Dimensions and boundaries: Comparative analysis of occupational structures using social network and social interaction distance analysis

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Abstract

Social interaction data on occupations can be revealing about the structure of social stratification and inequality in at least two ways. Firstly, a social interaction distance analysis using association models for the prevalence of social connections between occupations can be used to identify broad dimensions of the probabilistic social distance between occupations. These dimensions are often interpreted as markers of an order of stratification or status aligned to occupations. Secondly, the techniques of social network analysis can be used to chart the actual patterns of connections between occupations (rather than their probabilistic tendencies), which can help us identify particular occupations which have disproportionately many links between them, or indeed boundaries between occupations across which disproportionately few individuals interact. We present results from an ongoing project which compares both analytical techniques applied to data on social connections between occupations.

In this analysis we focus on what data from the IPUMS census harmonisation project can tell us about comparative differences in occupational structures. We use sample data from the USA, Romania, the Philippines and Venezuala. IPUMS offers data on jobs which are socially connected through intra-household links; such connections are plausible albeit imperfect indicators of patterns of social interactions, and they have the advantage of being readily available from a wide range of countries and time periods. From country to country, and over time, we expect the dimensions and boundaries of social interactions between occupations to be broadly stable, but, given differences in institutional arrangements, it would be a surprise were they identical. When differences emerge, moreover, theoretical claims can be evaluated according to whether they account for the empirical pattern. Preliminary findings are of only small differences in dimensional structures, largely influenced by gender segregation and farming jobs; there are however more substantial differences in network connections between occupations, which vary from context to context.

1. Introduction

An extended sociological tradition has used information about patterns of social interaction between occupations to investigate and summarise how social structures connect with detailed occupational positions. This paper seeks to compare and evaluate the contributions which can be made by two different means of analysing interactions between occupations: social interaction distance analysis, and social network analysis.

Social Interaction Distance analysis

In 1966 Laumann and Guttman published an influential analysis of friendship links between occupations where statistical patterns within those links were interpreted as a means of understanding occupational positions themselves, and several other contributions of the approximate era applied comparable methods to undertake investigations into occupational patterns at a more or less detailed level (e.g. Lauman and Guttman, 1966; McDonald, 1972; Stewart et al., 1973; Prandy, 1990; Bakker, 1993)[i].

In more recent decades, at least two ambitious international projects have sought to undertake multiple comparative analyses of social interaction patterns in occupations, using broadly standardised approaches with the principle intention of generating new maps of the social structure. Following the lead of the 'Cambridge group' of Stewart, Prandy and Blackburn (Stewart et al. 1973; 1980; Prandy, 1990), the CAMSIS project ('Cambridge Social Interaction and Stratification Scales', see Prandy, 1999 and 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 current CAMSIS website features scales from 27

countries for the contemporary period and in addition, through the related HIS-CAM project (Lambert et al., 2006), includes measures for seven countries for the nineteenth century.

The 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 for this purpose ('connections' of friendship, inter-generational mobility and inter-generational mobility have also been used for the same purpose), marriage records perform as well as any other datum whilst 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 disaggregations 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 stratificaiton 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. Prandy, 2002).

Over a similar period, Chan (2010) has coordinated a separate comparative project which has also derived social interaction distance scales across different countries using similar methods and approaches as those from the CAMSIS project. 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 error estimates 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', which is conceptualised as a different form of social structural force than the influence of class (Chan and Goldthorpe, 2007).

The social interaction distance analytical approach requires specification of some form of statistical model which summarises the average 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 each individual within the pair of connected occupations[ii]. These models calculate dimensions of difference between categorical positions according to the empirical occurrence of different combinations - parameters of these models therefore serve to indicate placement in one or more dimension of difference, and it these parameters, after rescaling, which constitute the actual values of the SID scale scores. More than one dimension of social interaction distance is usually found, which we will return to in section 3, but a principle dimension is consistently found to be 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 us a means of exploring detailed occupational positions, and mapping the placement of occupations within overarching social structures.

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 that these might be the sources of the second and third dimension summarised in Table 1, though the interpretation is open to question[iii].

TABLE 1 ABOUT HERE

Social Network Analysis

Social network analysis (SNA) provides an alternative methodology for depicting and interpreting patterns of social interactions. SNA focusses upon structures of interdependence between actors, and offers different methods for representing them, including graphical and statistical presentations on the volume of links. Critically, SNA examines social structure from the perspective that relationships between two parties are partly influenced by the external ties possessed by the other. These interdependencies are expected to accumulate throughout a network and thus to generate underlying social structures. However, unlike a SID approach, SNA does not construct probabilistic models of interaction, but seeks to chart the presence or absence of interactions and describe the connections and links experienced by different individuals. An SNA analysis might in principle depict the same occupational structure as a SID approach, but is much more likely in practice to highlight particular points of linkage which serve to differentiate positions which, in probabilistic terms, may be quite similar.

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. However, SNA is not merely a technique which can be applied to data, but is also portrayed as a theoretical perspective to the analysis of data, since it involves an explicit commitment to a certain characterisation of network connections (e.g. Knoke and Yang, 2008). Therefore, a rationale for why interdependence networks should be identified is essential for utilising a SNA approach.

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). Similarities in social background and socio-economic circumstance are certainly one reason why connections between individuals through their occupations may be made, and homophily and homogamy are central concepts to SNA, which presupposes that 'birds of a feather flock together' (McPherson et al. 2001). However occupations may also provide a conduit to social connections which do not involve performing the same occupation or requiring similar background traits such as educational qualifications: in addition, opportunities to interact between occupations could arise from people in different jobs sharing the same workplaces, localities, or work related facilities. Maps of Interdependence 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.

The concept of 'brokerage' in connections is therefore important to an SNA approach: two occupations which both have connections to another occupation may therefore have links 'brokered' between them via that route, and have, accordingly, similar positions. However, the probabilistic nature of an SID approach takes such similarities as granted (i.e., two occupations with comparable links to a third are both given similar scores regardless of whether they connect), whereas an SNA approach explicitly examines the scale of such brokerage and, if it is not found, seeks to find a means to descirbe the lack of connections between them (i.e. two occupations with comparable links to a third but without their own connections are treated as having different experiences). For example, we could anticipate a forensic scientist having work-based connections to both the police force and the dental professions. A SID analysis would therefore scale police officers and dentists in similar positions (all other things being even), but if an SNA showed no actual relations between the two, it would find a different means of summarizing occupational connections.

Whilst SNA might be most familiar through concepts such as brokerage (Burt 1992) and the 'strength of ties' (Granovetter 1973), additional tools for analysis are available. Patterns in the strength of homophily (Krackhardt and Stern 1988), network dynamics and change

(Snijders et al. 2010) and structural equivalence (Doreian et al. 2004) can all be utilised for identifying and interpreting occupational structure on the basis of analysis of the matrices used for social interaction distance analysis. Such tools could aid understanding of the tendency for groupings of occupations to internalise their marriage ties, evaluate changes in structure over time, and identify which vocations are positioned in structurally similar but geometrically distant locations. Therefore an SNA apporach can aid an SID style analysis through utilising the matrices in a different manner to explore underlying reasons for the patterns identified.

SONOCS project (Social Networks and Occupational Structure)

This paper emerges from the ESRC-funded SONOCS (Social Networks and Occupational Structure) project. In this project we are engaged in undertaking further analyses of social interation distance scales in extending and updating the collection of CAMSIS scales distributed at that project's website (www.camsis.stir.ac.uk). In addition we have applied social network analysis methods to the same data resources, and are evaluating the relative contributions which this approach can make to understanding of occupational structures. Key questions concern differences in the evidence revealed by the different methodologies, and differences between countries and over time in the wider structures revealed. In addition since educational systems (and educational data) sit alongside occupational structures as key measures relevant to understanding stratification and inequality, we have a particular interest in evaluating the combination of educational and occupational positions in the terms of analysis of social interaction data. This paper summarises our methods and presents results from four illustrative national analyses, using census samples from the USA, Romania, the Phillipines and Venezuela. These samples were chosen partly for convenience (since they provide ready access to relatively detailed occupational data), and are in addition intended to represent countries from across the spectrum of contemporary economic development.

In this paper we generate CAMSIS versions for the Philippines and Venezuela, which we compare to existing scales for the USA and Romania. We also add to the CAMSIS project through presenting a cross-classification of the CAMSIS data by educational level and occupational group and perform a

social network analysis of the matrices used to identify such patterns. This is an innovation in the use of the CAMSIS measure and one which we believe illuminates the patterns and structures of occupational interaction and aid our international comparisions of occupational inequality.

2. Data

Social interaction data

In this analysis all data resources are accessed from IPUMS-International (see Minnesota Population Center, 2010, and https://international.ipums.org/international/). IPUMS 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. Since population census data ordinarily takes the form of short socio-economic and demographic profiling questions, this resource can provide us with large scale representative data about micro-economic circumstances, covering the type of job and the composition of the family. However census data does not provide extended information about individuals' occupational circumstances or their wider social contacts. We discuss IPUMS and other sources of data that are exploited within our ongoing project 'Social Networks and Occupational Structure' in our recent technical paper (Griffiths and Lambert, 2011).

TABLE 2 ABOUT HERE

Our data on occupational links is therefore derived from intra-household connections between occupations, and its dominant component is in practice that of homogamy (the combination of occupations held by heterosexual coresident couples). This raises several issues for the analysis and interpretation of social interaction patterns involving occupations. Firstly, the male and female occupational distributions are sufficiently distinct and segregated that we would expect many asymmetries in the pattern of occupational connections through marriage and cohabitation. For example, we would expect the female incumbents of particularly prevalent female jobs, such as nurses, secretaries and teachers, to be spread much more widely in terms of their marriage patterns than the equivalent profiles for the male incumbents of the same jobs. In 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, see for instance Chan and Goldthorpe, 2004), whilst a confirmatory strategy, involving fixing gender segregation index scores to the model and testing model improvement achieved by this, could also be applied. Secondly, the interpretation of social network connections is necessarily adapted slightly from some conventional accounts. Intra-household connections clearly have the characteristics of 'strong' rather than 'weak' bonds (cf. Grannoveter, 1973). Most analysis of social interaction patterns in occupations has in fact been calculated on strong ties (marriage, friendship or inter-generational ties). However it could be argued that it is the pattern of weak rather than strong ties which is most important to understanding certain pay-offs to social structure, such as the capacity to 'bridge' into a new community of support.

