular basis;
- statistically robust;
- available for the whole of Northern Ireland at a small area level in a consistent form.

The intention was to include a parsimonious collection of indicators that comprehensively captured the deprivation for each domain, within the constraints of data availability. During the process of consultation, some very interesting sources of data were suggested, such as Community Audits. Whilst some of these contain a wealth of useful information, they are not consistent across the whole of Northern Ireland. If Community Audits were standardised and made comprehensive in the future, they would make a very valuable contribution to an updated version of the Measures of Deprivation. In the meantime, Community Audits may have a role in describing the distribution of deprivation within the particular that they cover. At present, however, it was not possible to include these data in the Measures of Deprivation. Other indicators were not included as they did not meet one or more of the criteria listed above or no data were available.

The indicators that were included in the Measures of Deprivation have been constructed using a range of techniques. Some of the data were obtained at individual level (with due regard to issues of confidentiality) and aggregated to

ward/ED level; some were obtained at other levels (e.g. Labour Force Survey Local Authority (LFSLA) data) and then "modelled down" to ward level. Postcoded data were assigned to 1984 wards using a Central Postcode Directory (CPD) furnished by the Northern Ireland Statistics and Research Agency (NISRA). The assumption had to be made that postcodes supplied were correct and accurate and they were therefore used as given. As far as possible, all the data included relate to mid-1999.

6. THE SMALL NUMBERS PROBLEM AND THE SHRINKAGE TECHNIQUE

One problem which had to be addressed at the outset of the construction of the Multiple Deprivation Measure was the question of how the indicators should be scored or scaled (if at all) to allow fair comparisons between areas and appropriate combination with other indicators. The data were not all in the same units of measurement and if the raw data had been used the results would have largely been driven by the size of the population. For these reasons, it was not possible to count the numbers of people experiencing each deprivation and add them together. Instead, where possible, rates or some other standard form of measurement were used, which allow areas of different sizes to be compared.

In some areas of Northern Ireland, particularly where populations at risk are small, data can be unreliable, with particular wards getting unrepresentatively low or high scores on variables in certain domains. The extent of a score's "unreliability" can be measured by calculating its standard error.

This problem emerged in the construction of other indices or measures of multiple deprivation in the past and this has prompted the use of the signed chi squared statistic.[8] However, this technique has been much criticised for its use in this context because it conflates population *size* with *levels* of deprivation.[9] Given the problems with the signed chi squared approach, another technique – "shrinkage estimation" – has been used subsequently to deal with the problem.[10]

Shrinkage involves moving "unreliable" ward scores (i.e. those with a high standard error) towards the mean score of the LGD within which the ward is located. This move may be towards more deprivation or less deprivation. For the ED level Economic Deprivation Measure, the component Income and Employment scores were "shrunk" to the ward level Income and Employment scores respectively, within which the EDs were located, before being combined.

The actual mechanism of the procedure is to estimate deprivation in a particular ward using a weighted combination of (a) data from that ward and (b) data from another more robust source (for example the LGD mean). Using this method, the estimate for any ward would then, for example, move towards the LGD mean by taking a weighted average of the ward and LGD values, thus reducing any ward-level "noise" caused by small numbers. By this device, the unreliability of the ward-

level indicator is reduced by "borrowing strength" from a more reliable source; thus, the effect of random fluctuations and other sources of error is minimised. This methodology has a sound statistical basis and avoids the problem of indicator values being linked to the size of the area (scale dependency).

Although all scores move a fraction, only "unreliable" scores, that is those with a large standard error, move significantly. The amount of movement depends on both the size of the standard error and the amount of heterogeneity amongst the wards in an LGD (or ward, in the case of EDs being shrunk). The shrinkage procedure and formulae are presented in more detail in the Appendix.

7. COMBINING THE INDICATORS INTO DOMAIN DEPRIVATION MEASURES

For each domain of deprivation (Income, Employment etc.), the aim is to obtain a single summary measure whose interpretation is straightforward in that it is, if possible, expressed in meaningful units (e.g. proportions of people or of households experiencing that form of deprivation). In some domains (i.e. the Income and Employment Domains), where the underlying metric is the same and where the indicators are non-overlapping, the indicators can be simply summed. Where there are several indicators within a single domain that have different underlying metrics and cannot therefore be straightforwardly combined (i.e. the Health, Education and Social Environment Domains), a statistical procedure, factor analysis, can be used to identify weights for each indicator. The domain score is then a combination of the component indicators weighted according to the factor analysis results. For further details on factor analysis see the Appendix. The Housing Domain was constructed using a point scoring method.

