Dimensions and Boundaries: Comparative Analysis of Occupational Structures Using Social Network and Social Interaction Distance Analysis

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Abstract

This paper analyses social interactions between detailed occupational positions as a means of exploring social and occupational inequalities. Two methods are employed: descriptive techniques of social network analysis, and a well-established modelling approach (the 'CAMSIS' method of 'Social Interaction Distance' analysis). New results on occupational connections are presented for four countries - the United States, Romania, the Philippines and Venezuela – illustrative of a range of socio-economic regimes. Our analyses use detailed occupational measures based upon census data from 2000 to 2002, and we also use data on educational attainment, cross-classified by occupational positions. A broad, singular dimension of social stratification is shown to be the principal element of the structure of social interactions between occupations, but the methods also reveal the social role of various boundaries in occupational interaction patterns (defined by work location, education, and gender). We argue that such distinctions imply that occupational data at a disaggregated level can provide a more thorough understanding of social structure than is observable using amalgamated occupational schemes.

Keywords: *Social Interaction; Social Distance; Social Networks; Occupations*

Introduction

1.1 Social Interaction Distance analysis (SID) and Social Network Analysis (SNA) provide statistical devices which both offer exciting opportunities for applications to social science datasets. In this paper we apply both methods to data on connections between occupations, and examine what the approaches are able to tell us about cross-national differences in occupational structures.

Social Interaction Distance analysis

1.2 In 1966 Laumann and Guttman published an influential analysis of friendship links between occupations. Statistical patterns within those links were interpreted as a means of understanding the social positioning of occupations themselves; this paper and several other contributions of the approximate era applied comparable methods to identify dimensional structures within patterns of social connections between occupations at a more or less detailed level (e.g. Laumann and Guttman 1966; Blau and Duncan 1967; McDonald 1972; Stewart et al. 1973 and 1980)^[1]. Such 'Social Interaction Distance' (SID) analyses, which use modelling techniques such as Goodman's RCII models, correspondence analysis and multidimensional scaling (e.g. Goodman 1979), have made an enduring contribution to sociological research and continue to inspire further applications. In particular, two recent international projects have used similar methods as part of wide-ranging comparative analyses of social interaction patterns in occupations across different countries.

1.3 Following the lead of the 'Cambridge group' of Stewart, Prandy and Blackburn (Stewart et al. 1973 and 1980; Prandy 1990; Prandy & Bottero 1998; also cf. the similar work of Bakker 1993), the CAMSIS project ('Cambridge Social Interaction and Stratification Scales', see Prandy and Jones 2001 and <<http://www.camsis.stir.ac.uk>>) has since 2000 undertaken analyses of social interactions between occupations in different time periods and different countries with the purpose of generating and publishing scales which rank occupations in a dimension defined according to the average social

interaction patterns of the incumbents of occupations. The CAMSIS website features scales from 27 countries for the contemporary period (as of 16 May 2011), and in addition, through the related HIS-CAM project (Lambert et al., 2006), includes measures for seven countries for the nineteenth century. The CAMSIS scales are primarily based upon analyses of pairs of occupations connected by marriage or cohabitation, obtained from large survey samples and using the most detailed level of occupational position available. It is argued that whilst marriage is just one of a number of plausible indicators of social connections between occupations which could be used for this purpose ('connections' of friendship, inter-generational mobility and intra-generational mobility have also been used), marriage records perform as well as any other datum whilst having the advantage of being much more easily accessed and analysed (Prandy and Lambert 2003). Detailed occupational data is used because it is argued that the contours of social stratification are likely to cross-cut larger aggregations of occupations (Stewart et al. 1980), and that the role of gender segregation and differences in the male and female occupational structures can best be recognised through detailed disaggregation of positions (e.g. Prandy 1986). In the CAMSIS project, the argument is made that a core dimension of the empirical patterns of social interaction reflects the tendency of social reproduction in the stratification system through homogamy or homophily. Social reproduction is conceptualised as the very essence of stratification or enduring social inequality, so the principal dimension of social reproduction which is captured by a social interaction distance analysis is interpreted as a measure of the stratification structure. CAMSIS scales are therefore said to provide a probabilistic indication of what relative position, on average, the incumbents of occupations hold within the social stratification structure (e.g. Bottero and Prandy 2003).

1.4 Over a similar period, Chan (2010) has coordinated a separate comparative project which has also derived social interaction distance scales across different countries. In this work the number of different occupational positions considered for analysis has generally been lower, which has had the benefit of allowing calculation and evaluation of sampling errors associated with each occupation's estimated position. In addition, the scales produced under this project have been given a different substantive interpretation: since the measures of social interaction (marriage and friendship) are felt to emerge from evaluations of social honour and esteem, the structure that emerges from analyses of marriage and friendship patterns is therefore interpreted as a structure of 'status' (and, significantly, this is conceptualised as a different social structure from measures of social class, see Chan and Goldthorpe 2007).

1.5 The social interaction distance analytical approach requires specification of some form of statistical model which summarises average dimensions of difference in the patterns of connections between pairs of related occupations. In both the CAMSIS project and the analyses coordinated by Chan (2010), Goodman's RC-II association models (Goodman, 1979), and Correspondence Analysis techniques (themselves a subset of RC-II design), are applied to a cross-tabulation of the occupations held by pairs of connected individuals^[2]. Multiple dimensions of social interaction distance are usually found, but a principle dimension is consistently a smooth gradational marker of a general structure of social distance, which is also readily interpreted as a linear scale of social advantage and disadvantage, 'stratification' or 'status'. The parameters of that dimension can broadly be read as indicators of 'propensity to interact' (although it does not necessarily follow that occupations with similar scores do actually have any connections between them). Accordingly, social interaction distance analysis offers a means of exploring detailed occupational positions, and mapping the placement of occupations within overarching social structures.