Measures of detailed occupations

Our analysis used occupational records coded to ISCO-88 3-digit minor groups (ILO, 1990) for Romania, the Phillipine and Venezuela, and the US Census Occupational coding frame for that country. Analysis proceeded either on those units themselves, or after recoding those units into the 'microclass' scheme introduced by Jonsson et al. (2009). The latter scheme is intented to capture sociologically meaningful divisions between occupational positions, characterised by features such as shared institutional traditions, cultures and requirements. This is attractive since measures such as ISCO-88 and SOC have divisions between occupations which sometimes arise for somewhat arbitrary adminstrative or historical reasons. However since the microclass scheme attempts to classify all members of the working population, its authors acknowledge that some occupational categories are less homogeneous that they would in theory be. Moreover, we were not able to locate existing translation schemes linking either the US census scheme or ISCO-88 to the microclass

classification, so we derived our own translation for the purpose of this analysis (avaialble for download from www.geode.stir.ac.uk).

The comparative analysis of occupational positions between countries is challenging due to differences in the coding tools across countries, and potential difference of translation. We have benefitted from extensive harmonisation efforts of the IPUMS project and beforehand of the national statistical institutions of the countries studied, which themselves seek to provide detailed descriptions consistent to international standards. Occupational data is, moreover, relatively more easily measured and compared between countries than many other forms of information. Nevertheless some incomparabilities in operationalising the measures are inevitable due to administrative and historical differences in traditions, as well as to national differences in the labour markets themselves. This might be especially misleading in the case of analysis of the microclass scheme when from country to country it is possible that what are overtly the same occupations are for reasons of translation and adminstration located into different occupational units and in turn in different microclasses. A benefit of both the SID and SNA methodologies for comparative analysis is that they do not impose a priori structures across countries, but are instead free to place the same jobs in different ways between countries (a desirable outcome if the jobs are not really the 'same' after all). On the other hand, incomparabilities as they exist may well lead to some misleading interpretations based upon shared labels between countries (Figure 2, discussed below, is potentially an example of this process). We have not yet performed an extended sensitivity analysis of the scale of classification problems, although we anticipate that when we do so the majority of empirical patterns will not be substantially altered.

3. Features of the social interaction distance structure

Constructing the CAMSIS scales (Social Interaction Distance scales)

CAMSIS scales for each of the countries studied 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. Scales for the United States (2000) and for Romania (2002) were generated at earlier stages in the CAMSIS project, whilst the scales for the Philippines in 2000 and Venezuela in 2001 were generated during the course of work on this paper.

For all of these countries, separate scales are published for the distribution of male and female jobs - in practical terms, two scales exist, one based on the male occupational profile, the other on the female. The publication of these two scales often causes confusion, but is justified in terms of significant statistical differences between the occupational profiles, and substantive evidence of average differences between men and women (i.e. that being in the same job might not necessarily have the same relative social meaning for a man and a woman). In practice, across versions, the male and female scales are strongly correlated (and for simplicity we often analyse only the male scale scores, applied to both men and women), and it is strategically sensible to focus upon only one scale. However, it is scientifically more appropriate to derive and publish both.

The CAMSIS project webpages also feature information on different means of undertaking social interaction distance analysis and of publishing relevant scales. The scale for the USA used in this paper involved a relatively more extended analysis using the lEM software (Vermunt, 1997), using a cross-classification between occupational title and employment status, and using a relatively substantial element of manual review of the data. On the other hand the scales for Romania, the Philippines and Venezuela were derived using semi-automated programmes using the Stata software (cf. www.camsis.stir.ac.uk/make_camsis/). All of the methods and derivation strategies employed are open to adaptation by the researcher generating them; we find it most productive to refer to the CAMSIS scales used

here as 'versions' of social interaction distance scales, in order not to preclude the possibility of alternative or updated scales being generated from the same societies either as part of our own project or by other researchers (though correlations between different versions tend to be high; the only comparable scale that we are aware of is the status scale generated by Alberson, 2007 for the United States, which is strongly correlated with the CAMSIS scale score used in this analysis).

The most negotiable feature of SID scales concerns the treatment of combinations of occupations which have particularly high propensities to interact, but for reasons which are not believed to be revealing about the overall structure of stratification and inequality. Empirically it is common for major structures of social interaction to emerge which we suspect arise for other reasons (the two most common forms are occupatonal contiguity such as joint ventures or shared institutions, and the agricultural/non-agricultural sectoral division). In the CAMSIS approach such occupations, when identified, are described as 'pseudo-diagonals' and are conventionally excluded from analysis (see also detailed notes on this topic at www.camsis.stir.ac.uk). This marks a comparable strategy to explicit controls for sectoral affinity and exact reproduction which are commonly included in social mobility analyses (cf. Breen, 20004). However the decision of whether or not to exclude particular combinations is debatable, and could have a small impact on the resulting scale values – for this reason it is again desirable to emphasis that each particular scale be thought of as a 'version' which might readily be supplemented with a different one in due course.

Profiles of the CAMSIS scales for contemporary USA, Romania, the Phillipines and Venezeuela

Figures 1a, 1b, 2, 3 and 4 seek to summarise features of the CAMSIS scales across the four countries. Figure 1a firstly 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 Venezuala. The figure shows the correlation of the male and female scales against the ISEI scale (a measure profiling the average income and educational level of occupations across countries, see Ganzeboom and Treiman, 1996). There is a strong positive correlation but it is

slightly different between men and women. The gradation of scores is reasonably even across the population, but there is also clustering of scale positions due to the uneven nature of the occupational distribution itself.

FIGURES 1a and 1b ABOUT HERE

In Figure 1b we seek to portray the overall spread of occupational positions. The histograms show that there is gradation across the range in all countries, but relatively high positive skew in Romania and the Philipines which is not present in the USA and Venezuela. Such 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 suggest a pattern towards divergence within Romania, and perhaps the Philipines, shared consistently on the male and female scale, whereas the USA and Venezuela have more even gradation across the range, but relatively more divergencies betwene male and female positions for the same occupations. Again, we suspect that the relative economic development in each country accounts for these differences, suggesting greater social segregation and inequality in the Phillipines and Romania.

Figures 1a and 1b do not yet show where particular jobs fit within the occupational order of stratification as detected through social interaction patterns. Figure 2 does this in terms of the 'microclass' units of Jonsson et al (2009), which make a convenient measure of apparently comparable detailed occupational positions between countries (though see section 2). Figure 2 confirms that the broad pattern of occupational stratification is one of similarity between countries (or the 'Treiman constant' following Treiman's influential 1977 analysis). Equally however, the figure reveals often substantial variation from country to country in the relative ranking position assigned to an occupation. In general terms, we see again more gradation in the United States, and Venezuela, particularly in the more advantaged occuaptional positions, whereas the pattern seems reverse in Romania and the Phillipines with relatively less dispersion at higher levels, and more dispersion at lower levels. (It should be stressed that the positions in Figure 2 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).

FIGURE TWO ABOUT HERE

Figures 3 and 4 seek to unpack the relationships between SID scale scores and education positions. Figure 3 shows that all countries have a profile of difference in scale scores across educational levels, this is surprisingly undifferentiated by age (credential inflation may lead us to expect more payoff to education to older cohorts), but is differentiated by gender (in all countries, women measured on the male scale have more priviledged occupations at medium education levels, but there is a narrowing of the gap at higher levels). Figure 4, however, proves particularly revealing in showing the extemely 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 1b) and reveal a very 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).

FIGURES THREE AND FOUR ABOUT HERE

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 Phillipines than elsewhere.

4. Features of the social network structure of homogamy

Occupational networks

The approaches utilised to develop the CAMSIS analysis provides matrices of occupational marriage or cohabitation pairings which can additionally be used to examine occupational structure using social network analysis (SNA)[iv]. To do this, the proportion of married men and women within the respective workforce of sample members is generated and enables the construction of an 'expected number' of husband-wife partnerships for every possible occupational grouping. This expectation can be compared to the actual number of partnerships to understand the density and shape of over-represented pairings[v]. We apply criteria to determine the levels of over-representation we regard as evidence of frequent social interacts. The mere presence of a single occupational pairing does not imply a social pattern as it could be envisioned all possibilities exist at least once in large societies. We initially apply the logic that all occupational pairings must occur at least twice as often as would be expected by chance, with at least five cases identified to ensure singular chance encounters by small occupational groupings are not miscoded as being regularly formed. However if this produces unwieldy large networks due to large sample sizes we increased the number of over-representation by one and require a frequency of at least twice that number for a sufficient number of cases to be uncovered.

Given an assumption of occupational homogamy we could envision people marrying others in socially similar as well as the same roles. However 'pseudo-diagonals', which describe occupations with a structured rationale for social interaction, such as doctors and nurses sharing the same workplaces also hold potential for over-representation of marriage ties. Combining commonality (by microclass) and pseudo-diagonals can produce a theoretical network of occupations it could be expected to be heavily reproduced. It would not be expected that occupational marriage patterns were entirely random, as our technique measures, but rather that some pairings would be more likely than others (for instance, doctors being more likely to marry nurses than textile factory workers). Figure 5 shows a hypothetical depication of a how an occupational marriage structure network could look, using pseudo-diagonals and microclasses to link the OUGS used in the 2000 USA Census. The

network comprises no real centre, but rather a circular structure of interlinked cliques (the microclasses) linked a few shared occupations (the pseudo-diagonals). Not all occupations form part of the structure but hold some connections (microclasses which lack any pseudo-diagonals). There is no obvious effect of occupational prestige in these networks, chiefly because pseudo-diagonal relationships outside of mircoclasses often occur between differing macroclasses (i.e., managers and their employees sharing a workplace but a difference in occupational prestige).

