

Looking Inwards: Towards a Geographically-Sensitive Approach to Occupational Sex-Segregation

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Abstract

In this article we question implicit assumptions in the literature and explore the issue of occupational sex-segregation from a geographical standpoint. First, we examine the degree of variation in patterns of occupational sex-segregation across regions and districts in England and Wales. Specifically, we investigate whether the proportion of workers in each occupation who are women and the Index of Dissimilarity vary across local labour markets, operationalized as Government Office Regions and Local Authority Districts. Second, we explore whether using indicators of occupational feminization calculated from aggregated national-level data biases estimates of the effect of occupational sex-segregation on wages. Results suggest that both occupational feminization and occupational dissimilarity vary widely across regions and districts, that little bias is introduced to estimates of the impact of occupational feminization on wages when indicators of sex-segregation derived at the national level are used, and that such effect varies significantly across districts.

Keywords: *occupation, sex-segregation, geography, local labour markets, Britain*

1. Introduction

Most research on occupational sex-segregation assumes that a single labour market operates within national boundaries, and hence that indicators of such segregation should be measured at the national level. However, work-related research with a geographical focus has suggested that several local labour markets (LLMs) with different characteristics and occupational structures co-exist within each nation, which may bear implications for research on the sex-composition of occupations.

In this article, we investigate in which ways geography may intersect with occupational sex-segregation. Firstly, we explore whether the proportion of workers who are women in each occupation and the level of occupational dissimilarity vary across sub-national geographies in England and Wales using data from the 2001 UK Census. Secondly, we examine whether intra-national differences in levels and patterns of occupational sex-segregation affect the results from existing research by means of a case study -the effect of occupational sex-segregation on wages- using data from the British Household Panel Survey (BHPS).

2. Literature Review

Space matters

For long, researchers have demonstrated that the public and private spheres of human life are heavily entrenched, and that individuals decide how much time and resources to allocate to each of these simultaneously rather than separately (Mincer and Polachek, 1974; Becker, 1981; Menaghan and Parcel, 1990). More recently, it has been claimed that a third dimension, a contextual one, should also be considered and theorised, as opportunities and constraints relating to the public and private life-spheres of individuals are embedded in a spatial context which is shaped by social networks, physical conditions, and cultural practices (Granovetter, 1985; Hanson and Pratt, 1992; Peck, 1996). This is, in fact, the grounding axiom of the discipline of human geography: people who live close to each other tend to be more alike than individuals who are geographically separated.

This spatial dimension is an important factor influencing labour market processes, as demonstrated by growing research on how the practices of both employees and employers are sensitive to space (see Fernández and Su, 2004 for a review). From the supply side, the distance between place of residence and workplace influences workers' job choices (Hanson and Pratt, 1992), while decisions to change residence are affected by job opportunities emerging elsewhere (Mincer, 1978; Bartel, 1979). From the demand side, employers take into account the availability and accessibility of the pool of workers they wish to attract when deciding the placement of production centres (Glaeser and Mare, 2001). There are also other labour market processes which are moulded by local idiosyncrasies, and where geographical space can facilitate or constrain the work opportunities of specific subsamples of the labour force. Some examples of this are the role of social networks in channelling the job opportunities of spatially segregated racial minorities (Fieldhouse and Gould, 1998; Mollica et al, 2003; Stainback, 2008), and of workplace proximity in determining women's decisions on whether and how to participate in the labour market (Ward and Dale, 1992; Hanson and Pratt, 1995).

The concept of local labour market

In economics, goods markets are conceptualised as a set of established conditions in which buyers and sellers meet to exchange goods, services, and money. Not unlike these standard markets, labour markets are the result of exchanges of products (i.e. work) between sellers (i.e. workers) and buyers (i.e. employers). Because in labour markets the commodity which is traded is inseparable from one of the economic agents, accessibility to prime materials and tools to perform the work is of uttermost importance. Consequently, geographical location plays a larger part in the functioning of labour markets than it does for other markets.

The unspoken practice in socio-economic research is to use the terms 'labour market' and 'national labour market' as synonyms. Thus, the possibility that different labour markets co-exist and operate within the same nation is conceptually, theoretically, and empirically neglected. However, research has demonstrated that individuals usually search for jobs within a finite spatial area (Simpson, 1992; van Ommeren et al, 1997),

and rarely commute beyond a given threshold (Yapa et al, 1971), or move houses over a long distance for job-related reasons (Taylor, 2007).¹ Besides, employment policies are often implemented at the local and regional levels (Buckner, 2009). Therefore, individuals living in different parts of a country may face very different employment contexts and do not necessarily compete with each other for jobs, as is the case for individuals living in the vicinity of each other. In this way, what is usually conceptualised as a single national labour market can be seen as a compendium of smaller local labour markets (LLMs). This analytical category would capture any existing intra-national geographic disparities which are averaged out at the country-level, including local differences in sectors of economic activity, natural resources, transport and communication infrastructure, the urban/rural character of settlements, the institutional environment, and cultural practices.