1.6 The main practical difference between the CAMSIS and Chan social interaction distance analyses concerns the number of occupational unit groups: the CAMSIS approach has tended to use as many distinctions between unit groups as possible (typically around 200 units are scaled), whereas the Chan approach attempts to produce more robust results through aggregating units to increase category sizes (typically around 30 units are scaled). Neither project has a universal implementation however – for instance Alderson et al.'s (2007) contribution for the Chan project uses a scale with 94 units, whilst five of the published CAMSIS scales are estimated only at the ISCO-88 2-digit unit group level (30 units). In an influential research programme, Grusky, Jonsson and colleagues have argued for the benefit of differentiating detailed occupational positions within analysis (e.g. Grusky and Weeden 2006; Jonsson et al. 2009). These authors seek to define 'microclass' schemes (with around 100 different units) which capture sociologically meaningful divisions between occupations or small groups of related occupations. This level of aggregation may prove an attractive alternative to occupational unit group categorisations, such as ISCO (ILO, 2010), where divisions between occupations sometimes arise for somewhat arbitrary administrative or historical reasons. On the other hand, such schemes rely upon prior theoretical assumptions of occupational similarity, and might not necessarily represent optimal empirical divisions. Within the social interaction distance approach to analysing occupations, therefore, there are significant questions concerning the level of occupational detail used in analysis, and our results below include evaluations of different levels of detail including using a 'microclass' scheme.

1.7 Table 1 shows elements of the results of a social interaction distance analysis, in terms of CAMSIS scale scores for the USA in 2000, by way of illustration of the features of this approach to summarising detailed occupational positions. The dominant dimension in this correspondence analysis is one which appears to be reasonably interpreted as a dimension of social stratification or inequality (note the scores attributed to a selection of occupations, which we would expect to correlate with other measures of average levels of social advantage). In addition the table shows scores from two further dimensions of the social interaction space. These are harder to interpret, but it may be reasonable to assume that they reflect the influence of factors other than the general structure of social stratification upon empirical patterns of social connections. Two such possible influences are the gender profile of the occupation in question, and the sectoral/geographical distribution of occupations. We suggest these might be the sources of the second and third dimension summarised in Table 1, though the interpretation is open to question (farming, and gender segregation, are most commonly noted as major subsidiary dimensions in

Table 1: Illustration of features of a CAMSIS scale estimation: USA, 2000

Selected Census Occupational Groups (% in job)	Scores for males / females		
	Dim 1 (Stratification)	Dim 2 (?Gender)	Dim 3 (?Public Sector)
1 Chief Executives (1.41 / 0.30)	0.82 / 0.86	0.20 / -0.11	0.10 / 0.18
120 Actuaries (0.02 / 0.01)	1.21 / 1.44	-0.68 / -1.05	0.14 / 0.38
220 Post-secondary teachers (0.80 / 0.71)	1.28 / 1.26	-1.35 / -0.98	-0.34 / -0.17
232 Secondary teachers (0.39 / 0.75)	0.70 / 0.97	-0.26 / -0.35	-0.22 / -0.36
313 Registered Nurse (0.18 / 3.82)	0.41 / 0.53	-0.13 / -0.06	-0.34 / -0.45
385 Police and patrol officers (0.90 / 0.07)	0.30 / 0.12	0.50 / 0.59	-0.09 / -0.14
414 Dishwashers (0.07 / 0.09)	-1.53 / -1.28	-1.32 / -0.92	0.41 / 0.37
485 Sales reps (1.61 / 0.55)	0.45 / 0.35	0.34 / 0.24	0.06 / 0.31
570 Secretaries and Admin assistants (0.13 / 6.96)	0.41 / 0.14	-0.07 / 0.40	0.025 / -0.09
652 Sheetmetal workers (0.24 / 0.01)	-0.40 / -0.85	0.29 / -0.06	0.09 / -0.60
720 Auto mechanics (1.60 / 0.02)	-0.53 / -0.65	0.10 / 0.01	0.08 / 0.15
896 Production workers (all others) (1.31 / 0.79)	-0.81 / -1.01	-0.36 / -0.43	-0.31 / -0.34
903 Aircraft pilots and engineers (0.22 / 0.01)	0.93 / 0.69	-0.04 / 0.33	0.43 / 0.40
913 Drivers / Truck drivers (5.04 / 0.22)	-0.57 / -0.58	0.03 / 0.17	-0.01 / 0.05

Syntax used in Stata: `ca hocc wocc [fw=freq] if diag2==0 & farmp==0, dimensions(3)`
 Description: 'hocc' and 'wocc' indicate male and female partners' occupations; 'freq' is a weighting variable; diag2 indicates h/w same 2-digit minor group and 'farmp' both in any farming occupation (selection term excludes these 'diagonals' from model). For further notes on derivation, see www.camsis.stir.ac.uk

Model fit statistics

Total inertia = 0.4315, 473 rows by 425 columns

Dim 1 inertia

0.145

Dim 2 inertia

0.021

Dim 3 inertia

0.013

Correspondence analysis biplot

USA 2000

Source: IPUMS-4, N=2051298 both-working couples, 473 M occs and 425 F occs

(Graphical depiction of the first two dimension points using CA method)

Social Network Analysis

1.8 Social network analysis (SNA) provides an alternative methodology for depicting and interpreting patterns of social interactions. SNA examines social structure from the perspective that relationships between two parties are partly influenced by the external ties possessed by each other. These interdependencies are expected to accumulate throughout a network and thus to generate underlying social structures. Typically, the analytical methods of SNA do not focus on singular probabilistic structures of interaction (as a SID approach does), but seek to chart the presence or absence of interactions and describe the links experienced by different actors (see Knoke and Yang 2008)^[3]. SNA relies on matrices of relationships between actors, with data gathered on the presence, or volume, of ties between each party. Matrices of data on occupational interactions therefore present an opportunity for a

network analysis to be conducted.

1.9 As with SID techniques, occupations could be measured at more and less detailed levels, and SNA approaches used to identify which occupational unit groups (OUGs) share similar connections and network positions, thus enabling analysis of similarity in structural positioning. Importantly, OUGs with similar social interaction distance dimensional scores do not necessarily interact with each other, or even with the same alters. SNA can therefore map existing connections to understand both general structures, and specific patterns such as of cliques or clusters. An SNA analysis might in principle depict the same occupational structure as a SID approach, but is likely in practice to highlight particular relationships which serve to differentiate some positions (that in probabilistic terms may be quite similar), or to link other positions which we would otherwise expect to be differentiated.