FIGURE 5 ABOUT HERE

Table 3 shows the composition of occupational structure within the four countries in this paper. The sample sizes differ from 108,000 married couples in Venezuela to over 2 million partnerships in the USA. Differences within the classification of occupations are relatively consistent between all four countries, demonstrating the ability for both the microclass scheme and CAMSIS to enable international comparisons. Educational differences are more observable with stark differences between the USA and Venezuela, for instance. Gender effects are relatively consistent. There is a slight tendency for less homogamy within the USA than the other countries, although differences in size of each group by structure and gender make direct comparisons inaccurate.

TABLE 3 ABOUT HERE

Networks have been generated for each of the four countries within this paper, as shown in Figures 6-9. The nodes represent one of the occupational unit groups (OUGs) as generated within IPUMS International. They are coloured by their position within their national CAMSIS, with the darker nodes representing those with a male score of over 60 whilst the lightest nodes are those with a male score under 40. The network is directed, with arrows pointing from the male occupation to the female (and often reciprocated).

FIGURES 6-9 ABOUT HERE

All four networks produce similar basic structures. The most advantaged occupations generally form one part of the network, with the least prestigious OUGs forming a separate cluster. The patterns of occupational homogamy can be visualised stronger than demonstrated in Table 3. This is due to the treatment of the data, being converted from the actual numbers of relationships sharing a grouping to demonstrating the occupations which are structurally close within the country. The distinction between these networks and the hypothetic version in Figure 5 is stark. The circular notion of the theorised version is replaced by an almost binary network which separates the most and least advantaged occupations, chiefly bridged by those occupations with a CAMSIS score within 10 of the mean. Social divisions are observable in all four countries, operating not as an extension of structural similarities in occupations and workplaces but through the relative advantage of occupations producing over-representation of marriage partnerships.

The network for the USA produces a few differences to the other three structures. For Romania, Venezuela and the Philippines, there appears to be a three-level system in place. The highest CAMSIS occupations generally link to each other or a small number with an average score. The lowest CAMSIS occupations behave the same. Those vocations with a score within 10 of the mean generally either interlink with the most prestigious or least advantaged rather than connecting to both groups. This produces, essentially, a linear-type structure which could be easily manipulated to mirror the CAMSIS diagrams displayed earlier in Figure 1b without unduly altering their composition.

The USA network operates slightly differently. The principal structure mirrors that of the other countries. Starting at the top of Figure 6, the lowest CAMSIS occupations link to a few of the average vocations, which then create ‘interlocks’ with the most prestige jobs. However, the grouping of advantaged occupations holds ties to many other vocations close to the CAMSIS mean which appear distant to the lowest prestige groupings. Whilst the USA retains a core to its advantaged region, non-prestigious occupations appear to encircle those vocations with only a proportion of that layer holding ties to the most disadvantaged positions. This implies the absence of any linear effects, but rather the most advantaged occupations have a more developed relationship with slightly lower strata vocations.

Distinctions between patterns of social hierarchy could be symptomatic of differences within the composition of advantaged occupational groups. Within the countries with lower educational attainment there appears a pattern of a strong core of professional occupations with dense rates of marriage partnerships. The advantaged groups outside of these cores appear to either connect to occupations with a slightly lower CAMSIS or hold no external ties. Within the USA there are fewer instances of prestige occupations holding no ties to the less advantaged groups, indicating lower levels of social distance between professionals and other non-manual workers. The circular structure of the USA highlights a tendency for certain occupations to possess access to pseudo-diagonals bridging links between the most and least advantaged occupations, with professionals segregating by sector rather than through their social position.

Similar patterns are identified when analysing occupational partnerships using the microclass scheme. However reducing the different OUGs into a shared scheme has the benefit of supporting further statistical comparison. An I/E (Internal over External) ratio has been created to explore the patterns within microclasses. The E-I Index (External – Internal) is an established SNA tool for examining tendency towards homophily by comparing the percentage of possible ties formed with members external to the group to those generated internally (Krackhardt and Stern 1988). However it is not possible to replicate the E-I Index within our data. The Index presupposes that all possible ties can be generated, which is not true of our data due to the requirement for an over-representation to exist to create a tie. It is not possible for an occupation to produce more ties than would be expected give its size to all other vocations. This means only a proportion of possible ties can be generated. The Index also requires relatively large proportions of ties to be formed as it subtracts the percentage of potential internal ties formed from the percentage of external ties formed. This creates a number between 1 and -1 which indicates levels of homophily. Our data can produce relatively sparse networks, giving low proportions of both external and internal ties which would make many networks appear to have a score of around 0, indicating a tendency towards neither homophily nor heterophily, regardless of any actual patterns. Therefore we have generated a measure which utilises the logic of the E-I index and provides a more robust interpretation of networks which cannot form every link. The I/E ratio divides the average number of ties formed per internal group member to the average

number formed per external group member. This ratio is essentially the internal average divided by the external average. It has the benefit of providing a more robust way of measuring tendency towards homophily amongst sparser networks, albeit with the limitation of not being able to measure groups with no external ties (due to the impossibility of dividing by 0).

A network was generated for each country using the microclass scheme to identify over-represented marriage partnerships. Figure 10 shows the I/E ratios for the professional and manual macroclasses. The USA showed greater homophily amongst manual workers than the other countries, as indicated by the I/E ratio. The USA ratio for professional workers was the second lowest. This is despite the ratios being similar for both occupational groupings. Within the USA, there is little difference in levels of homophily between the microclasses. The other three countries, to varying degrees, showed significantly higher levels of homophily, or social closure, for professional macroclasses compared to manual occupations. Similar patterns can be identified looking solely at the internal links within groups. The USA held consistent levels of closure for the manual and professional workers. Greater levels of closure are observable for professionals in all three other countries. Social closure within the USA microclass networks is consistent across levels of occupational advantage, despite the increased tendency for closure with prestigious vocations elsewhere.

FIGURE 10 ABOUT HERE

These networks enable an alternative analysis of the shape and structure of occupational homogamy. The tendency for the USA networks to provide similar levels of social closure across occupational groupings and produce a network shaped more through pseudo-diagonal structures than shared prestige suggests a lower gradient of social advantage than demonstrated in Romania, the Philippines and Venezuela.

Social networks and educational systems

Social networks can be generated from marriage data based not solely on occupational data, as detailed at the beginning of Section 4, but also by cross-classifying by levels of educational attainment. Table 3 shows the differences in educational levels by country, demonstrating the increased levels of attainment within the USA and the lower levels within Venezuela.

Educational factors can add another dimension to prestige and closure. Networks have been generated utilising the methodology discussed in Section 4 after dividing membership of each occupational grouping by attainment or non-attainment of a degree[vi].

Networks cross-classifying microclass and degree attainment showed similar structures to those discussed within Section 4[vii]. The patterns generally demonstrated a distinction between graduates and non-graduates, with ties between the two groupings chiefly members of the same occupation with different educational backgrounds. Again, the USA had a circular structure compared to the linear shaping for other countries, with USA graduates and non-graduate ties being over-represented more commonly than elsewhere.

These distinctions can be shown from the I/E ratios, shown in Figure 11. Groups were created to examine homophily within level of degree (i.e., ties to other groupings which share an educational level regardless of microclass) and microclass (i.e., ties to other groupings within microclass regardless of educational attainment). Homophily was strongest in the USA for graduates in the professional and routine non-manual categories, implying graduates generally marry other graduates regardless of their occupational position. Non-graduates in relatively privileged jobs have low levels of educational homophily. However, they have high levels of closure within their own macroclass, particularly for routine non-manual workers. The pattern of internal macroclass ties for graduates was lower. Graduates, it seems, chiefly marry other graduates irrespective of occupational position, whilst non-graduates in non-manual jobs tend to marry people from similarly as advantaged vocations irrespective of educational background.

FIGURE 11 ABOUT HERE

Social patterns were not as identifiable in Romania or the Philippines. Romania was relatively consistent regarding educational homophily, whilst social closure was more pronounced for the professional graduates and routine non-manual non-graduates, representing the more popular educational grouping within each microclass. The Philippines similarly showed very little difference in homophily patterns by educational attainment and similarity in terms of microclass positions albeit with a slightly higher tendency towards homophily for routine non-manual graduates.

Levels of degree attainment could be responsible for such differentials between countries. A network comprising microclasses and a secondary school completion dichotomy was also created. The USA network mirrored that of other countries, producing a linear-style network effect rather than the circular pattern implying work-specific underlying structures overly influenced the construction. I/E ratios across the school completion-microclass dimension, as shown in Figure 12, demonstrate a distinction between the USA and the three other countries. Levels of homophily were higher for those who completed secondary school than those who did not for the three major microclasses. Elsewhere, this pattern was evident for professionals, chiefly due to the dominance of people who completed their secondary schooling within those occupations, whilst the reverse was true for routine non-manual and manual workers. The difference for routine non-manual workers between the USA and Romania, for instance, is noteworthy due to the overwhelming dominance of secondary school completers within the grouping in both countries.

Adding dimensions of educational attainment to the microclass and macroclass analysis produces a more nuanced understanding of the differences between the USA and countries with lower levels of degree attainment. The USA is shown to have differing patterns for graduates and non-graduates within the non-manual workers, with the former grouping forming marriage partnerships more structurally through educational kinship and the latter through occupational position. Such patterns cannot be applied to Romania, the Philippines or Venezuela, which appear to have a different underlying process generating their structures.