8. STANDARDISING AND TRANSFORMING THE DOMAIN DEPRIVATION MEASURES

Having obtained a set of Domain Deprivation Measures, these needed to be combined into an "overall" Multiple Deprivation Measure. In order to combine Domain Deprivation Measures which are each based on very different units of measurement, there needed to be some way to "standardise" the scores before any combination could take place. A form of standardisation and transformation was required that met the following criteria. Firstly, it must ensure that each domain has a common distribution; secondly, it must not be scale dependent (i.e. confuse size with level of deprivation); thirdly, it must have an appropriate degree of "cancellation" built into it (discussed below); finally, it must facilitate the easy identification of the most deprived wards. Having considered other options, the exponential transformation of the ranks best met these criteria.

Other procedures were considered, such as z-scores or untransformed ranks. Using the ranks for each domain would solve some problems but would introduce others. Ranks would certainly put domains on to the same metric. The problem is that the distance between each of the scores underlying the ranks is not equal. Once ranked, this "distance" is made equal and some of the information of the data is lost. The symmetrical nature of ranks and "z scores" of normally distributed data means that a "good" score on one domain could fully cancel out a "bad" score on another. This means that a relative lack of deprivation in one domain, would have had a major impact on a more severe deprivation in another domain, when combined into an overall deprivation result.

The exponential distribution has a number of properties. Firstly, it transforms each domain so that they each have a common distribution, the same range and identical maximum/ minimum value, so that when the domains are weighted and combined into a single Multiple Deprivation Measure, the impact of the weights is absolutely clear and explicit. Secondly, it is not affected by the size of the ward's population. Thirdly, it effectively spreads out the part of distribution in which there is most interest – that is, the "tail" which contains the most deprived wards in each domain. Finally, it enables one to determine the desired cancellation properties.

The exponential transformation involved ranking the scores in each domain. The ranking standardised the domain scores (between 566 for the most deprived and 1 for the least deprived for the purposes of the calculation). These ranks were then transformed to an exponential distribution, using the formula presented in the Appendix. This had the effect of transforming the ranked domain scores to a value between 0 (least deprived) and 100 (most deprived), on an exponential basis, i.e. larger (more deprived) scores are given greater emphasis.

The exponential transformation stretches out the distribution so that greater levels of deprivation score more highly. The most deprived 10 per cent of wards have values between 50 and 100 after exponential transformation.

The issue of cancellation is clearly important for understanding the nature of multiple deprivation. If, for example, there were data on an individual who was known to be at the top of the income distribution, but who had no educational qualifications, an argument *might* be made that the *lack* of income deprivation should cancel out fully the education deprivation, and that this individual should be judged to be not deprived. However, even here there would be arguments against such a direct and full cancellation.

Our approach in the Measures of Deprivation has been to conceptualise the various deprivations as measured by each domain as separate and distinct, although they may have cumulative effects in an area (or for any individual). Thus, to be poor *and* in ill-health is clearly a worse state than experiencing just one of these deprivations on their own. It would be conceptually inappropriate for someone who is poor but

healthy to have their income deprivation ignored because they are fortunate enough to be in good health.

The significant advantage of the exponential transformation is that it gives *control* over the extent to which lack of deprivation in one domain cancels or compensates for deprivation in another domain. In particular, it allows precise regulation (although not the elimination) of these cancellation effects. The exponential transformation has been used in a way that reflects a level of cancellation appropriate for this approach to multiple deprivation.

The exponential transformation formula selected gives approximately 10 per cent cancellation. This means that in the extreme case, a ward which was ranked top on one domain but bottom on another would overall be ranked at the 90th percentile in terms of deprivation (if the two domains were equally weighted). This compares with the 50^{th} percentile if the untransformed ranks or a normal distribution had been used instead. For example, a ward that came top in terms of income deprivation (i.e. the most deprived) but was bottom on the Housing Domain (i.e. the least deprived) would still be at the 90^{th} percentile (top 10 per cent) if these two domains were combined with equal weights. In fact income deprivation is weighted more highly, which would further reduce the impact of the non-deprived result for the Housing Domain.