1.10 The occupational marriage structure is a system of marked social inequality, where the incumbents of different occupations have substantially different patterns of connections (Kalmijn 1998). However the mechanisms behind social connections between occupations can be divided between two categories. On the one hand are those linked to workplace similarities between occupations, which may lead to numerous different interactions between OUGs. For instance 'structured' interactions in the performance of a job, such as between doctors and nurses treating patients together, shopkeepers and shop assistants contributing to the same business, or air pilots and stewards; through performing unconnected occupations within the same physical location, such as dentists and physiotherapists; or through sharing occupational associations and institutions, such as primary and secondary school teachers sharing trade unions, training courses and engagements with local associations, despite having few direct working ties. Such workplace connections are increasingly recognised in studies of occupational circumstances, including in the conception of 'microclasses' as groups of different occupations which shared cultures and institutions (Jonsson et al. 2009), and the term 'situs' which is often used to describe structurally linked occupations (cf. Morris and Murphy 1959). In social interaction distance analysis, connections between occupations which occur disproportionately often due to these mechanisms are referred to collectively as 'pseudo-diagonals' (differentiated from 'diagonals', which refer to combinations involving the same occupations, which are also usually over-represented).

1.11 Secondly, connections between occupations can be expected through the shared social positioning and social institutionalisation of the incumbents of occupations. Examples may include doctors and lawyers having generated connections through their similar university upbringings, or occupations with similar socio-economic profiles being connected through workers living and socialising in similar locations and sharing patterns of cultural consumption (Bennett et al. 2009; Chan 2010). Most critically, these latter processes include the core drift towards social reproduction and stability which mean that occupational patterns are characterised by homogamy and endogamy (cf. McPherson et al. 2001). Prandy and Bottero (2003) in particular give an extended explanation of how such social connections represent the very production and reproduction of the social order of stratification and inequality. However whereas in the Social Interaction Distance approach, the first set of mechanisms (pseudo-diagonal connections) are usually conceived of as 'noise' to be separated out of the more important mechanisms of social stratification and reproduction, in a network analysis both types of links may be of equal importance in describing points of social connection. Indeed, the former mechanisms may provide an important conduit to social connections for some individuals whose occupation puts them in proximity with others of very different circumstances. Maps of interdependent networks of occupations may not merely reflect social stratification and inequality, therefore, but may also help understand significant points of connection (or separation) which shape the wider social structure.

1.12 Figure 1 shows a hypothetical depiction of how an occupational marriage structure network map may look, as influenced by these various types of process, using the example of the occupations shaded by quartiles of CAMSIS score^[4]. The network structure depicts a general pattern of differentiation by CAMSIS score (i.e., representing differentiation by social stratification and inequality). We also see a number of heavily interlinked clusters, these are intended to represent 'microclasses' (i.e. groups of occupational titles with closely shared circumstances), and we see other links which may involve pseudo-diagonal relationships which often cut across microclasses and across levels of the CAMSIS quartiles. Occupations within the same microclass are generally within the same quartile, but this is not always the case.

Figure 1. Hypothetical structure of USA Census 2000 occupational marriage network

Notes: The points represent occupations ('Nodes' or 'Actors' in the terminology of SNA), and the lines represent connections occurring between nodes more often than average ('relations'). Clusters represent groups of occupations which all share links with each other. In this hypothetical examples, the occupational structure is differentiated into numerous 'microclasses' with pseudo-diagonals connecting them to other occupational clusters.

Data

2.1 The data on social interaction connections between different occupations that we use in this paper is comprised of intra-household marriage connections between occupations^[5]. In this analysis data resources are accessed from IPUMS-International (IPUMS-I) (see Minnesota Population Center 2010, and <<https://international.ipums.org/international/>>). IPUMS-I provides access to (and a substantial volume of supporting material associated with) microdata extracts from census records from a range of countries and time periods. This resource can provide us with large scale representative data about micro-level circumstances, covering the type of job and the composition of the family. As male and female occupational distributions are substantially segregated we would expect many asymmetries. For example, female incumbents of particularly prevalent female jobs, such as nurses, secretaries and teachers, should spread much more widely in terms of their marriage patterns than the equivalent profiles for the male incumbents of the same jobs^[6].

2.2 We use occupational records coded to ISCO-88 3-digit minor groups (ILO 2010) for the Philippines, Venezuela and Romania, and to the US Census Occupational coding frame for that country (see Table 2). Analysis proceeded either on those units themselves, or after recoding those units into the 'microclass' scheme introduced by Jonsson et al. (2009). As we were unable to locate translation schemes linking either the US census scheme or ISCO-88 to the microclass classification, we derived our own translation for the purpose of this analysis (available for download from <www.geode.stir.ac.uk>).

Table 2: Summary of social interaction data used in analyses

	<i>Number of m-f couples with occupations</i>	<i>Occupational unit</i>	<i>Notes</i>
United States, 2000	2191104	US Census 2000 occupations (475 units)	
Romania, 2002	221950	ISCO-88 3-digit (116 units) ^{viii}	Some divergences from ISCO scheme*
Philippines, 2000	262855	ISCO-88 3-digit (130units)	Some divergences from ISCO scheme*
Venezuela, 2001	108273	ISCO-88 3-digit (115 units)	Some divergences from ISCO scheme*

*See the relevant pages under 'national versions' at <www.camsis.stir.ac.uk> for more details.

2.3 Our focus upon these four countries is partly for the convenience of access to data. Naturally these four countries reflect differing social structures and a varied geographical and political landscape. Conventionally, Romania (due to its regime history) and the Philippines (due to its large primary sector) would be portrayed as in earlier stages of economic development, followed by Venezuela and lastly the United States, although no such ranking is unequivocal. Across the four countries, however, variations in sample sizes, histories, occupational structure and profiles of educational attainment^[8] provide us at the very least with opportunities for testing the consistency of SID and SNA approaches across different conditions.