Operationalizing the LLM

Operationalizing LLMs in empirical research designs is difficult due to data availability and to the fundamental problem of where boundaries should be placed. Studies usually choose between two alternative strategies.² The first approach is to define LLM as administrative regions, which has the advantage that data for such geographical units is collected by the government and major surveys. In the case of Britain, administrative geographical levels include relatively large units such as Government Office Regions (GOR) and Local Authority Districts (LAD), as well as smaller territories such as Parliamentary Constituencies, Census Wards, and Postcodes. A second approach is to define LLMs as areas in which the majority of the resident population also works within the same area, so that commuting flows are more accurately captured. An example of this for Britain is the Travel to Work Area (TTWA). Unfortunately, data at this geographical level is rarely available. Besides, individual-level information on the geographic location in which people live and work precise

¹ The exception are highly educated individuals and individuals who do highly specialized work, for which available job opportunities are often concentrated in specific places and who search for jobs nationally and internationally rather than locally (Van Ham, 2002).

² There are other ways to model the spatial dimension of work processes, for example, using workers' subjective time-space perceptions (Recker et al, 2001) and datasets comprising addresses from employees working for given companies (Sassen, 1995). Here, we only use definitions based on pre-existing boundaries, as these are more widespread and relevant data are more easily available.

enough to construct this sort of classification is unavailable or restricted, as it seriously compromises surveys' commitment to the ethical principle of anonymity.

None of these two approaches is flawless. The use of administrative territories to define LLMs has been criticised because commuting patterns cut across administrative boundaries (Sassen, 1995). This is particularly true for urban areas and smaller geographical units. For instance, individuals who live in a given postcode in London are unlikely to restrict their job search to that postcode, and are likely to commute to others areas within the city. The use of a definition of the LLM which relies on commuting flows is still imperfect, because commuting tolerance varies by socioeconomic characteristics such as gender and class. For example, labour force participation and job choices are more contingent to workplace proximity for women and poorer people than for men and wealthier people (Markham and Pleck, 1986; Bielby and Bielby, 1992; Hanson and Pratt 1992, 1995).

Geographically-sensitive work-related research: a typology

Geographically-aware studies on work-related issues differ in how they overcome the inevitable trade-off between coverage and depth. The empirical literature features different types of studies ranging from analyses of all available geographical units to case studies of a single local area.

An example of a 'large N' study which uses all sub-national units within a country comes from Fieldhouse and Gould (1998), who explore variation in unemployment rates for ethnic minorities across LLMs (operationalized as LADs) in England. In their analyses, they estimate multilevel-models (MLMs) in which individuals (level 1) are nested within local areas (level 2) using data from the Sample of Anonymised Records (SARs) of the UK 1991 Census. Their results indicate that unemployment rates vary widely across LLMs for ethnic minorities but not for the white population, and illustrate how the national average for a given characteristic may or may not be consistent at lower geographical levels. However, this type of study pays little attention to specific local processes driving observed patterns of geographical variation.

Hanson and Pratt (1992) is an example of the analytical strategy which falls at the other end of the quantity-specificity continuum: the case study. The focus of such article

is on the role of local networks and employers' in the formation of gendered work practices, with results indicating that seemingly gender-neutral family- and work-related decisions produce strong segmentation between men and women at work. All analyses use a sample of individuals who live within the boundaries of a single LLM -Worcester-located in the state of Massachusetts (US). The advantage of this analytical approach is that it allows for detailed exploration of mechanisms such as local configurations of market skills, social networks, and employment opportunities, as well as the interactions between these. However, such case studies lack generalisability.

Other studies have research designs which fall in-between these two scenarios, sharing advantages and disadvantages with them. For example, Hiebert (1999) analyses labour market segmentation on the basis of gender and ethnicity in three metropolitan areas in Canada using 1991 census data. By providing in-depth analysis of a small number of selected LLMs, precise mechanisms which vary by LLM can be identified through the use of counterfactuals.

The choice between the three possible designs for the analysis of LLMs depends on whether the aim of the research is to explain context-specific mechanisms operating in a given LLM or to establish generalisable findings on the degree and patterns of geographical variation across LLM. In this article, we follow a 'large N' strategy.

Occupational segregation in LLMs: why do we care?

While research on the variability of occupational sex-segregation across LLMs is scarce, there are reasons to believe that a geographically-sensitive approach to this phenomenon may be useful.

First, indicators of work-related gender inequality, gender relations, and gender roles have been shown to vary across local areas within countries (Duncan, 1991; Cotter et al, 1999), with rates of labour force participation receiving the most attention (Ward and Dale, 1992). As an illustration, in the 1980s in the US there was more variability in the labour force participation of women across LLMs at a single point in time than at the national level in the preceding three decades (Deitch, 1985). In this way, it is plausible that the sex-composition of occupations fluctuates across sub-national geographies too. Oppenheimer advanced this idea proposing that "*a given occupation may be*

predominantly female in one labor market area but predominantly male in another” (1970, p.66). Similarly, Walby and Bagguley point out that “*there may be more intense segregation at the local level than revealed in nationally aggregated data*” (1990, p.61), while Lorence emphasises that “*aggregate national data [...] mask variation prevailing across local labour markets*” (1992, p.135). Hypotheses on the sources of these intra-national differences are manifold. Occupations may vary in their sex-composition across LLMs due to local differences in the gender distribution of individual-level socio-demographic characteristics or to macro-level structural aspects. The latter could be market conditions such as industrial mix (Jones and Rosenfeld, 1989) and occupational structure (Abrahamson and Sigelman, 1987) or place-specific normative factors such as the degree of traditionalism in sex-norms with respect to the types of work viewed as socially acceptable for women (Oppenheimer, 1970) or local women’s occupational culture (Hanson and Pratt, 1995).