5) Discussion: Comparing dimensions and boundaries

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, 2002; Weeden and Grusky, 2005; Oesch, 2006; Guveli, 2007; Jonsson et al., 2009; Rose and Harrison, 2010), or of scaling and analytical approaches which locate detailed occupational positions within dimensional locations (e.g. Ganzeboom and Treiman, 1996; Wong, 2007; McGovern et al., 2007; 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.

Our analysis suggests that detailed occupational positions are indeed important to take into consideration 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 - the social experience of being in an advantaged occupation in a less economically advanced country is more isolated and tightly bound than it is in a society such as the United States, for instance. Education, however, was seen to be a major dividing force in all countries, but occupational positions describe important heterogeneity within educational locations, and reveal patterns about social relationships and structure which could not be adequately understood with cruder measurement instruments using qualifications or broad occupational positions.

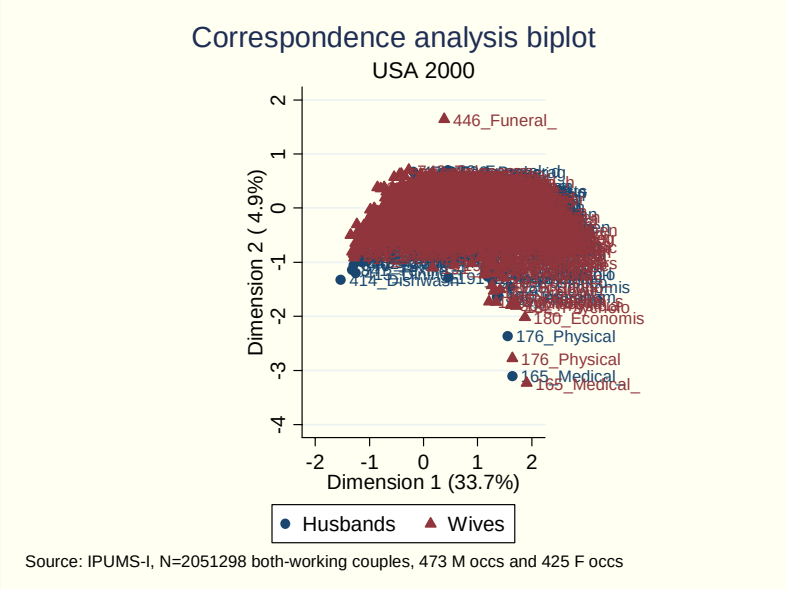
Tables used in the text

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

Selected Census Occuaptional 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 Acturaries (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 Sheet metal 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)	-.057 / -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	Dim 1 inertia	Dim 2 inertia	Dim 3 intertia
Total intertia = 0.4315, 473 rows by 425 columns	0.145	0.021	0.013



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

Table 2: Summary of social interaction data used in analyses

	Number of m-f couples with occupations	*Occupational unit*	*Notes*
United States, 2000	2191104	US Census 2000 occupations (475 units)	
Romania, 2002	221950	ISCO-88 3-digit (116 units)	Some divergencies from ISCO scheme
Philipines, 2000	262855	ISCO-88 3-digit (130units)	Some divergencies from ISCO scheme
Venezuela, 2001	108273	ISCO-88 3-digit (115 units)	

Table 3: Description of data taken from Ipums International

		USA 2000		Romania 2002		Philippines 2000		Venezuela 2001	
	Both working married couples	2,191,104		221,950		252,307		108,237	
		Men	Women	Men	Women	Men	Women	Men	Women
Education	% with degree	28.0%	26.8%	14.8%	11.9%	13.0%	19.4%	0.3%	0.3%
	% completed secondary school	90.6%	92.6%	77.2%	68.2%	53.4%	56.3%%	27.1%	33.1%
	% marrying within level	69.9%		73.3%		74.6%		79.1%	
Macro classes	Professional managerial	29.6%	36.3%	23.0%	25.2%	16.0%	24.1%	47.8%	34.2%
	Routine non-manual	18.1%	39.8%	6.4%	19.3%	13.6%	27.3%	11.4%	21.9%
	Manual	49.9%	23.1%	50.3%	31.1%	34.1%	25.7%	36.5%	43.2%
	Primary	2.2%	0.9%	20.2%	24.4%	36.3%	22.9%	4.4%	0.5%
	% marrying within macroclass	40.4%		59.3%		58.9%		54.5%	
CAMSIS (based on IPUMS Occ coding)	CAMSIS over 60	26.0%	25.8%	24.6%	9.0%	23.7%	37.7%	27.1%	18.7%
	CAMSIS between 40 & 60	40.4%	56.7%	60.2%	61.8%	34.5%	39.3%	49.4%	49.3%
	CAMSIS less than 40	33.5%	17.6%	15.2%	9.3%	41.8%	23.1%	23.5%	32.0%
	% within 15 points on score	66.5%		80.0%		74.9%		66.0%	
	% marrying within CAMSIS category	47.2%		68.1%		64.6%		50.4%	

Table 3: Description of data taken from Ipums International

Figures used in the text

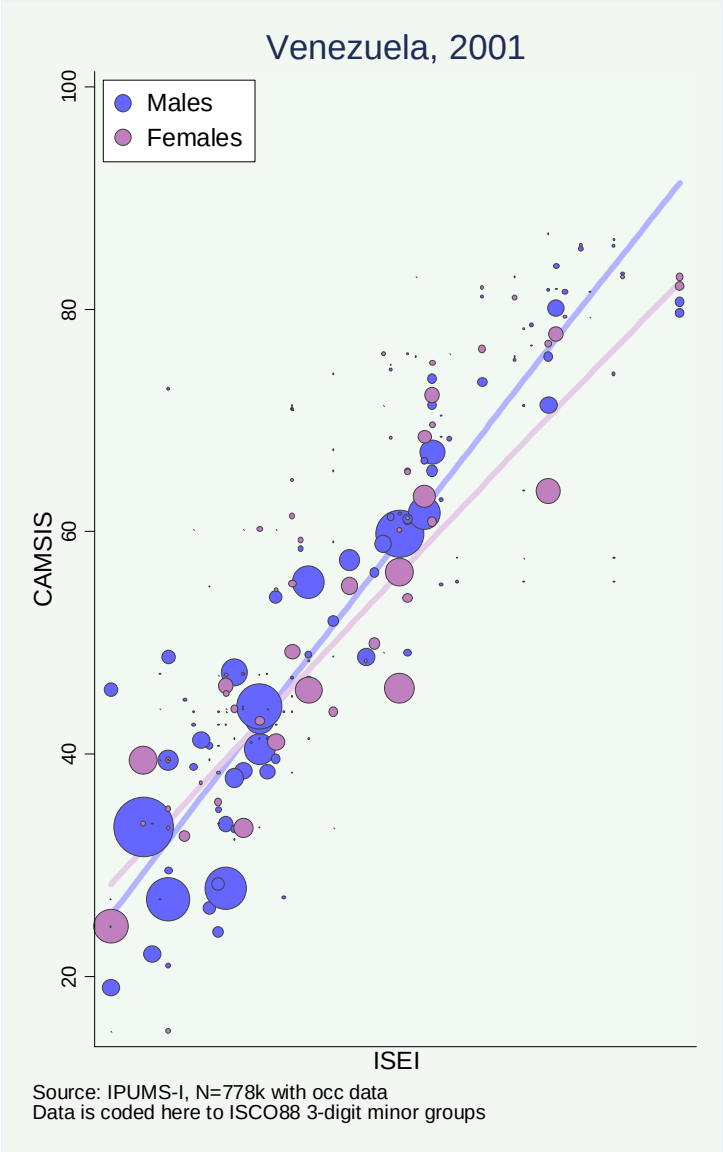


Figure 1a: Illustration of the stratification order of CAMSIS scales for males and females (Venezuela, 2001)