2.4 The comparative analysis of occupational positions between countries is challenging for many reasons (cf. Rose and Harrison 2010). We have benefitted from the extensive harmonisation efforts of the IPUMS-I project, and beforehand by the national statistical institutions of the countries studied. Occupational data is, moreover, arguably more easily measured and compared between countries than many other forms of information (e.g. Kolsrud and Skjak 2005). Nevertheless some incomparabilities in operationalising the measures are likely to remain due to administrative or linguistic differences. This might be especially misleading in the case of analysis of the microclass scheme, as from country to country it is possible that what are nominally the same occupations are, for reasons of translation and administration, located into different occupational units and in turn in different microclasses (cf. Jonsson et al., 2009). Indeed, an attraction of both the SID and SNA methodologies for comparative analysis is that they do not impose *a priori* structures, but are instead free to interpret the same jobs in different ways between countries - a desirable outcome if the units are not really the 'same' after all (cf. Lambert et al., 2008).

Results (1): Social Interaction Distance scales for the USA, Venezuela, Romania and the Philippines

3.1 We calculated CAMSIS scales for each of the countries using a social interaction distance analysis algorithm, and the resulting scales are available for download from the CAMSIS project website (www.camsis.stir.ac.uk). The scales are made available in the format of matrices of data linking occupations with scale scores, plus explanatory documentation on the process. These sources are suitable for direct inspection (arguably the scores are best thought of as sample-based estimates, and they may helpfully feature confidence intervals as cf. Chan 2000). Here we present an overview of the features of the four SID scales.

3.2 There are several means of undertaking social interaction distance analysis and constructing the relevant scales^[9]. An important option concerns the treatment of combinations of occupations which are considered to be 'pseudo-diagonals' (as also described above, these are occupations with high propensities to interact for reasons which are not believed to be revealing about the overall structure of stratification and inequality and are conventionally excluded from analysis - see further notes on this topic at <www.camsis.stir.ac.uk>). Controls for pseudo-diagonals have many similarities to controls for sectoral affinity and exact reproduction which are commonly included in social mobility analyses (cf. Breen, 2004). However the decision of whether or not to exclude particular combinations is debatable, and could have a small impact on the resulting scale values. In addition, in these examples, separate scales are published for the male and female occupational profiles in each country. The publication of gender-based scales

risks causing confusion, but is justified in scientific terms due to significant statistical differences between the occupational profiles and circumstances of men and women (see Prandy, 1986). In practice, across versions, the male and female scales are strongly correlated, and it is often strategically sensible to focus upon only one scale, typically the male scale, applied to all individuals.

3.3 Figures 2 to 6 summarise features of the CAMSIS scales generated in each of the countries. Figure 2 first tries to portray the general character of CAMSIS scales, which is in fact shared across all of the countries though only illustrated in this example for Venezuela. The figure shows the correlation of the male and female scales against the International Socio-Economic Index (and indicator of average income and educational levels across occupations, see Ganzeboom and Treiman 1996). The figure reveals a strong positive correlation, but one that is slightly different between men and women. We also see that the gradation of scores seems to be reasonably even across the population, but there is clustering of positions due to the uneven nature of the occupational distribution itself.

Figure 2. CAMSIS and ISEI scales for Venezuela

Figure 3. Distributions of CAMSIS scales across four countries

3.4 In Figure 3 we portray the overall spread of occupational positions and their CAMSIS scale scores. A key question concerns whether the distribution of positions in the dimension of social interaction distance is evenly gradational, or is characterised by clustering or discrete boundaries. The histograms suggest that there is steady gradation across the range of positions in all countries, although there is positive skew in Romania and the Philippines which is not present in the USA and Venezuela. Skewness patterns seem to reflect the relative economic development of the nations, whereby countries with larger agricultural and industrial sectors have positive skew with a smaller number of more advantaged positions. The unweighted scatterplots show that in all countries, whilst there is a general correlation between male and female scores for the same occupation, there are equally plenty of examples where the male and female scores are slightly different (i.e., whereby the average relative position of men in the space of social interaction distance is not necessarily the same as the average relative position of women). Distributionally, the scatterplots may suggest some divergence between higher and lower groups of occupations within Romania, and perhaps the Philippines, shared consistently on the male and female scale, whereas the USA and Venezuela have more even gradation across the range, but relatively more divergences between male and female positions for the same occupations. Again, we suspect the relative economic development in each country accounts for these differences, suggesting greater social segregation and inequality in the Philippines and Romania. Whilst these plots provide a heuristic representation of the spread of scale scores, however, the number of occupational units involved could also influence interpretations – it is conceivable, for instance, that if the occupations within the Romanian and Philippine data were disaggregated into smaller units, then scores for these units might fill up the apparent gap between top and bottom.

3.5 Figure 4 shows the occupational order of stratification in terms of where particular jobs fit within the occupational order of stratification as detected through social interaction patterns. It does this in terms of the 'microclass' units of Jonsson et al. (2009), which make a convenient measure of nominally equivalent detailed occupational positions between countries. Figure 4 confirms that the broad pattern of occupational stratification is similar between countries (coined the 'Treiman constant' following Treiman's influential 1977 analysis). Equally, the figure often reveals substantial variation from country to country in the relative position assigned to an occupation. In general terms, we see again more gradation in the United States and Venezuela, particularly in the more advantaged occupational positions, whereas the pattern seems to reverse in Romania and the Philippines, with relatively less dispersion of scores at higher levels, and more dispersion at lower levels^[10].

Figure 4. CAMSIS scale scores by microclass units

Figure indicates male CAMSIS scale scores across four countries using 'microclass' units.