In the previous "Robson Measures", the signed chi-square approach was used both to address the problem of unreliable small numbers and as a form of standardising the different indicators. As has been indicated, the more robust "shrinkage" approach has been used to deal with the small numbers problem in the new Measures of Deprivation. The signed chi-square approach was rejected as a method to standardise the indicators in the Measures of Deprivation because there are many problems associated with this method. These are, briefly, its scale-dependency (that is, it conflates the size of the area or population with the seriousness of the problem in a non-linear way) and its lack of transparency. There has been widespread criticism of the technique from academic quarters (e.g. Chisholm and Connolly, 1999). For example, the implication of the scale dependency of the signed chi-square technique is that, other things being equal, a larger ward would get a higher deprivation score even if it had the same or even a lower level of deprivation as a smaller ward.

9. WEIGHTING THE DOMAINS

Weighting *always* takes place when elements are combined together. Thus, if the domains are summed together to create a Multiple Deprivation Measure, this means that they are given *equal weight***.** It would be incorrect to assume that items can be combined without weighting.

The Domain Deprivation Measures must be combined in such a way that their weights are explicit. The exponential transformation procedure, as has been noted, ensures that the domains can be combined without "hidden" weights. It would be inappropriate simply to sum the standardised Domain Deprivation Measures because this would give each Domain equal weight.

The criteria for selecting a set of weights for the standardised domains are as follows:

- The importance of their contribution to an overall concept of multiple deprivation;
- Robustness of the indicators comprising the domain.

The Income and Employment Domains were regarded as the most important contributors to the concept of multiple deprivation and the indicators comprising the domains were very robust. Hence, it was decided that they should carry more weight than the other domains. The weightings of the domains is supported by the research team's work, the consultation process and, where available, the wider academic literature.

On the second criterion it is important to stress that only indicators which are sufficiently robust have been included within the Multiple Deprivation Measure. Nonetheless, some indicators are more robust than others, but only those which are sufficiently robust, as well as meeting the other criteria ("domain specific", measuring major features of that deprivation, up-to-date, capable of being updated on a regular basis, available across Northern Ireland at a small area level) have been selected.

Based on these criteria, the following weights have been used (weights must total 100 per cent).

Table 1: Weighting the domains

Domain	Weight
Income deprivation	25 %
Employment deprivation	25 %
Health deprivation and disability	15 %
Education, skills and training deprivation	15 %
Geographical access to services	10 %
Social environment	5 %
Housing stress	5 %

10. CONCLUSION

It is our belief that in order to best measure "multiple deprivation" at small area level, it is essential to have a clear conceptual model and translate this into a series of measures using the best data available. The measures should be driven by the conceptual framework, not by the data. The statistical techniques selected to standardise and combine the data should also be chosen to support the conceptual framework. In themselves, they will produce no "magic" answer.

We hope this exercise has moved the debate on measurement of small area deprivation on and away from the inadequacies of the decennial census. We do not claim this to be the definitive measure. As data quality and sources improve, so will the estimation procedures. We strongly advocate reviewing and developing these measures over the years to come.

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10. Noble, M. *et al*., 2000. *Welsh Index of Multiple Deprivation 2000*, The National Assembly for Wales; Noble, M. *et al*., 2000. *Measuring Multiple Deprivation at the Local Level: The Indices of Deprivation 2000*, DETR.

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APPENDIX

1. The "Shrinkage" Technique

The "shrunken" estimate of a ward-level proportion (or ratio) is a weighted average of the two "raw" proportions for the ward and for the corresponding LGD. Where appropriate, the weighted average is calculated on the Logit scale. This is principally for technical reasons because the Logit of a proportion is more nearly normally distributed than the proportion itself. The weights used are determined by the relative magnitudes of within-ward and between-ward variability.

The "shrunken" ward estimate is the weighted average

$$z_j^* = w_j z_j + (1 - w_j) z$$

where: z_j is the ward level proportion;
z is the LGD level proportion;
w_j is the weight given to the "raw" ward-j data;
$(1-w_j)$ the weight given to the overall proportion for the LGD.