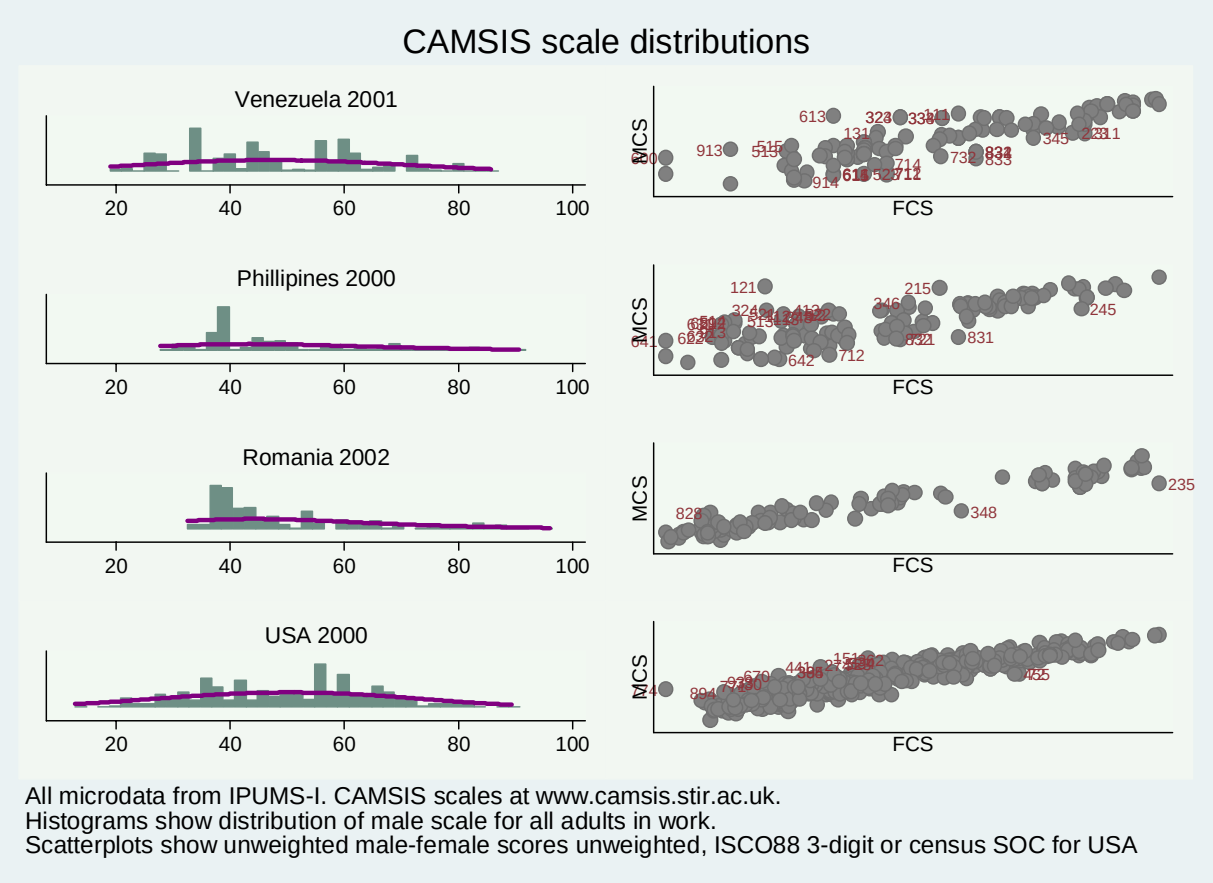


Figure 1b: Distributional summaries of CAMSIS scales over four countries

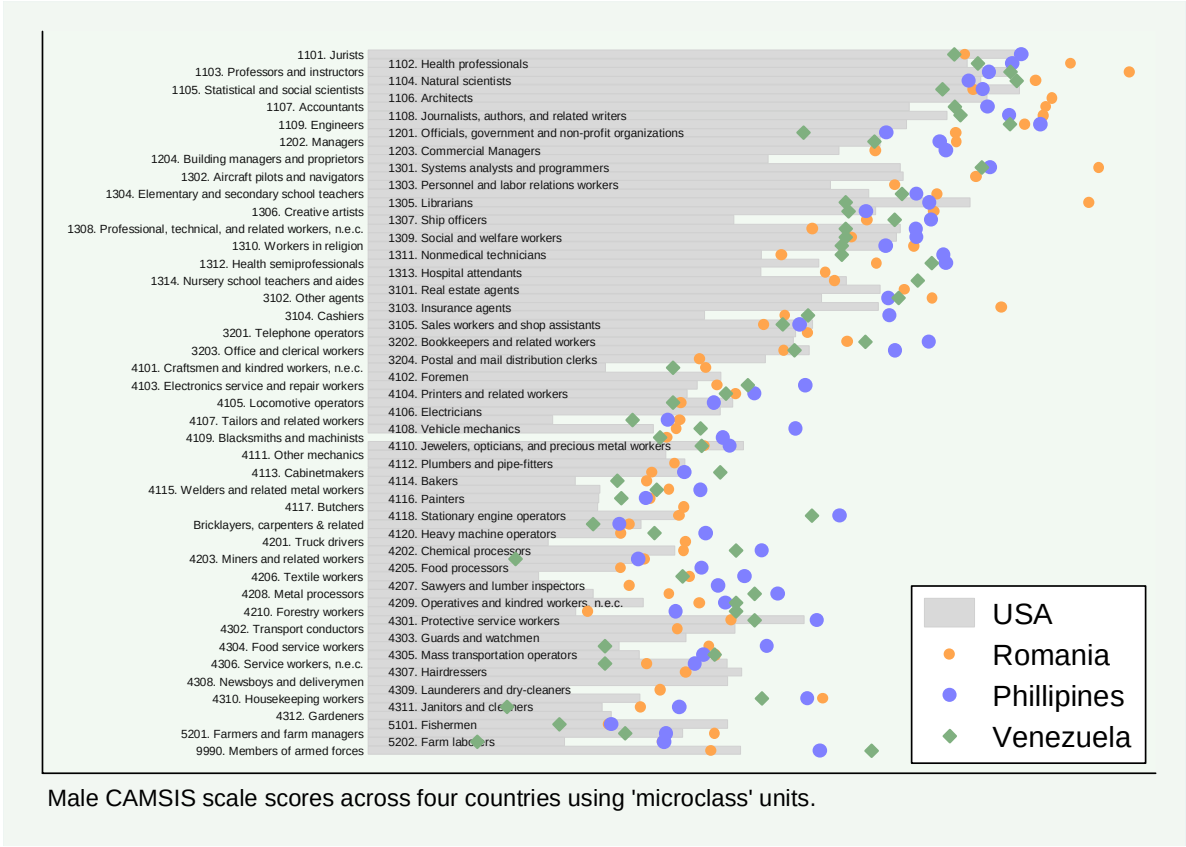


Figure 2: Exploring cross-national differences in the social interaction distance structure