3.6 It is also possible to explore the relationships between SID scale scores and educational levels. Figure 5 shows that all countries have a profile of difference in scale scores across educational levels. This relationship differs by gender (women in all countries have more privileged occupations at given educational levels; this is particularly so at medium levels of education, but there is a narrowing of the gap at higher levels). However the relationship is surprisingly undifferentiated by age, whereby similar levels of occupational positions are held given educational qualifications across different age groups (credential inflation may have lead us to expect more payoff to education to older cohorts, but in fact credential inflation and occupational upgrading would seem to have gone hand for younger cohorts). Figure 6 proves particularly revealing in showing the extremely strong structuring by educational level associated with the social interaction distance space. This figure reports scales where the base units are not just occupations, but are the occupational unit cross-classified by educational level. The top four panels show the relation between male and female jobs (similarly to the right hand plots of Figure 3) and reveal a strong pattern of relative advantage to the occupations with qualifications versus those without. The lower two panels summarize the same jobs with and without higher levels of qualifications. All points lie above the line of equality which suggests that higher education was always linked to greater advantage, and moreover there is strong structuring of differences within jobs between those with higher and those with lower levels of education (that is, the advantaged jobs on the scale are dominated by jobs with more people in advantaged positions – i.e. the dark circles dominate – whilst the less advantaged jobs have relatively more people with lower levels of education – i.e. the light circles are more prominent).

Figure 5. Average levels of CAMSIS scores by educational level categories

SID scores by age and education

Data from IPUMS-I, N = 6.9M (US); 783k (RO); 1.8M (PH); 691k (VE).
Lines show mean CAMSIS score (male scale) for occupations held per age/education/gender group.

Figure 6. SID scales on units of occupations cross-classified by educational level

SID scales on occupation by education

Data from IPUMS. Points show scale scores for units defined by cross-classifying occupation and education.
For Venezuela and Philippines, units are for all occupations with or without 'secondary' level or above.
For Romania units are for all occupations with or without 'university' level.
For USA, only occupations in SOC range 1-196 & 370-593 disaggregated by university level, with others coded to modal level.

3.7 In summary, the core pattern revealed in this description of the SID scales for each country is of

gradation between social positions, strongly marked by educational levels. The probabilistic distribution of social advantage is of a similar character in all countries, but there are particular differences from country to country, and far greater skew of positions and clustering of the most advantaged positions in Romania and the Philippines than elsewhere. This evidence is consistent with other cross-national comparisons of SID scales (e.g. Chan 2010; Prandy and Jones 2001): the empirical dimension of social interaction distance as estimated across countries reveals a gradational structure indicative of social advantage or stratification; SID analysis reveals some national specificities and gender differences between scaled positions, but the main evidence concerns a general single dimension of social structure.

Results (2) Social Network Analysis of occupations in the USA, Venezuela, Romania and the Philippines

4.1 The same data on pairs of occupations connected by marriage or cohabitation can be used to examine occupational structure using social network analysis (SNA). We define a threshold at which point occupations are said to be 'connected', namely whether the occupational combination occurs more than twice as commonly as expected given the size of the occupational groups and given that the tie is formed in at least 1 in 10,000 marriages (after removing all cases where either at least one partner has no known job title or both individuals are within the same occupational unit group)^[11]. This enables us to identify relatively similar sized networks irrespective of the sample size of our datasets, whilst protecting ourselves from overstating the importance of pairings which are statistically over-represented but are still rare occurrences.

4.2 There are, however, at least two unresolved problems with this approach. Firstly, as Table 2 highlighted, there are inconsistent numbers of occupational unit groups (OUGs) across surveys. Whilst our criteria for connections controls naturally for variations in sample size, it does not control for the situation where some samples hold much larger numbers of OUG's than others (the number of different positions can be expected to directly influence a network description). Standardisation, such as by using the microclass scheme throughout, could address this incomparability, but this would nevertheless mean ignoring more detailed data, and in fact our preferred solution is to estimate scales with different numbers of units. Secondly, our proportional thresholds prevent occupations performed by less than 1 in 10,000 individuals within a gender from generating any ties. Table 3 shows the threshold limits for each country and that some OUGs, therefore, cannot generate any connections. We believe when exploring national patterns in terms of dimensions and boundaries that this is a reasonable exclusion (since sparse occupational groups should not in any case have a great influence upon the wider occupational structure), although this strategy might not suit all possible research questions on networks. These restrictions are only applied within gender groups, however: Table 4 shows examples of Romanian occupations which cannot produce any ties for one gender, but include a sizeable number of the workforce of the other. In such examples, the sparse categories are excluded from the respective gender profile, but not from the opposite group.

Table 3. Sample sizes and thresholds for frequency of ties to be within one in 10000 relationships (after removing couples in the same OUG)^[12]

	Cases	OUG's	Threshold	Male OUGs too small	Female OUGs too small
Philippines, 2000	166,896	130	17	2	7
Romania, 2002	173,506	369	18	49	48
USA, 2000	2,099,773	475	209	22	114
Venezuela, 2001	93,786	115	10	11	20

Table 4. Exemplar of highly gendered occupations within Romania 2002, after removing couples in the same OUG (average cases per OUG: 470).

	Men	Women
3141. Ships engineers	139	7
4111. Stenographers and typists	4	236
5161. Firefighters	641	10
7436. Sewers, embroiderers and associated workers	7	115
8311. Locomotive-engine drivers	859	16
8340. Ships' deck crews and related workers	273	5
8888. Armed Forces	112	1

4.3 Networks have been generated for each of the four countries within this paper, as shown in Figures 7-10^[13]. Nodes represent the OUGs, as obtained from IPUMS-I^[14], shaded by their CAMSIS quartile. Such amalgamation of OUGs by CAMSIS quartile is a rather simplistic mechanism which can create the same

division between the 75th and 76th percentile that is displayed between the 51st and 100th. However the sizeable proportion of field crop workers in the Philippines makes divisions into a larger number of groups impractical.

Figure 7. SNA depiction of occupational networks in the USA, 2000

Figure 8. SNA depiction of occupational networks in Romania, 2000

Figure 9. SNA depiction of occupational networks in the Philippines, 2000

Figure 10. SNA depiction of occupational networks in Venezuela, 2001

4.4 It is apparent that the actual networks generated across the four countries differ to the hypothetical version shown in Figure 1. Venezuela aside, the networks generally consist of a single dominant composition and a few smaller connected strands. There is an apparent lack of formation of tight clusters such as microclasses; couples appear to be formed through a more general force of stratification homogeneity. In addition whilst the hypothetical model links the microclass clusters through numerous pseudo-diagonal ties, often outwith CAMSIS quartiles, the observed networks demonstrate strong stratification effects and relatively few 'long distance' connections.