The formula used to determine w_j is

$$w_j = \frac{1/s_j^2}{1/s_j^2 + 1/t^2}$$

where s_j is the standard error of the ward level proportion
t^2 is the inter-ward variance for the k wards in the LGD, calculated as

$$t^2 = \frac{1}{k-1} \sum_{j=1}^{k} (z_j - z)^2$$

2. Factor Analysis

In the domains where individuals can be identified as being deprived or not in terms of the domain definition, the number of deprived people can simply be summed and divided by a suitable denominator to create an area rate. In other domains, deprivations tend to exist in different spatial and temporal forms so, for example, an area will be education deprived if the adults in the area have no qualifications or if the children do not obtain any GCSEs. These two situations co-exist in an area but relate to different individuals at any given point in time. It is hypothesised that an underlying factor exists at an ecological level that makes these different states likely to exist together in a local area. This underlying factor cannot be measured directly but can be identified through its effect on individuals (e.g. failure to obtain GCSEs

and failure to enter higher education). These variables need to be combined at an ecological level to create an area score. Fundamentally, this score should measure, as accurately as possible, the underlying factor.

There are a number of problems in achieving this goal. The variables:

- are measured on different scales;
- have different levels of statistical accuracy;
- have different distributions;
- may or may not apply to the same individual;
- measure, to different degrees, the underlying factor imperfectly.

Maximum Likelihood (ML) factor analysis was used with a view to overcoming these problems. Other methods, such as applying a linear-scaling model[1], deal with only some such problems. Alternative statistical methods, such as Principal Components Analysis (PCA), do not address all these problems. PCA, for example, ignores both measurement error (*error variance*) and the variables' imperfect measurement of the underlying construct (*specific variance).* This is because it does not attempt to separate *common variance* (i.e. variance shared between three or more variables) from *specific variance* and *error variance*. The appropriate technique, where specific and error variance are suspected (i.e. problems 2 and 5), is a form of *common factor analysis* of which ML factor analysis is a type.

The premise behind a simple one-common-factor model is that the underlying factor is imperfectly measured by each of the variables in the dataset, but that the variables which are most highly correlated with the underlying factor will also be highly correlated with the other variables. By analysing the correlation between variables, it is therefore possible to make inferences about the common factor and, indeed, to estimate a factor score for each case (i.e. ward). This, of course, assumes that the variables themselves are all related to the underlying factor to some extent and are, in most cases, fairly strongly related to it.

It is not the aim of this analysis to reduce a large number of variables into a number of theoretically significant factors, as is usual in much social science use of factor analysis (i.e. exploratory factor analysis). The variables will be chosen because they are believed to measure a single area deprivation factor. The analysis therefore involves testing a one-common factor model against the possibility of there being more than one factor. If a meaningful second common factor were found, it would suggest the need for a new domain or the removal of variables. Decisions over whether a meaningful second common factor exists are aided by standard tests and criteria.

Once a satisfactory solution is achieved, a factor score can be estimated for each ward. That is, the combined indicators, using weights generated by the factor analysis process, are then used as the domain score. Thomson's method for estimating factor scores was used.

3. Exponential Transformation of the Domain Deprivation Measures

The precise transformation proposed is as follows. For any ward, denote its rank on the domain, scaled to the range [0,1], by R, with

- ($R = 1/N$) for the least deprived,
- ($R = N/N$) i.e. R=1 for the most deprived,

where N = 566 which is the number of wards in Northern Ireland.

The transformed domain, X say, is

$$X = -23 * \log\left\{1 - R * \left[1 - \exp\left(-\frac{100}{23}\right)\right]\right\}$$

where: log denotes natural logarithm;
exp the exponential or antilog transformation;
* denotes multiplication.

This formula may at first sight seem complicated, but it is calculated in a very straightforward manner and is, in fact, simpler than the commonly-used transformation to a normal curve which necessitates the use of a look-up table.

Each transformed domain has a range of 0 to 100, with a score of 100 for the most deprived ward. The chosen exponential distribution is one of an infinite number of possible such distributions. The constant (23) determines that ten per cent of wards have a score higher than 50. When transformed scores from different domains are combined by averaging them, the skewness of the distribution reduces the extent to which deprivation on one domain can be cancelled by lack of deprivation on another.