Second, it has been argued that there is an overreliance on national- and regional-level analyses in research on gender inequality in the labour market, and that the local level offers a “*truer picture*” of the situation and experiences of individual employees (Buckner, 2009, p.59). The options, preferences, and decisions of individual agents which together create processes of gender (in)equality are not shaped at the national level, but embedded in more local geographical contexts (Leoni, 2006). When attempting to understand occupational sex-segregation, context is not only important historically but also geographically, as processes of labour market segmentation occur at a fine geographical scale (Hanson and Pratt, 1995). In practical terms, local-level analysis may be particularly relevant because most labour market policies are implemented at the local level through local councils, agencies, and employers (Buckner, 2009, p.59).

Finally, there is abundant research on trends, predictors and -especially- outcomes of occupational sex-segregation, with virtually all studies using indicators of occupational sex-composition calculated from national-level data. If occupations vary in their sex-composition across regions or districts within the national territory, this may bear implications for the findings from such literature. For example, results from analyses of the effect of occupational feminization on wages might be biased, as the relevant parameters may be sensitive to whether the feminization indicator is specified at the

local or the national level. Besides, the interpretation of the negative effect of occupational feminization on wages typically found in the literature as signalling the devaluation of female-dominated lines of work would be obscured.

Geography-sensitive research on occupational sex-segregation

A relatively prolific literature has concerned itself with the analysis of cross-country and cross-cultural variation in levels of occupational dissimilarity between men and women (Hakim, 1979; Charles, 1992; Jacobs and Lim, 1995; Anker, 1998; Jarman et al, 1999; Chang, 2000; Blackburn et al, 2000; Bridges, 2003; Charles and Grusky, 2004; EC, 2009). Well-established findings in this strand of research are that occupational sex-segregation is high in virtually all nations examined and that there is a large degree of between-country variability in levels of occupational dissimilarity, and in the lines of work undertaken primarily by men or women. Such cross-national disparities are usually attributed to differential cultures, gender regimes, and national policies. There are, however, very few studies which approach the issue of occupational sex-segregation from an intra-national geographical point of view.³ In this section we discuss research on the sex-segregation of occupations across LLMs within national boundaries.

The literature on sex-segregation in LLMs originated in the US in the 1970s, and has developed slowly since then. Most of the US studies use data from the 1960-1990 US population censuses, metropolitan statistical areas (SMAs) as the geographical unit of interest, and the Duncan and Duncan (1955) Index of Dissimilarity as their indicator of occupational dissimilarity. This line of research can be divided into four strands.

First, a group of articles analyses the variability in and predictors of occupational sex-dissimilarity in LLMs. Martin and Poston (1972), Rogers and Goudy (1981), Semyonov and Scott (1983), Abrahamson and Sigelman (1987), Lorence (1992), and Cotter et al (1998) follow this route and identify occupational structure, female labour force participation, labour force participation sex-ratio, demand for female labour, age profile of the workforce, size and growth of the population, rate of unemployment, rate

³ A related and somewhat larger literature on sub-national variation in levels of occupational segregation by race/ethnicity has also emerged (see e.g. Semyonov et al, 2000).

of net migration, educational differences between the sexes, region, and strength of the service sector as predictors of occupational dissimilarity by gender in LLMs in the US.

Second, two studies exploit spatial variation in levels of occupational sex-segregation to improve our understanding of phenomena which are normally explored using national-level data. Williams and Register (1986) test whether the devaluation effect of occupational feminization can be explained by differences in the value of the marginal products produced by individuals in male- and female-dominated occupations. The authors find that wages in a given labour market are higher when the occupation employs relatively more males than in other labour markets, which supports the devaluation hypothesis. Jacobs and Blair-Loy (1996) explore how the variability in the degree of sex-segregation in an occupation across LLMs affects local average wages for such occupation. Their findings indicate that the effect of occupational sex-segregation on wages operates mainly at the national level (through national culture and institutional devaluation) but also at the local level (through local decision-making in hiring and wage-setting).