4.5 The distinction between the highest CAMSIS occupations and the less advantaged jobs is striking. In the USA and Romania there are no connections between the highest quarter of occupations and the lowest half. The only such tie in Venezuela is between mid-level nurses and workers in personal care. Multiple connections exist within the Philippines, but these are chiefly at the level of agricultural and farming workers connecting to dignitaries within their villages, such as legislators, chiefs and school teachers, or through people working away from home such as deep-sea fishermen and the military. The actual structural relationship shows greater social distance than the hypothetical model predicted, implying that stratification position is much more important than workplace cultures and institutions in structuring social interactions.

4.6 The hypothetical model had an almost gravitational pull to the centre of its network, conceived as being through the large microclass grouping of 'managers' being linked through numerous pseudo-diagonals to employees. However such a structure is lacking from the empirical results. Venezuela provides a structure which almost separates the most advantaged occupations from the rest. In the US, 'Nursing, psychiatric and home health aides' (360) are the only occupation to link what would otherwise be unconnected clusters. Romania has three forms of connection between its advantaged and disadvantaged sectors, namely: female waitresses and bartenders marrying their managers (5123 and 1315), chemical (3111) and mechanical (3115) technicians brokering ties to both engineers and production workers; and a less obvious tie, perhaps explained through geographical connections, between male farming and forestry advisors marrying the rather large female category of primary school teachers (3213 and 3310).

4.7 It is evident within Romania and the US that occupational similarities do define some clusters. For instance, we can observe a structure in Romania (top left of Figure 8), composed of the positions of restaurant managers (1315); cooks (5122) and waiters, waitresses & bartenders (5123). Their only outward

ties are to retail managers (1314), housekeepers (5121), sales assistants (5220) and bakery assistants (7412). This implies the restaurant industry generates social connectivity, which is then shared with others performing similar roles. However this cluster would not be measured by the microclass scheme of Jonsson et al. (2009), which would place food service workers in a different 'macroclass' to their managers, whilst assigning bakers their own classification and breaking down sales assistants by industry. Gender distinctions could also be observed. Waiters and waitresses both have strong marriage ties to cooks, but whilst waitresses have their only other tie to restaurant managers, waiters hold theirs to sales assistants and bakery assistants. This demonstrates how we should not perceive occupational ties as operating outwith gender, as in this example we can see how females within an occupation might often cohabit with partners of more advantaged socio-economic circumstances, whilst their male colleagues in the same occupation may not do so.

4.8 Sectoral distinctions are most clearly observed within the US data. Figure 11 shows occupational networks with sectoral similarities highlighted. As with Romania we can observe a food service industry cluster, comprising food service managers (31); chefs (400); food service supervisors (401); bartenders (404); and waiters and waitresses (411). This cluster also holds ties to cooks (402) and cashiers (472). The three principal farming occupations, namely farm, ranch and other agricultural managers (20), farmers and ranchers (21) and miscellaneous agricultural workers including animal breeders (605) also share connections, possibly due to geographical location and family businesses. Similarly, as with Romania and Venezuela, a healthcare cluster can be identified operating to bridge the chiefly professional and manual segments of the network. This implies pseudo-diagonal relationships are generated within certain occupations in a variety of nations. The geographical restrictions placed upon farming communities, the workplaces and hours of the food and drink service industry and the wide variety of workplace interactions within hospitals produce heightened levels of social interactions across social boundaries.

Figure 11. USA 2000 network, grouped by occupational cultures

4.9 The segregation of professional occupations is perhaps more evident within the US network than the other three countries. There is certainly a heavily connected core to the professional network, comprising of lawyers (210), social workers (201), counsellors (200), teachers (220, 231, 232, 233), and educational administrators (23), seemingly dominated by graduate occupations which hold little interaction with other graduate professions. This cluster of advantaged occupations with little seeming connection (other than heightened levels of graduates) is uncovered in all four countries. The US, however, appears to reduce the critical mass of such a grouping through their fragmentation into occupationally similar roles. There is a segment of the network which links together three sales roles, with another linking together three higher management roles along with management consultants. Food service and farming managers are separated from other managers. Those managers experience the same dislocation from other professionals also experienced through the heavily bonded relationship between airline pilots (903) and stewardess (495).

4.10 A distinction between the SID and SNA analysis is that whilst the former provides an indicator of the

average position of all marriage ties within each OUG, the latter seeks to identify over-represented bonds irrespective of other ties. Therefore, professionals from all OUGs are likely to hold many marriage ties to people with a similarly advantaged role, but not on a relatively high basis to any individual vocation. However, the CAMSIS positions of managerial roles, especially those positioned within the manual segment, appears to differ within the USA network. Food service (31) and farming (20) managers are both found within the third quartile of CAMSIS, with their bonded relationships held with OUGs in the lower half of the scheme. Marketing and sales (5) and health managers (35), however, appear in the highest quartile, possessing linkages not solely to other professions in the upper half of the CAMSIS scheme but also to occupations which have strong bonds to other advantaged groups. Whilst the difference in CAMSIS quartiles does not always indicate major differences in stratification position (due partly to the artificial boundaries imposed at certain percentiles, and partly to potential sampling error), there is evidence of differing social interaction patterns amongst managers by sector.

4.11 Expansion of the professional workforce is a plausible explanation of the increased tendency for the US network to follow sectoral patterns. Occupations with the general professional core of the US network, as listed above, are generally found within the professional cores in all four countries (although educationalists are missing from the Venezuelan core). However, the strongest mutually connected cores in other countries all possess many more occupations, including university lecturers, medical doctors, chief executives, business administrators, financial managers, other higher corporate roles and engineers (except Venezuela). Whilst these are all advantaged occupations within the US, they tend to form strong ties to other vocations similar to their work rather than simply based upon levels of advantage. In contrast, the professional cores outwith the US are all entirely interlinked. This is not the case in the US, implying its professional core is more fragmented.