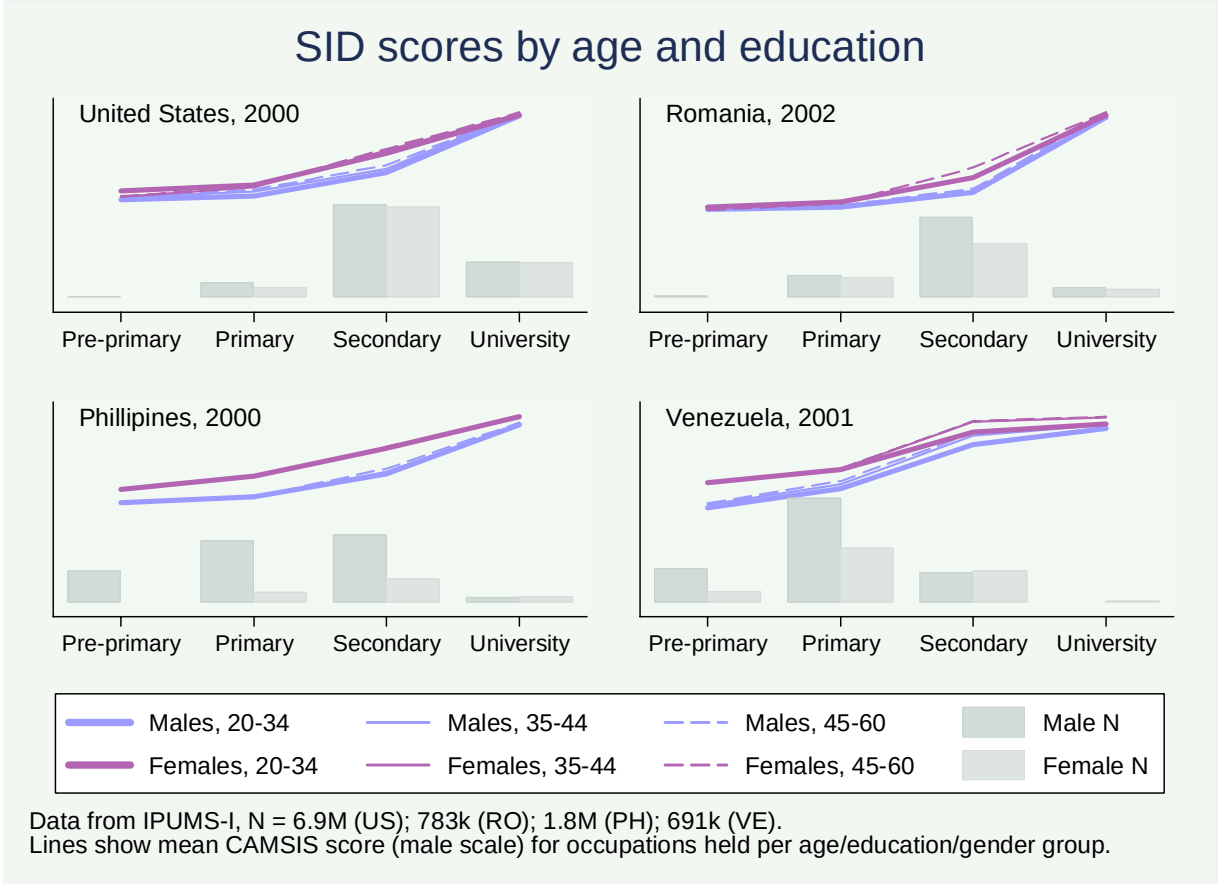


Figure 3: The relationship between age, education and SID score

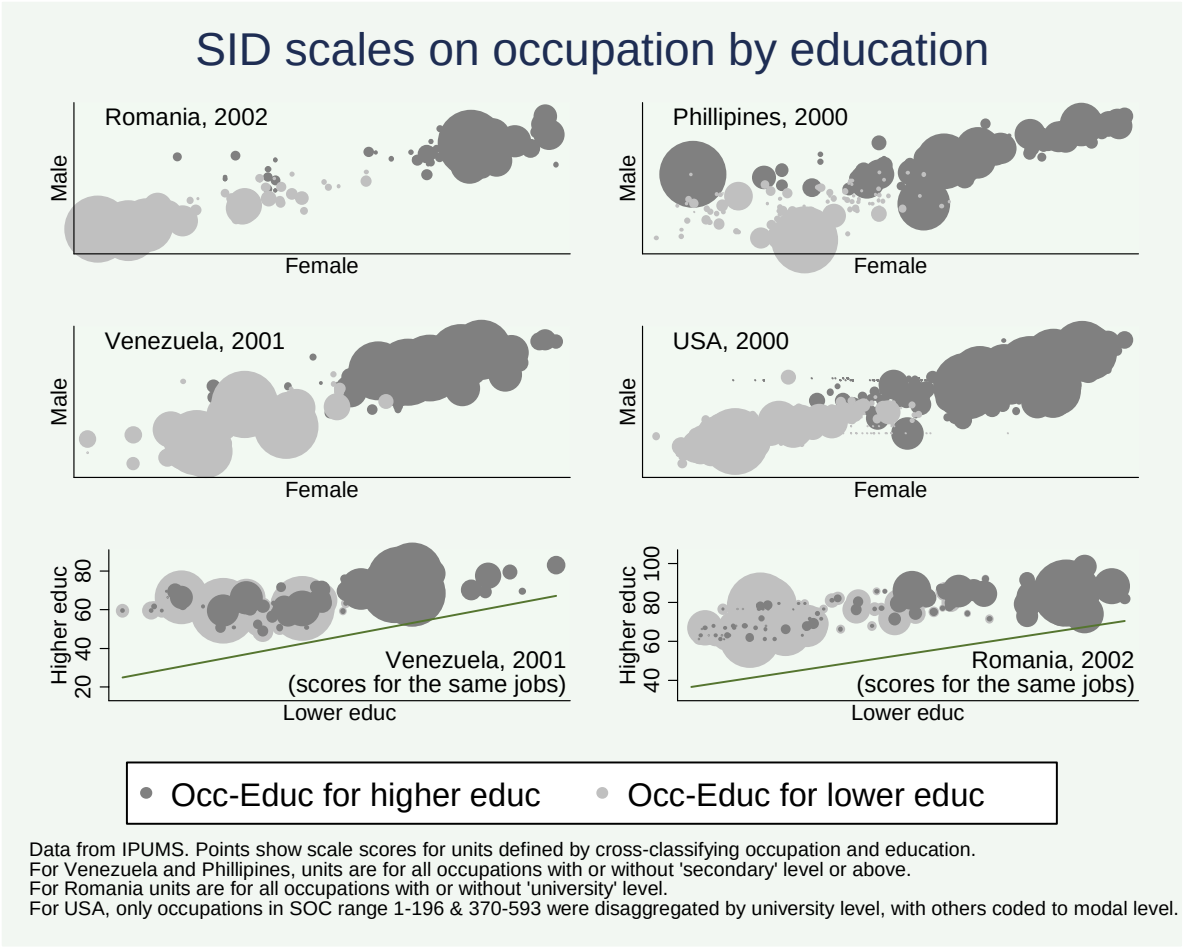


Figure 4: The disaggregation of SID units by educational levels

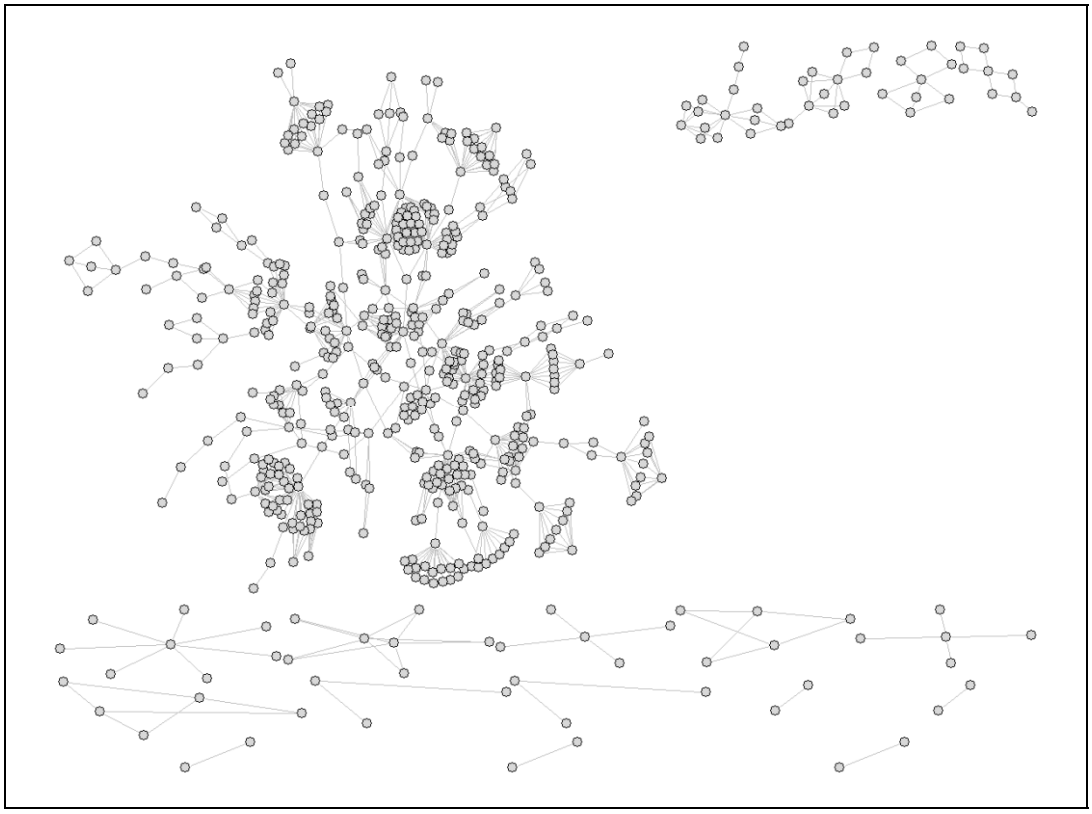


Figure 5: Hypothetical structure of USA Census 2000 occupational marriage network

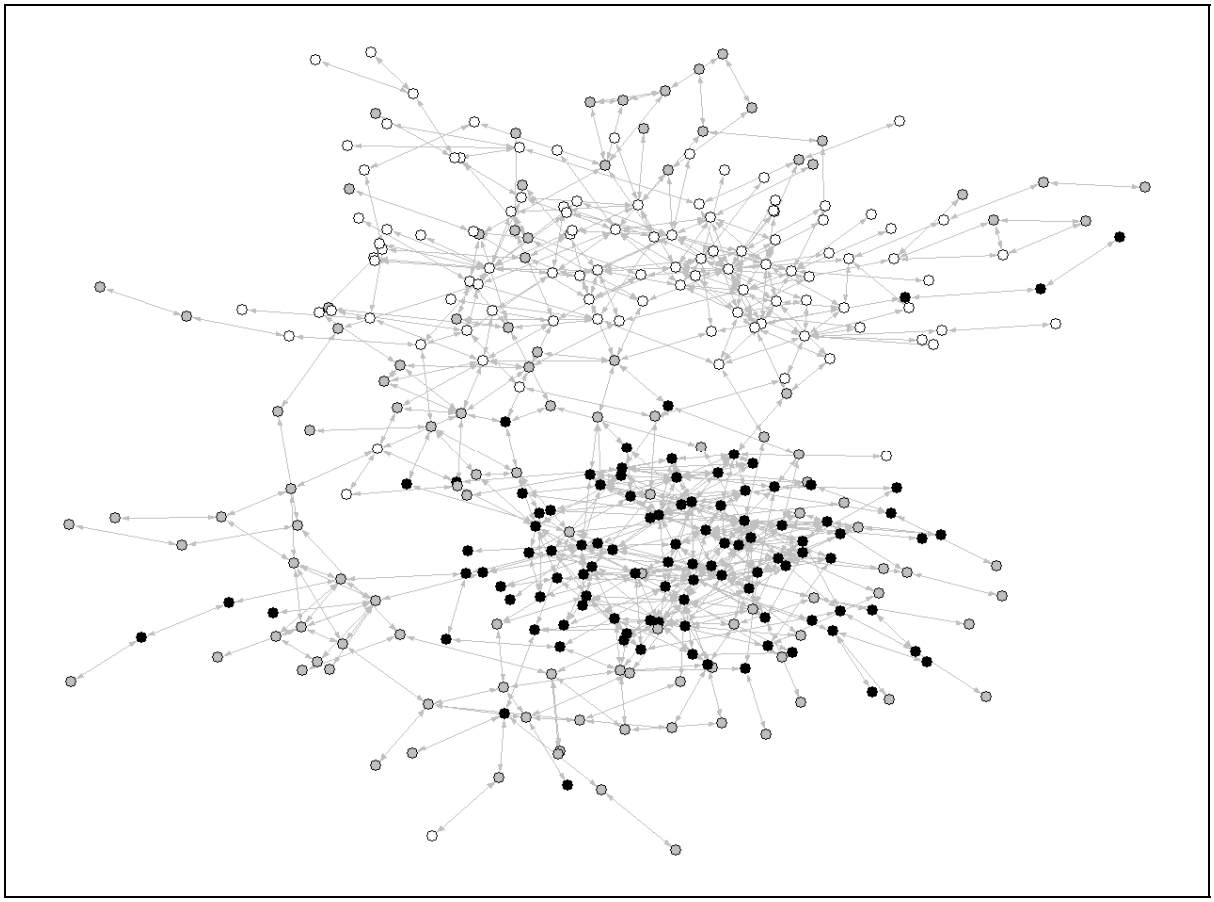


Figure 6: USA 2000 network (freq>=8; value>=4)