Third, Cotter et al (1997) and Cohen and Huffman (2003a, 2003b) use MLMs in which individuals are nested within local areas. Cotter et al (1997) explore the variation in gender inequality in wages across metropolitan areas as a function of occupational dissimilarity, and find that occupational integration is strongly associated with gender equality in earnings. Similarly, Cohen and Huffman test whether the devaluation of female-dominated occupations (2003a) and occupation-industry cells (2003b) is stronger in highly-segregated labour markets. Their results indicate that wage penalties associated with working in female-dominated lines of work are stronger in localities which are highly segregated.⁴

Fourth, Cotter et al (1996) compare indicators of gender equality between metropolitan and non-metropolitan areas. Their results indicate that gender equality in the labour market is comparable in metropolitan and rural areas, with the exception of

⁴ These results are particularly interesting because they contrast with those from studies which compare occupational dissimilarity across countries (rather than across regions or districts within a country). The cross-national studies usually find a positive relationship between the level of occupational sex-segregation and the degree of gender equality in a country; that is to say, countries in which occupational sex-segregation is high have low levels of gender inequality (Bettio, 2002; Blackburn and Jarman, 2005; Bettio, 2008; EC, 2009).

occupational sex-segregation. Such segregation is noticeably higher and has fallen at a slower pace in rural compared to non-rural LLMs.

Geographically-aware research on the sex-segregation of occupations in the UK is scarce. Walby and Bagguley (1990) use data from the Changing Urban and Regional System in the UK initiative and the 1970/1980 UK censuses, and document differences in levels of sex-segregation between the UK as a whole and a sample of five LLMs. However, sex-segregation is measured across industries and socioeconomic groups, rather than across occupations. Duncan (1991) uses 1980 UK Census data to identify spatial variation in indicators of labour equality across districts, and finds that gender divisions of labour in Britain are marked, vary across LLMs, and are associated with differences in household structures. However, the sex-segregation of occupations is not among the empirical indicators considered. More recently, Buckner (2009) uses 2001 UK Census data to illustrate the importance of looking below the national level in research on segregation and clustering in the labour market. Her results indicate that there is considerable variation in sex-segregation across major occupational groups between three selected local areas and the national territory.

3. Data

The UK Census

The UK Census is a decennial survey which takes place the first year of each decade, and in which all individuals who reside in England and Wales are interviewed.⁵ The most recent Census data available for research purposes is from 2001.⁶ The key advantage of using the Census for the aims of this article is its large sample size, which provides a unique opportunity to undertake precise analyses of small geographies. As a drawback, the Census contains little or no data on many aspects relevant to social scientists interested in work, including information on wages, careers, working environment, perceptions and attitudes, and life course events. Information from the UK Census is disseminated by the Office for National Statistics (ONS) through a number of

⁵ The 2001 UK Census also contains information on individuals living in Scotland. However, this is not always comparable to that collected from people living in England and Wales. Therefore, we exclude the Scottish sample from our analyses.

⁶ Although the 2011 Census took place on 27th March 2011, data is still unavailable for research purposes.

channels. Commissioned Tables from the 2001 Census contain aggregated information for the population in England and Wales and selected geographies within them unavailable in standard Census reports. We use existing commissioned tables c0086 and c0822 to derive indicators of the percentage of workers in each occupation who are women and measures of occupational dissimilarity at all levels of occupational disaggregation for each GOR and LAD. These two geographical levels are our proxies for the LLM.⁷ There are 10 GORs in England and Wales with a mean population size of 5,7 million and 374 LADs with around 140,000 inhabitants on average.⁸ We use the Controlled Access Micro-Samples of the 2001 Census (CAMs) to derive contextual variables for each of these regions and districts. The CAMs dataset contains information from a 3% sample of the population in England and Wales, but can only be accessed in a secure data laboratory at ONS premises. Other variables were derived using Census data accessible through the NOMIS⁹ and WICID¹⁰ web-interfaces.

The British Household Panel Survey

Because the UK Census has no information on the wages of employed individuals, we use data from the British Household Panel Survey (BHPS) to examine whether estimates on the impact of occupational feminization on wages are sensitive to the geographical level at which occupational feminization is defined. The BHPS is a panel survey in which the same respondents have been interviewed on an annual basis every autumn since 1991, with data up to 2007 available at the time this article was written. The first wave of the panel consisted of over 10,000 respondents living in around 5,000 nationally representative randomly selected households across Britain. The BHPS offers advantages for the study of occupational sex-segregation: it is representative of the

⁷ Tranmer et al (2003) argue that similar analyses executed at different levels of geographical (dis)aggregation may produce different associations and/or averages of level-specific associations due to differences in population distributions. This is known as the ‘scaling effect’. To avoid this, they recommend that the spatial dimensions of labour market processes are analysed comparing hierarchically-nested geographical units. Following this, our analyses are done at two hierarchical levels of geographical aggregation (i.e. LADs and GORs).

⁸ The 10 GORs are the North East, North West, East of England, Yorkshire and the Humber, East Midlands, West Midlands, South East, South West, London, and Wales. There are, in fact, 376 recorded LADs, but data for the City of London and Penwith is not released by the ONS due to small sample sizes leading to issues of anonymity and confidentiality. See Appendix 1 for the full list of GORs and LADs used.

⁹ <http://www.nomisweb.co.uk/>.

¹⁰ <http://cider.census.ac.uk/cider/wicid/query.php>.