4.12 As with the CAMSIS analysis, occupational networks can be depicted after additionally controlling for levels of educational attainment. This can be achieved by recoding an individual's occupational code by whether they are a graduate or non-graduate^[15]. As the number of OUGs is doubled, we have relaxed the threshold for inclusion to an occurrence in 1 in 20,000 households. Due to its low levels of graduates, as measured in our data, Venezuela has been left out of this phase of analysis. Figures 12-14 show the occupational networks by degree. The greyscale represents non-graduates, whilst the blue shows graduates. The darker colours indicate higher CAMSIS quartiles. There are many similarities between the Romanian and Philippine networks, holding essentially three sections, for graduates, non-graduates working in advantaged jobs, and non-graduate manual workers. Few instances of strongly bonded ties crossing both degree and OUG boundaries could be found. The examples principally involved workplace locations, such as ties between office clerks and lawyers, legislators, government officials and public services administrators in Romania or between physician science technicians and computer assistants in the Philippines; or through individuals undertaking professional roles without obtaining degrees, such as primary and pre-primary school teachers in Romania or special education teachers in the Philippines. The boundaries between the three segments of the workforce appear rigid, with the connections between graduates and manual workers being brokered solely through shared OUGs whilst the manual workers and professional non-graduates connect through a different set of occupations.

Figure 12. Occupational network by degree attainment, USA 2000

Figure 13. Occupational network by degree attainment, Romania 2002

Figure 14. Occupational network by degree attainment, Philippines, 2000

4.13 The US network differs greatly to that from Romania and the Philippines, showing stronger signs of connectivity to the non-controlled network. A clear boundary exists between the graduate and non-graduate occupations. Therefore, rather than a three-fold structure being created, there is a clear dichotomy between graduates/professions and manual workers. Unlike in Romania and Venezuela, this is not brokered through ties across degree levels within OUGS. The only two connections across the professional/graduate to manual sections are through farmers and nurses. The only connections across both degree and OUG contours are examples of pseudo-diagonals, namely between lawyers and paralegals/legal secretaries and between nurses and both physicians and pharmacists. One graduate occupation apparently dislocated in the manual section is food service managers, who are seen to interact with fellow employees rather than those with similar stratification positions.

4.14 Whilst CAMSIS quartiles are, self-evidently, proportionally similar across countries, there is a wider variation in the numbers of graduates. Graduates comprise 27.4% of the US both-working married workforce, compared to 15.6% in the Philippines and 13.4 % in Romania. The differences between the structures within the US and Romania/Philippines, therefore, could plausibly be attributed to this distinction, as most of the highest quartile in the US are graduates, unlike elsewhere. The integration of professional workers into graduate circles could therefore lead to greater social bonding between professionals within the US, potentially restricting wider social connections. Romania and the Philippines also show a boundary between graduates and non-graduates, in addition to the professional/manual dichotomy in occupational structure.

4.15 Analysing occupational network maps suggests that in the US levels of occupational advantage are less rigidly divided across sectoral grounds than in other countries. This could partly be explained by the larger professional workforce within the US, producing a smaller number of organisations within the 25% of most advantaged jobs in comparison to other countries. In the United States, the evidence that the core of professional occupations is both smaller and less strongly connected, and the incorporation of non-graduate professions more tightly connected, than in other countries, suggest that industrialisation processes are linked to differences in network connections. The dislocation of food service managers, operating alongside their employees rather than others sharing their educational background and economic resources, as evidenced in terms of both network settings, demonstrates that managerial positions within the US do not necessarily incorporate part of the professional core, with strong ties to all of the most advantaged occupations, as is the case elsewhere.

Discussion: Comparing dimensions and boundaries in the social structure

5.1 The sociological analysis of detailed occupational positions is arguably enjoying a revival in popularity. Whilst the extended analysis of work and occupations was once a core feature of sociological endeavours, it is possible to identify recent bodies of literature which have either downplayed the relative importance of occupational circumstances in comparison to other social differences (e.g. Pakulski and Waters 1996; Kingston 2000; Bennett et al. 2009), or alternatively have tended to reduce the use of occupational data to relatively broad-brush schematics (e.g. Blossfeld and Hoffmeister 2005). Over the last decade, however, we arguably see a resurgence in studies which pay attention to detailed differences between occupational positions, evidenced for instance in the construction of finely nuanced occupation-based schemes (e.g. Weeden and Grusky 2005; Oesch 2006; Güveli 2006; Jonsson et al. 2009; Rose and Harrison 2000), or of scaling and analytical approaches which locate detailed occupational positions within dimensional structures (e.g. Ganzeboom and Treiman 1996; McGovern et al. 2007, c7; Chan 2010). In this paper we have described and compared how the analysis of social interaction data involving detailed occupational positions can inform us about the occupational structure and wider structures of social stratification.

5.2 Both Social Interaction Distance, and Social Network Analysis, techniques can be used to depict structures of social stratification and inequality on the basis of analysis of social interactions involving occupations. We see clear patterns of gradation between occupations which seems to reflect social stratification relations – a well established sociological finding (e.g. Stewart et al. 1980). We see very slight variations between countries in those relationships, but we see much more substantial variations in other factors and mechanisms which drive social interactions, which have traditionally been subsidiary considerations in social interaction distance analysis but are more prominent features in a social network analysis. Social policies which seek to influence the social structure, such as to promote social mobility or opportunities for the disadvantaged, may be productively informed from network evidence on connections between occupations.

5.3 Our analysis suggests that detailed occupational positions are important since they reveal nuances and boundaries in the occupational structure which would be occluded by more aggregate measures. For instance, we have found that whilst the same occupations are found in the same countries, their relative circumstances are similar but not identical. Members of advantaged occupations in less economically advanced countries appear to interact more widely with other advantaged roles, rather than generating ties within their own industries or sectors irrespective of social position. However the expected roles of pseudo-diagonals and microclasses in bonding together occupations proved not to be as substantial as expected, particularly outside the USA where most individuals seemed to generate ties based upon social stratification hierarchy. Our speculative interpretation is the less industrially complex nations have relatively fewer people within the most advantaged occupations, and therefore differentiate themselves from the wider community more starkly. Within the US, the larger proportions of people in advantaged occupations, generates a critical mass which is too large to sustain an isolated, homogenous group, leading instead to fragmentation within advantaged sectors in terms of commonalities of occupational norms. Therefore, the system moves away from generating social interaction patterns defined predominantly by social position, and towards those based increasingly upon other mechanisms.