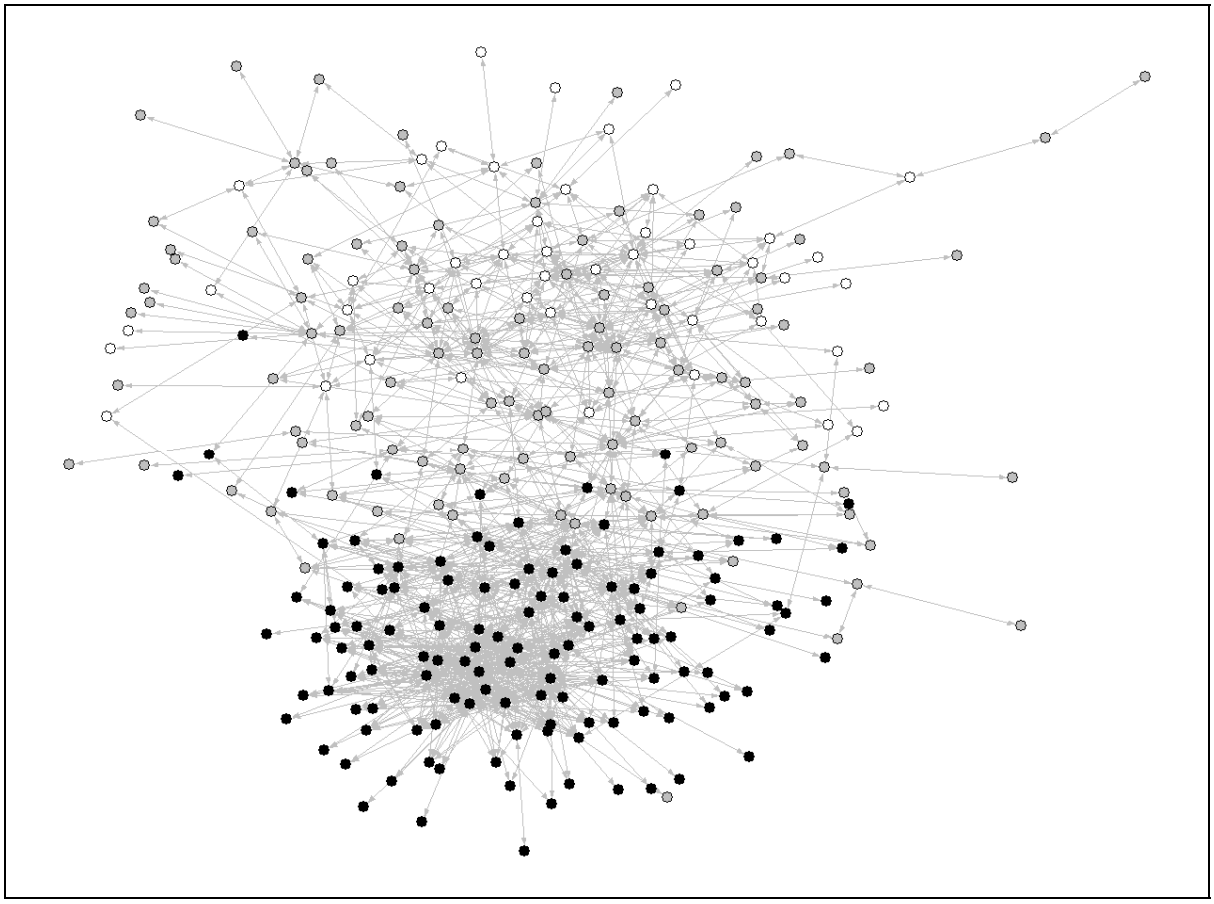


Figure 7: Romania 2002 network (freq>=6; value>=3)

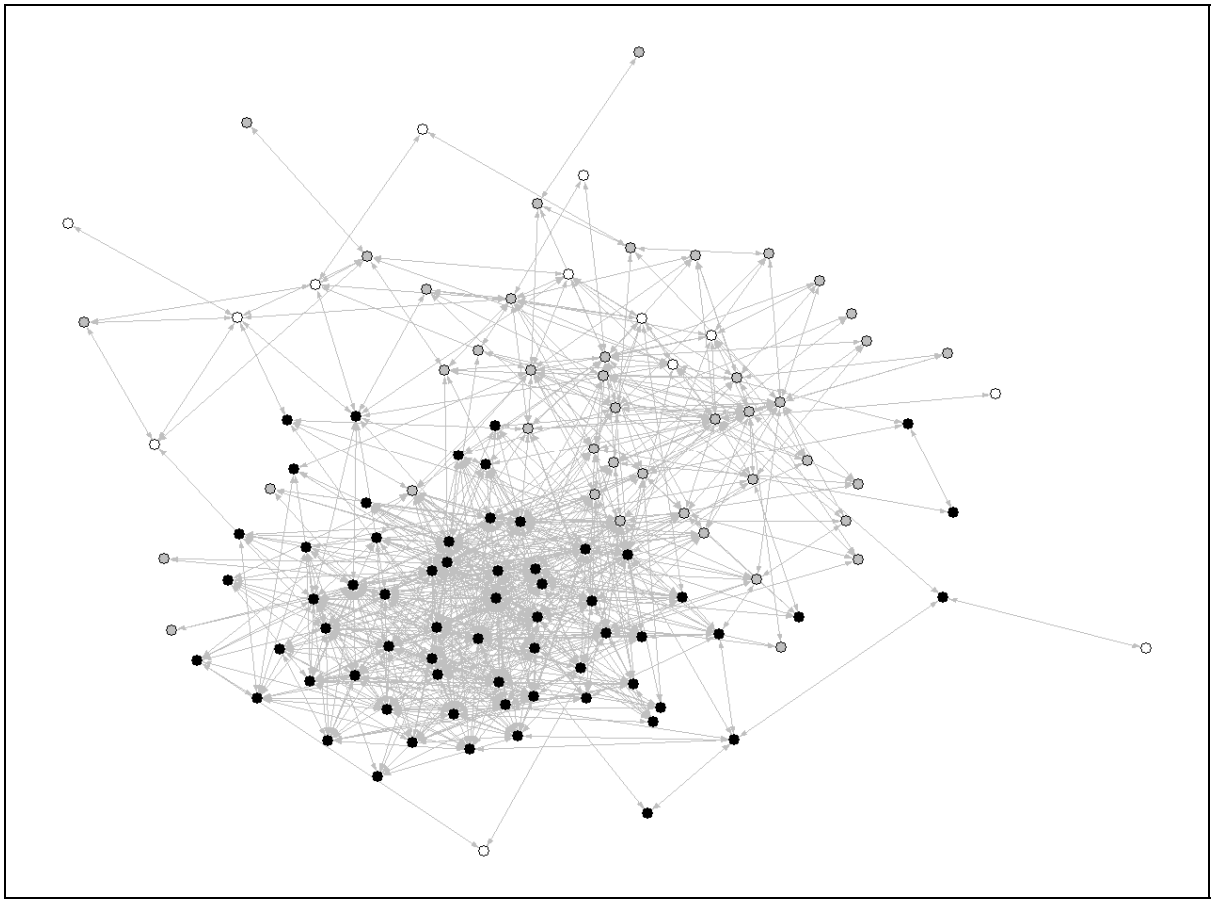


Figure 8: Philippines 2000 network (freq>=5; value>=2)

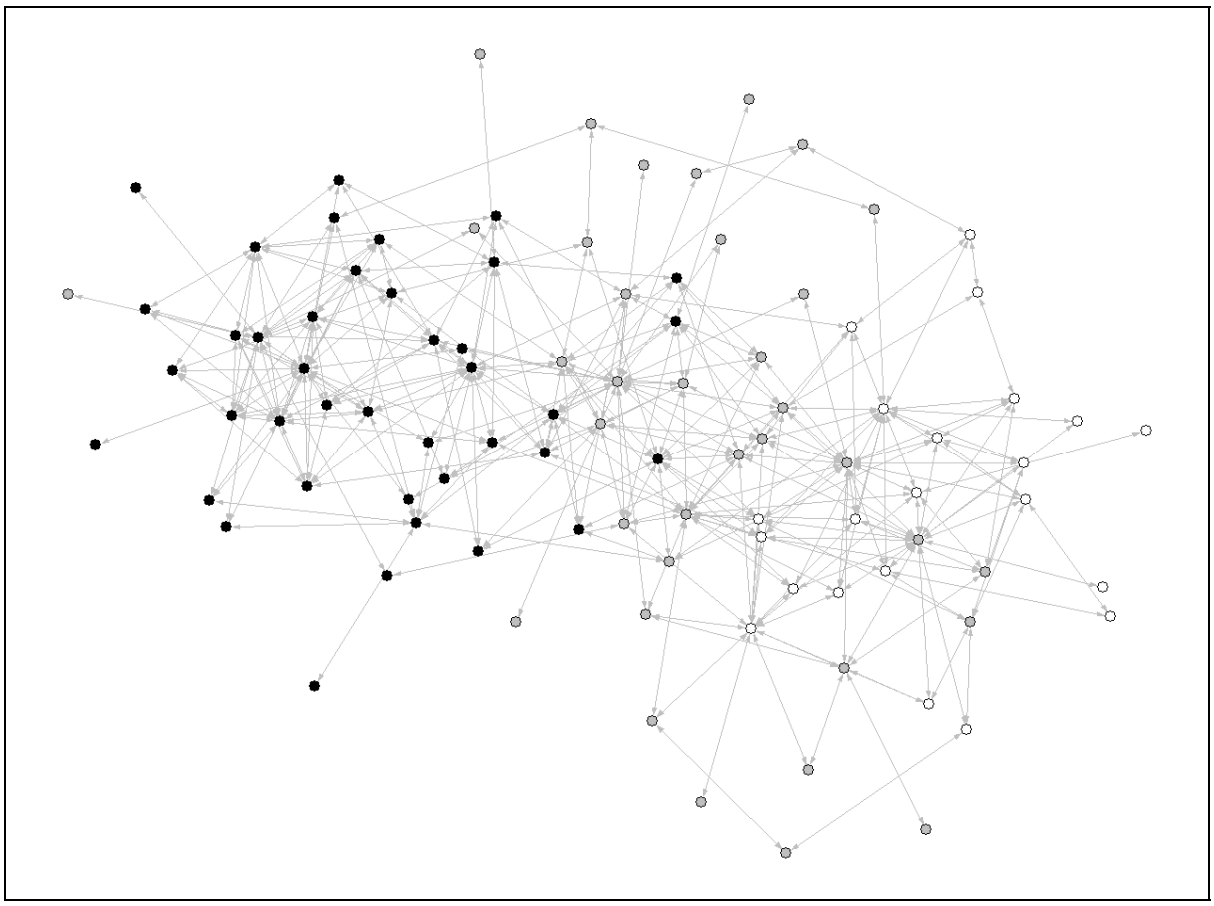


Figure 9: Venezuela 2001 network (freq>=5; value>=2)