British population, it collects a wide range of contextual information, and it includes detailed information on the occupation. Different indicators of occupational feminization derived from Census data are matched to respondents of the BHPS by SOC2000, region, and LAD.¹¹ Our multivariate analyses use seventeen waves of the BHPS covering the period 2001-2007 and are based on a sample of working age employees (men aged 18 to 64 and women aged 18 to 59) outside full-time education and with no missing information on key variables. Applying these criteria we obtain a net sample size of over 5,600 individuals and 24,400 person-year observations.

4. Results

In this section we present the results of our empirical enquires. In the first part, we use data from the 2001 UK Census to provide evidence on the variation of OSS across LLMs, quantify such variation, and examine which factors produce it. In the second part, we assess misclassification issues in nationally-aggregated data, and then merge Census and BHPS data to estimate the bias in existing studies of the impact of occupational feminization on wages. For comparative purposes, results are presented for all possible permutations of geographical (GORs and LADs) and occupational units (1-, 2-, 3-, and 4-digit SOC2000).

Does OSS vary across LLMs? Some initial figures

Table 1 offers a first glimpse at geographical variation in occupational feminization using the most aggregated occupational classification (1-digit SOC2000, 9 occupations) and the most aggregated sub-national geography (GORs, 10 regions). Results show that there are few differences between the proportion of workers who are women in major occupational groups across GORs in England and Wales and the proportion of workers who are women in major occupational groups at the national level. If we were to consider GORs as appropriate proxies for the LLM, we would conclude that the sex-composition of major occupational groups varies little across these. Alternatively, it could be argued that GORs are too big geographical units to capture local job processes,

¹¹ Information on LAD of residence is only available in a special-license version of the BHPS.

and that this is the reason why their rates of occupational feminization mirror those observed for the nation as a whole. A third interpretation would be that major occupational groups encompass differently segregated occupational sub-units, and only the latter vary across GORs.

Graph 1 uses data from Table 1 to estimate weighted differences in percentage female (WDPF) in the 1-digit occupation by GOR. WDPF is the sum of the absolute values of the differences between the percentage of workers who are female in each occupation in a given region and the percentage of workers who are female in the same occupations at the national level, weighted by the number of workers in the occupation-region cell divided by the total number of workers in the region. This can be expressed mathematically as:

$$WDPF_r = \sum_o [\text{abs}(F_{or} - F_{on}) * (S_{or}/S_r)] \quad (1)$$

where subscripts ‘r’, ‘n’, and ‘o’ stand for region, nation, and occupation, ‘F’ represents the percentage of workers in the occupation who are female, and ‘S’ is the number of workers. Intuitively, this figure indicates how much on average the sex-composition of occupations in a GOR differs from the sex-composition of occupations at the national level, measured in percentage points of occupational feminization and weighted by how much each occupation contributes to total employment within the GOR.¹² Results indicate that WDPF is considerably higher in London than in all other GORs. On average, the sex-segregation of major occupational groups in London varies 3.44 percentage points from the sex-segregation of major occupational groups in England and Wales as a whole. This could be the result of London being the country’s capital city, being home to positively selected young migrant workers, or having employers with more progressive attitudes towards gender equality at work. It may even be the case that London is the only GOR that successfully approximates a LLM: it is the only genuinely urban GOR -all others comprise a mixture of urban and rural settlements- and also the smallest. This means that there are shorter distances and less if any empty areas between parts of London, and consequently no natural boundaries which may prevent fluxes of workers. In contrast, the North West has the lowest WDPF (0.48), which may just signal the absence of a clear positive or negative profile with

¹² The same logic applies to districts (i.e. LADs).

respect to gender equality for this GOR. Estimates of WDPF for the rest of the GORs are very similar and are contained within 1 percentage point.

Graph 2 provides estimates of WDPF for each major occupational group.¹³ Results indicate that ‘sales and customer service occupations’ vary the most in their sex-composition across GORs (WDPF=3.81), while ‘skilled trades occupations’ vary the least (0.99). All other occupational groups have similar rates of WDPF which fall in between. The aggregated 1-digit category of ‘sales occupations’ includes job titles such as ‘sales assistants’, ‘cashiers’, and ‘call centre operators’. This occupational group may have the highest WDPF because the skills necessary to perform these jobs are low and workers are drawn from a pool of labour market entrants regardless of their sex, because there is no clear sex-label on ever-present sales occupations, or because the sex-composition of retail occupations varies across industry branches which are distributed unevenly across GORs. The aggregated 1-digit category of ‘skilled trades’ includes detailed occupations such as ‘electricians’, ‘bricklayers’, and ‘motor mechanics’. It may have the lowest WDPF because most occupational sub-groups falling under this category are strongly male-dominated and gender-stereotyped, and feature job tasks which are conspicuously associated with masculinity across the entire nation (e.g. manual, physical, and technology-heavy work).