For example, if the transformed scores on two domains are simply averaged, with equal weights, a (hypothetical) ward that scored 100 on one domain and 0 on the other would have a combined score of 50 and would thus be ranked at the 90th percentile. Averaging the untransformed ranks, or after transformation to a normal distribution, would result in such a ward being ranked instead at the 50th percentile: the high deprivation in one domain would have been fully cancelled by the low deprivation in the other. Thus the extent to which deprivation in some domains can be cancelled by lack of deprivation in others is, by design, reduced.

Endnotes

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1. Involves adding a large number of items that purport to measure the same construct together to increase the reliability of a scale – assuming error elements to be non-additive and random

DISCUSSION

Mr. Joseph Frey: The research carried out by Mike Noble's team represents an important step forward in both the fields of social policy and social administration – in particular in relation to resource allocation. In any summary presentation of such a major research undertaking, it is perhaps difficult for researchers to give a full picture of the amount of work and the level of professional expertise which is encapsulated in it. Let me begin therefore by acknowledging the complexity of the task which Mike Noble and his team undertook and by congratulating him on the outcome.

Indeed, some two years ago the Housing Executive's research department had itself embarked on a much smaller scale project, in partnership with consultants who had considerable experience in the context of English housing, the aim of which was to develop a resource allocation model based on local area statistics. This model was to be based on the government's new Targeting Social Need (TSN) initiative. A major part of the work involved the development of a statistical baseline, which not only took into account physical housing conditions and housing need, but also the levels of deprivation at a local level. The initial work that we had undertaken already highlighted the many difficulties of producing a consistent, sufficiently detailed yet practicable set of indicators. I can only say that it was therefore with some relief when I found out that a team from Oxford was going to undertake a major part of our task. So I have to thank the Oxford team on a more personal basis as well.

In the course of the next few minutes, I would like to take the opportunity to indicate the importance of this piece of research for housing in Northern Ireland. I am sure you are all aware of the background of social unrest which led to the foundation of the Northern Ireland Housing Executive in 1971 and I do not intend to dwell on it here. Suffice to say that the importance of equality and, indeed, being seen to be equal have been guiding principles for the Housing Executive since its foundation. In the early years issues of equity revolved in particular round the fair allocation of public sector housing in Northern Ireland. This was achieved on the basis of a points-based allocation scheme and has been measurable in that none of the few cases of alleged discrimination in the allocation of housing were ever upheld in any of the very small number of subsequent investigations undertaken by the Commissioner of Complaints.

In the 1970s and in the early 1980s resources were not such an issue – particularly for housing in Northern Ireland, which for many years was a spending priority for the government here. This began to change in the mid-1980s, partly because of the rapid progress which had been made in improving housing conditions (unfitness, for example, had already been halved from 20 per cent in 1974 to 10 per cent in 1984) and partly because public expenditure was becoming more and more closely scrutinised. This resulted in a growing demand for indicators which showed that the allocation of scarce resources was being carried out equitably. Initially, when there

was still a considerable way to go in relation to improving the housing stock, expenditure could be justified in relation to age of stock, lack of amenities or the need for modernisation. As the 1990s progressed, however, and as further strides were taken in relation to improving housing conditions there was growing awareness that many of the most important and most intractable housing problems could not be addressed by pumping more and more money into improving the physical fabric of the buildings. Indeed, in many of the most difficult estates the actual houses themselves were of a very high quality. It was at this time that new terms such as "housing plus" crept into the vocabulary – a concept which recognised the importance of good housing and a sound social infrastructure for the success of any housing development. More and more of the housing investment in many estates had to be in less tangible matters such as participation by residents in the planning and management of their estates. More and more resources had to be devoted to dealing with what became known increasingly as "anti-social behaviour" – a term which can cover anything from dog fouling to breaking and entering.

The question arose of how to be seen to be allocating scarce resources for housing fairly and equitably to areas of need based not just on the physical fabric of dwellings – although this remained of considerable importance – but increasingly to areas of socio-economic deprivation. The mid 1990s had seen the Robson indicators being used in relation to the identification of Rural Priority Areas, which in turn highlighted areas where the Housing Executive's Rural Strategy would concentrate resources (for example, housing improvement grants for the private sector). Mike Noble has already noted some of the problems with the Robson index. Suffice for me to say that from a very practical point of view, because it was based on 1991 census data and because of the major demographic, social and economic changes which had taken place by the late 1990s, this index had really outlived its usefulness.