5.4 This analysis also shows how in the US, although not elsewhere, the classification of managers by their occupational position, rather than sector, groups together individuals with different socialisation patterns and levels of socioeconomic advantage. The absence of such distinctions elsewhere demonstrates how disaggregated groups can allow for nuances of national interpretations which may not be fully maintained within internationally comparable classifications. Education was also seen to be a major dividing force in all countries, but occupational positions described important heterogeneity within educational locations, and revealed patterns about social relationships and structure which could not be adequately understood with cruder measurement instruments using qualifications or broad occupational positions.

5.5 Our interpretation of the effects of economic development, and widespread educational attainment, on the generation of networks based around similarities in the nature and locations of workers is just one perspective. It is plausible that, rather, developments in the nature of interactions and socialisation are influencing the social structure – the Bowling Alone thesis (Putnam, 2000), for instance, might suggest that US has a society comprising interactions being based around work, whereas other, less economically developed societies have maintained more community activities and interactions between neighbours (who are likely to be of similar circumstances). Comparison of four countries at a single time-point cannot determine which argument is the most substantial. We hope further analysis of additional datasets, societies and time-points, will increase our understanding of the underlying factors.

Notes

¹The tradition of 'social interaction distance' (SID) analysis of occupational data is ordinarily seen as originating in these studies, since they are characterised by using social interaction patterns in order to explore occupational differences. Nevertheless many earlier studies had also analysed social interactions, and noted the connections between social interaction patterns and occupational inequalities (e.g. Centers 1949; Lazarsfeld and Merton 1954; cf. McPherson et al. 2001).

²Estimation of these models for the purposes of social interaction distance analysis have most commonly been undertaken in IEM (Vermunt 1997); Stata (e.g. Hendrickx 2000); and by using the gnm package in R

(Turner and Firth 2007).

³By some accounts, Social Network Analysis incorporates any technique which can be applied to data on social connections. Accordingly, Knoke and Yang (2008: 113) portray correspondence analysis (which is a staple instrument of social interaction distance analysis), as a particular type of SNA. In our account, however, we conceive of SNA techniques as restricted to those which emphasis depiction of the presence or absence of ties.

⁴Colours here and in Figures 7-11 use the following order, going from highest CAMSIS quartile to lowest: black; pink; blue; brown. Quartiles are generated from all individuals in married both-working partnerships based on the male CAMSIS score.

⁵ We discuss in more details in our technical paper IPUMS and other sources of data that are exploited within our ongoing project 'Social Networks and Occupational Structure' (see Griffiths and Lambert 2011, and <<http://www.camsis.stir.ac.uk/sonocs>>).

⁶In addition, the force of gender segregation itself would be expected to form part of the structure of social interactions – that is, we would not expect to find high numbers of marriage links between jobs at the extremes of gender segregation, such as between crane drivers and carpenters, or between midwives and library clerks. In social interaction distance analysis it has been standard practice to recognise gender segregation in occupations as a separate dimension of interaction patterns. It can usually be identified through an exploratory approach (interpreting an unstructured dimension as one of segregation, whilst a confirmatory strategy, involving fixing gender segregation index scores to the model and testing model improvement achieved by this, can also be applied.

⁷For the social network analysis, the 4-digit codes have been used with 469 OUGs. The 3-digit codes are shown in the CAMSIS discussion for comparison to other countries. The 4-digit codes are shown in the network analysis to preserve data.

⁸Frequencies of individual variables are available on the IPUMS-I website. Generally educational profiles follow the expected patterns in each country. However, in the IPUMS-I data Venezuela has one of the lowest levels of respondents coded as graduates (0.3% of the population). This probably reflects a harmonisation or coding inconsistency, which impacts our later analysis of educational qualifications in that country.

⁹ The CAMSIS project webpages discuss these differences in greater detail (<<http://www.camsis.stir.ac.uk>>). The scale for the USA used in this paper involved a relatively more extended analysis using the IEM software (Vermunt 1997), using a cross-classification between occupational title and employment status, and with a relatively substantial element of manual review of the data. The scales for Romania, the Philippines and Venezuela were derived using semi-automated programmes using the Stata software (cf. <http://www.camsis.stir.ac.uk/make_camsis/>). All of the methods and derivation strategies employed are open to adaptation; we find it most productive to refer to CAMSIS scales as 'versions' of social interaction distance scales, and note that correlations between different versions tend to be high.

¹⁰The positions in Figure 3 are not weighted according to the number of cases, which explains the apparently different overall profiles between countries – in all countries the scales are in fact standardised to mean 50, standard deviation 15.

¹¹More information on the SNA methods we used can be obtained from our project website, <<http://www.camsis.stir.ac.uk/sonocs>>. A Stata .do file to derive an SNA matrix from social survey data involving husband and wife occupations can be obtained from: <<http://www.camsis.stir.ac.uk/sonocs/do/pajek.do>>.

¹²This table excludes couples where both partners have the same OUG, hence the lower sample sizes than Table 2.

¹³Networks are displayed as directed, pointing from the male to the female occupations. This is a simple representation issue and could equally be reversed.

¹⁴Labels can be derived from: <<https://international.ipums.org/international-action/variables/OCC/codes>>. Stata do files to implement these labels can also be found at <<http://www.geode.stir.ac.uk>>.

¹⁵A Stata .do file to derive an SNA matrix from social survey data involving husband and wife occupations separated by educational attainment can be obtained from: <http://www.camsis.stir.ac.uk/sonocs/do/pajek_uniocc.do>. For this section of the analysis, we have dropped members of the same occupation from the analysis after they have been split by educational attainment: i.e., rather than removing all cases of policemen marrying policewomen we have kept instances of graduate police officers marrying non-graduate police officers.

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