Table 2 shows descriptive statistics on the variation in the percentage of workers who are female in selected occupations across GORs. This implies moving from the most aggregated 1-digit occupational level in previous analyses (9 occupations) to the most disaggregated 4-digit level (353 occupations). Because figures for all occupations cannot be presented due to space constraints, we show descriptive statistics for occupations which provide interesting case studies. The top four rows in Table 2 show information for several occupations in which variation in occupational feminization across GORs is substantial. For instance, while 30% of ‘weavers and knitters’ in England and Wales are women, this figure ranges from 21.42% in the East Midlands to 66.53% in the East of England. This implies a reversal in the sex-typicality of the

¹³ The formula to calculate WDPF across occupations is similar to the formula to calculate WDPF across regions, but inverting the ‘r’ and ‘o’ subscripts in the equation: $WDPF_o = \sum_r [\text{abs}(F_{or} - F_{on}) * (S_{or}/S_o)]$. In this context, WDPF indicates how much on average the sex-composition of an occupation varies across regions, measured in percentage points of occupational feminization and weighted by how much each region contributes to national employment in the occupation.

occupation – it is male-dominated in one region and female-dominated in another. The range between minimum and maximum occupational feminization across GORs is also very high among ‘public service associate professionals’ (27.98), ‘dry cleaners’ (27.5), and ‘cooks’ (23.95). Conversely, the bottom four rows of Table 2 show descriptive evidence on the variation in the percentage of workers who are female for some occupations which have a consistent sex-profile across GORs. Among these we find female-dominated occupations such as ‘childminder’ and ‘nursery nurse’ and male-dominated occupations such as ‘carpenter’ and ‘heavy good vehicle driver’, for which ranges are always lower than 1.2 percentage points.

Table 3 presents equivalent evidence across LADs (n=374). As it could be expected given the finer geographical specificity, differences between the maximum and minimum occupational feminization across LADs tend to be higher than for GORs.¹⁴ Gender-integrated occupations such as ‘assembler’, ‘sewing machinist’, ‘farm worker’, or ‘waiter/waitress’ show high variation in occupational feminization; while sex-segregated occupations such as ‘secretary’, ‘motor mechanic’, ‘electrician’, or ‘plumber’ show very little variability.

Overall, this section has demonstrated that while the sex-segregation of major occupational groups is relatively constant across GORs, when looking at detailed occupations and/or lower geographies such segregation varies considerably across LLMs. Furthermore, there seems to be more variability among occupations which are sex-integrated at the national level. In the following section we quantify such variability and explore its distribution across occupations, GORs, and LADs.

How much does OSS vary across LLMs?

Table 4 offers descriptive evidence on how WDPF varies across LLMs at different levels of geographical and occupational (dis)aggregation. Information in row one (1-digit occupations within GORs) is analogous to that in Table 1 and Graph 1. Results in

¹⁴ To avoid using unrepresentative examples due to measurement error resulting from small sample sizes of certain occupations within certain LLMs, in this table we only present results for occupation-LAD cells in which there are at least 50 workers and for occupations which had at least 50 workers in half (187) of the LADs. In robustness checks we have iteratively re-estimated WDPF in all other tables using only occupation-GOR and occupation-GOR cells which had at least 20, 50, and 100 workers, with few changes to the results.

this table show that mean WDPF increases with geographical and occupational disaggregation, and is largest when using the 4-digit occupational classification and LADs (4.66 percentage points). The range (maximum-minimum) is higher when using LADs than when using GORs, but is similar when using more and less disaggregated occupational classifications (with the exception of 4-digit occupations within LADs). Similarly, the interquartile range (p75-p25), increases substantially with geographical but not with occupational disaggregation. Taken together, these results suggest that LADs capture the structure of LLMs more successfully than GORs, especially when more disaggregated occupational categories are used. Besides, the finding that the interquartile range for WDPF remains stable as we use more disaggregated geographical and occupational units indicates that the increase in the mean values of WDPF is not the product of the increase in the number of categories.

Table 5 presents information on how WDPF varies across occupations. Information in row one is analogous to that in Graph 2. The mean, range, and interquartile range tend to be higher when using LADs than when using GORs, and when using more aggregated occupational classifications. This suggests that variation in WDPF across occupations is driven by both geographical and occupational disaggregation. When we use 4-digit occupational classifications the range increases disproportionately compared to the interquartile range, which indicates that at this level of disaggregation there are outliers in the distribution.

Table 6 focuses on variability in rates of occupational integration across GORs and LADs. Occupational integration is measured by the Duncan and Duncan (1955) Index of Dissimilarity (D). This is defined as:

$$D = (0.5) * \sum_o \left| \frac{M_o T_o}{\sum_o M_o T_o} - \frac{F_o T_o}{\sum_o F_o T_o} \right| \quad (2)$$

where subscript ‘o’ represents occupation, ‘M’ is the percentage of workers who are men, ‘F’ is the percentage of workers who are women, and ‘T’ is the total number of workers. Possible values for D range from 0 (complete integration) to 1 (complete segregation). Intuitively, D can be interpreted as the proportion of men and women required to change occupations for the occupational structure of the labour market to become fully gender-integrated. In line with theoretical expectations, the data shows