It was therefore very opportune from our housing perspective that in July 2000 the Northern Ireland Statistics and Research Agency commissioned research to provide an updated, comprehensive measure of deprivation based on data which could be reliably disaggregated to the local area and could be readily updated on an ongoing basis.

Before looking more specifically at the housing deprivation indicator, let me refer briefly to the consultation process which Mike Noble's team undertook as part of the research. I think this is one of the most difficult and yet most important areas for this type of research. It is impossible, given the objectives for such a set of indicators, to fully satisfy all the various interest groups and I feel that the researchers coped admirably with the task, not only of consultation itself, but also of exercising professional judgement in the "adjudication" process to come up with a balanced view of the importance of different and sometimes conflicting standpoints. Mike Noble deals with some of these issues in his paper and emphasises the indispensable necessity of value judgements which are ultimately reflected in the weighting process.

I mention this as well because of the fact that housing is given a weighting of only 5 per cent in the overall Multiple Deprivation Measure. And I think that this is soundly based. Some of the initial comments on the research were based on an insufficient appreciation of the concept of "housing stress" as it is called in the report. Housing stress relates not to the housing circumstances of the occupants but merely to the physical fabric of the dwellings. It is quite possible therefore for a family to live in a dwelling that is of good quality but have insufficient room because of its household composition. The circumstances of this family would not be reflected in the "housing stress" indicator but in, for example, the income deprivation indicator – because they cannot afford say a larger home. When this is borne in mind the allocation of a 5 per cent weighting is understandable.

The issue of data quality in relation to housing is also of importance. The only real consistent source is the House Condition Survey which is carried out on a five yearly basis. In 1996 this involved a sample survey of around 10,000 dwellings which represents less than 2 per cent of the total stock. The statistical expertise of the research team allowed this information to be reliably disaggregated to ward level. Analysis of the outcome of this threw up a number of apparent anomalies. One of the obvious ones was Cherryvalley – an essentially middle class area in East Belfast – which showed up as having a relatively high level of housing stress. Closer examination, however, showed quite clearly that this is an area with a high level of older stock and a high percentage of elderly heads of household – a combination which is often associated with a high level of disrepair. The index therefore accurately reflected the situation on the ground. Similarly surprise was expressed at the fact that no wards in Derry/Londonderry were among the top 200 wards with housing stress despite high levels of economic deprivation in some parts of the city. Again this quite correctly reflects the actual situation on the ground where over the years the Housing Executive has spent millions of pounds in redeveloping and improving large swathes on the housing stock.

Of course, no one can state with absolute confidence that there are no exceptions. The nature of any such index and the nature of the data on which it is produced implies that there will be some anomalies and that, for example, the ward rankings may not exactly reflect the physical fabric of the dwellings in all areas. However, this to my mind should in no way detract from its robustness and its usefulness as a planning tool at the strategic and local level.

Before concluding, let me give a live example of how the Multiple Deprivation Measure is already being used in the housing world. The Housing Executive was recently asked for its advice on the allocation of "Peace II" funds to areas of deprivation which had been particularly adversely affected by the conflict. The starting point for the Housing Executive's work was Oxford's Multiple Deprivation Measure. It was only on this basis that local information was used to whittle down these most deprived wards to produce the 10 areas to be put forward for the first tranche of Peace II money. I, too, have now re-activated our own strategic research project which will help the Housing Executive develop a sound and more

transparent rationale for deciding on and justifying its major spending programmes. The Multiple Deprivation Measure will be an important component of this.

In conclusion, I can only re-iterate the importance of this project to all government bodies who are actively engaged in "tackling disadvantage" and "building communities". I am sure that given the Northern Ireland Assembly's commitment to these overarching goals that the "Noble Index", as it is already being called, will have a long and productive lifespan.

Allow me therefore to second the vote of thanks to Mike Noble for his stimulating presentation today and to congratulate the team from Oxford for the very important research they have carried out.