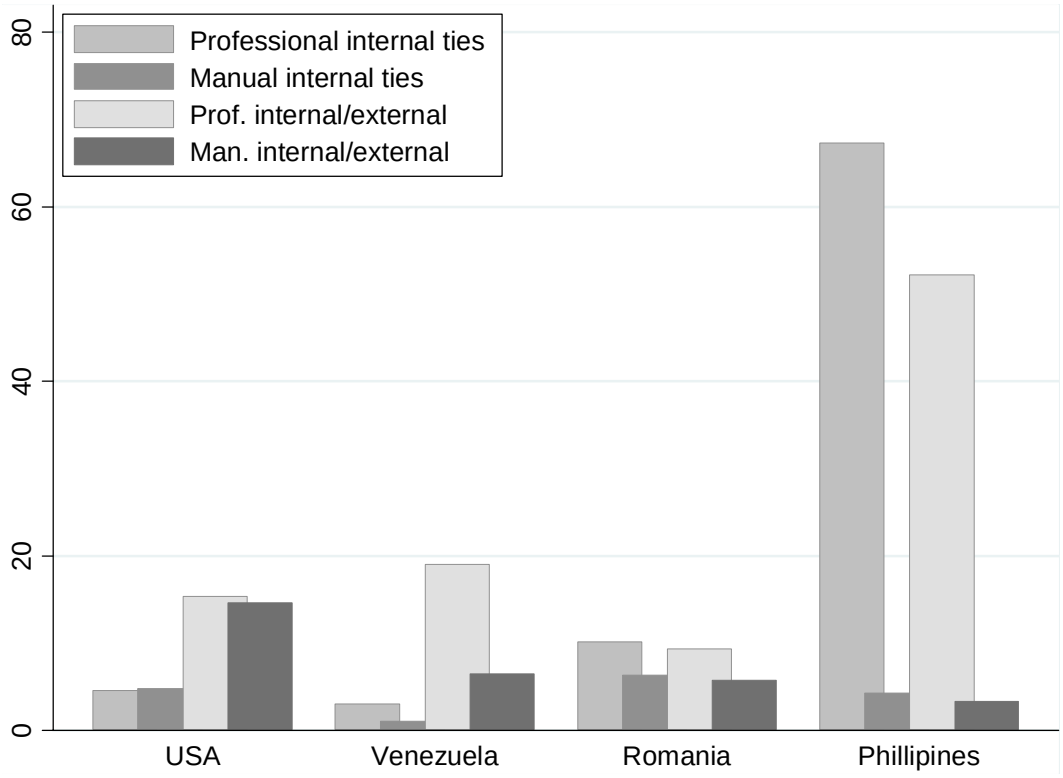


Figure 10: Internal ties and internal/external ratios by Microclass

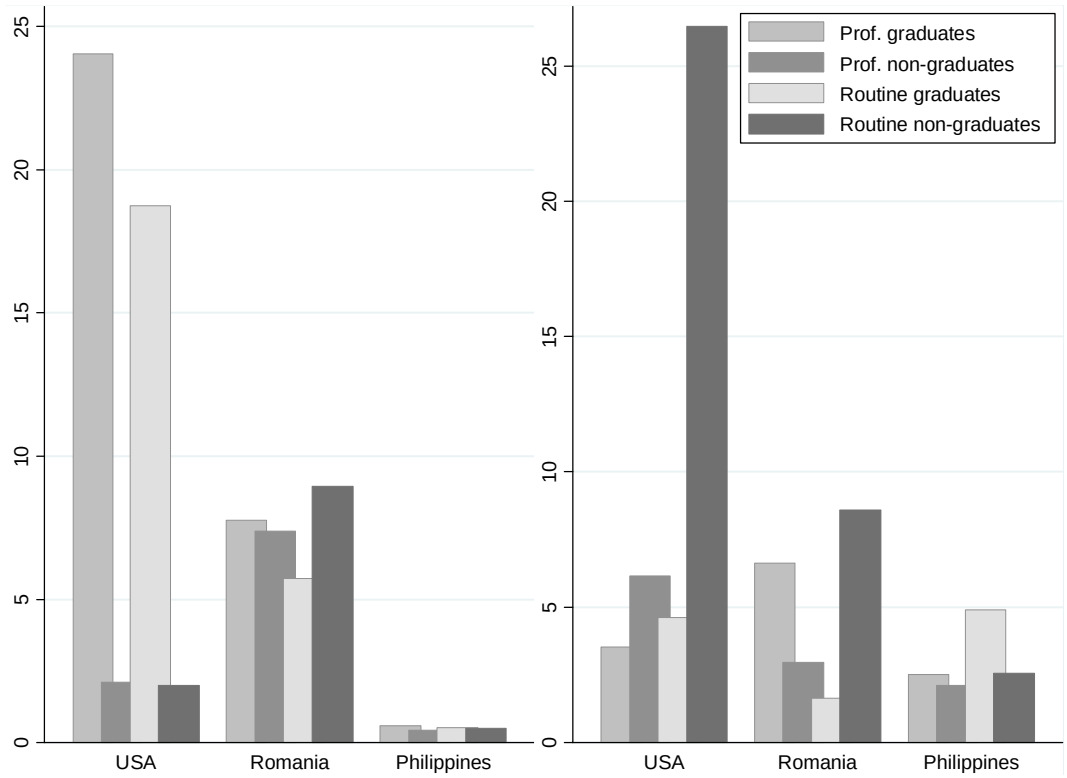


Figure 11: Internal/External ratios for degree-microclass, by commonality in degree (left) and microclass (right)

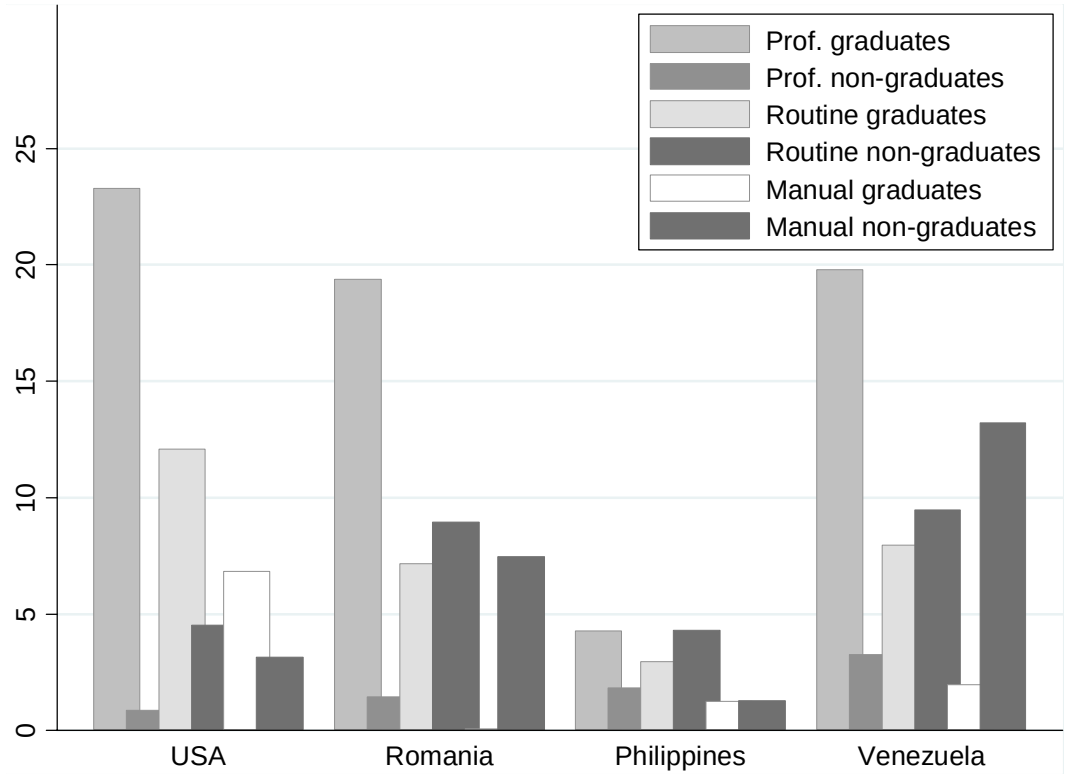


Figure 12: Internal/External ratios for secondary school completion-microclass

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Endnotes

[i] The 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 to explore complex occupational differences (some earlier studies had also analysed social interactions between occupations, but using broader occupational categories and with different objectives in mind – e.g. Centers, 1949).

[ii] Estimation of these models for the purposes of social interaction distance analysis have most commonly been undertaken in lEM (Vermunt, 1997); Stata (e.g. Hendrickx, 2000); and by using the gnm package in R (Turner and Firth, 2007).

[iii] Dimension two might perhaps also, upon inspection of the biplot, at first glance be interpreted as the dimension of life and death! The extreme points on the dimension, which are most visible in the graph, often arise from unexepectedly high levels of interactions in particular combinations, which may be the case here. Conventionally, such patterns are regarded as relatively unimportant in the SID approach.

[iv] At present our analysis involves husband-wife occupational structures. We are developing tools for examining wider patterns of social interactions, such as sibling and friendship networks.

[v] 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

[vi] A Stata .do file to derive an SNA matrix from social survey data involving both occupational and educational levels for husbands and wives can be obtained from: http://www.camsis.stir.ac.uk/sonocs/do/uniocc.do

[vii] Due to its very low levels of graduates it was not possible to include Venezuela in this section of analysis.