that for both regions and districts D is higher when calculated using occupational classifications which are more disaggregated – the ‘aggregation hides segregation’ phenomenon (see e.g. Reskin, 1993). Differences in occupational dissimilarity across regions are large. For example, using a conservative 1-digit occupational classification 30% of workers in London but 40% in the North East need to change occupations for labour market segregation to fade completely. The variability in D across LADs is even greater than that among GORs. At the most disaggregate level of measurement (4-digit occupations within LADs) the lowest segregation occurs in Camden (London), where 35% of workers need to change occupations to achieve complete market integration. Meanwhile, the highest segregation takes place in Barrow-in-Furness (North West), for which the corresponding figure is a much higher 69%. For both GORs and LADs, the range and the interquartile range are similar at different levels of occupational aggregation, suggesting that the precision with which occupations are defined does not affect estimates of the variability in D across LLMs. However, these statistics are noticeably bigger for LADs than for GORs, which suggests that variability in occupational sex-segregation across LLMs is underestimated when using the GOR as a proxy for the LLM.

On the whole, results in this section illustrate that both occupational integration and occupational feminization vary widely across GORs and LADs, and that such variation is not driven by outliers. The next sections explore which characteristics of the local area are associated with higher or lower variability in occupational sex-segregation from the national mean.

Which occupations vary more in their sex-composition across LLMs?

Having established that the variation in the sex-composition of some occupations across LLMs is higher than that of other occupations, this section analyses which factors are associated with low and high levels of WDPF.

Table 7 presents descriptive evidence on the relationship between WDPF, and the sex-composition and workforce size of occupations.¹⁵ The sex-segregation of occupations may be an important factor producing variation in WDPF if occupations which are traditionally associated to one sex at the national level (i.e. male- or female-dominated) have more rigid patterns of occupational feminization across LLMs, and are less likely to vary in their sex-composition than occupations in which more even numbers of men and women work. In the first column in Table 7 we test for this by regressing WDPF on sex-composition at the national level using the 353 4-digit occupations in SOC2000 as units of analysis. Results show that variability in occupational feminization across LLMs is larger for integrated than for sex-segregated occupations. The standardized coefficient on integrated occupations ($b=0.392$) indicates that an increase in 1 standard deviation in occupational size nationwide is associated with an increase of 0.39 standard deviations in WDPF relative to male-dominated occupations. Differences between sex-segregated occupations are negligible ($b=-0.002$).

Because occupational classifications may fail to recognise the diversity of female-dominated lines of work, the level of detail in occupational categories should decrease with occupational feminization (Steinberg, 1990; Blackwell, 2001, Grimshaw and Rubery, 2007). As a result, female-dominated occupations are on average larger than male-dominated occupations. Furthermore, research has shown that male-dominated occupations are geographically concentrated, while female-dominated occupations are more equally dispersed across the nation (Mincer, 1978; Shauman and Noonan, 2007; Perales and Vidal, 2011). Thus, male-dominated occupations will have comparatively small cell-sizes in LLMs which do not specialize in that type of work, while female-dominated occupations will have more even numbers across LLMs.¹⁶ Smaller occupations overall and in given LLMs may suffer from higher random error and

¹⁵ Occupations in which between 0% and 30% of workers are women are male-dominated, those in which between 30% and 70% of workers are women are integrated, and those in which between 70% and 100% of workers are women are female-dominated.

¹⁶ Thanks to the weighting factor in its formula, variation in the size of a given occupation across LLMs does not affect WDPF for occupations. However, WDPF cannot compensate for the fact that some occupations are small at the national level, and consequently small in all LLMs. This is better illustrated by means of a hypothetical example. WDPF would accommodate that there were only 2 people working as ‘agricultural managers’ in Westminster compared to 200 people in Cardiff. However, if only one person worked in the hypothetical occupation of ‘LAD mayor’ in each LAD, the random variation in sex-segregation would be higher than for an occupation with large sample sizes in all LADs such as ‘primary school teacher’. Thus, consistently small occupations bias WDPF due to higher random variation. The same reasoning applies to WDPF for GORs and LADs.

produce artificially high rates of occupational integration when results are averaged out at the national level. Thus, if occupational size at the national level and/or geographic variability in the size of occupations across LLMs are negatively correlated with WDPF, differences in the sizes of male- and female-dominated occupations might be behind the relationship between sex-segregation and WDPF. To explore whether this is the case, in column 2 we regress WDPF on the size of the occupation in the UK and the number of LLMs in which the occupation has more than 50 workers. Results show that the former is not significantly related to WDPF ($b=-0.010$) while the latter is strongly and negatively associated with it ($b=-0.605$), which indicates that occupations which are large in more LLMs have rates of occupational feminization which vary less across LLMs.¹⁷ In column 3, we regress WDPF on sex-composition and the number of LLMs in which the occupation has less than 50 workers at the same time to capture the relationships between these variables and WDPF net of each other. The standardized coefficient on variability in occupational size remains similar to that in the previous specification ($b=-0.655$). The parameter on sex-integrated occupations ($b=0.467$) is also comparable to the previous estimate, indicating that these occupations have higher WDPF than male-dominated occupations net of variability in occupational size. However, the coefficient on female-dominated occupations changes sign ($b=0.167$) and becomes statistically significant. This indicates that, after controlling for the number of LLMs in which occupations have more than 50 workers, female-dominated occupations have higher WDPF than male-dominated occupations. This reversal can be explained by female-dominated occupations having lower variability in size than male-dominated occupations, and indicates that male-dominated occupations are less likely to vary in their sex-composition across LLMs within the national territory. Together, size and feminization explain around 56% of the variance in WDPF ($R^2=0.559$). The magnitude of the standardized coefficients indicates that both factors explain about the same amount of such variance.

¹⁷ When we regress WDPF on occupational size without the control for geographic variability in occupational size the resulting parameter is strong, negative, and statistically significant ($b=-0.320^{***}$). Thus, the lack of economic and statistical significance of occupational size in column 2 seems to be the product of its high correlation with the variability variable ($r=0.51$). Including size rather than variability in the model in column 3 produces comparable results. From this, we conclude that both occupational size and its variability mediate the relationship between occupational sex-composition and WDPF.

Key findings from this section are that occupational feminization is more variable across LLMs for integrated than sex-segregated occupations,¹⁸ and that female-dominated occupations have higher WDPF than male-dominated occupations. We also found that a large portion of the variation in WDPF is due to variability in the size of occupations across LLMs. The next section focuses on variation in WDPF across LLMs rather than occupations.

In which LLMs does OSS vary more?

Map 1 shows the geographical distribution of WDPF across LADs in England and Wales. Districts falling within each quartile of WDPF have different filling patterns in the map, where higher density of dots indicates higher values. Evidence here suggests that WDPF is relatively large in rural areas of the North and the South West situated far away from large metropolises, and relatively low in the urban conurbations of Manchester-Liverpool, Birmingham, Newcastle, Leicester-Nottingham and Cardiff-Swansea, and their periphery. This may indicate that WDPF is related to the distribution of rural/urban economic enclaves, or that LADs which comprise large urban areas have larger populations and contribute more to national rates of occupational feminization than LADs with small populations. The exception is central London, for which we observe high rates of WDPF.

In column 1 in Table 8 we investigate which LLM characteristics are associated with WDPF in an OLS framework. Our predictors are sixteen characteristics of the LLM suggested in the literature, plus the number of occupations in the LAD which have at least 50 workers.¹⁹ The model has a sample size of 374 LADs, and explains nearly

¹⁸ WDPF may be higher in gender-integrated occupations because the occupational feminization variable from which the occupational categories of male-dominated, integrated, and female-dominated are derived is a proportion and, as such, the variation is artificially lower at the extremes of the distribution due to truncation at 0 and at 1. Besides, it is likely that occupations which are integrated in the nation as a whole are, by definition, occupations in which the sex-composition varies more across LLM, while male- and female-segregated occupations at the national level necessarily have consistent sub-national distributions closer to the extreme values of 0 and 1.

¹⁹ We also derived, tried, and rejected other independent variables used or suggested in previous literature. These include human capital variables (median educ. of men/women/all people, prop. of graduates); labour market characteristics (size of the workforce, prop. of men/women in (un)employment, prop. of workers commuting over 50km, rates of in and out migration, prop. of workers in large establishments); indicators of demographic composition (sex-ratio, elderly dependency rate, prop. of people over 65, fertility rate, youth dependency rate, average number of children per household, prop. of

two thirds of the variance in WDPF ($R^2=0.711$). The number of occupations in the LAD which have at least 50 workers is by far the best predictor of WDPF. This has a strong, negative, and statistically significant impact: an increase in 1 standard deviation in such variable is associated with a decrease of 0.65 standard deviations in WDPF. LLMs in which neighbourhoods score higher on the Index of Multiple Deprivation (IMD) have higher WDPF ($b=0.181$), perhaps because employers in these areas offer comparatively more unskilled jobs which are more often found in sex-segregated occupations. Similarly, overall unemployment rates in the LAD have a positive effect on WDPF ($b=0.193$), indicating that the sex-composition of occupations is more different to that of the nation as a whole in competitive rather than slack markets. This could be due to men taking traditionally-female jobs under in the threat of becoming unemployed. The proportion of women in the district with higher education is also positively and statistically significantly associated with WDPF ($b=0.177$).²⁰ This may occur because when women have a more competitive position within the labour market relative to men, they may have better access into high-status traditionally-male-dominated occupations. The proportion of workers in the LAD who are women has a negative and statistically significant impact on WDPF ($b=-0.078$), suggesting that when there is an oversupply of women in the labour market, women are channelled more often into sex-typical occupations. The sex-composition of occupations in LLMs which received a higher number of migrants in the previous year differs more from the national mean than that of LLMs which received less migrants ($b=0.095$). This may be because large ratios of net-migration signal economic vitality and a slack labour market, which may facilitate movement into occupations non-traditional for the worker's gender, or that immigrants do low-skilled work traditionally reserved to women. Among our indicators of gender-roles, only the proportion of women aged 25 or over who never worked had a statistically significant effect on WDPF ($b=0.284$), indicating that LADs with a more traditional gender division of paid and unpaid work have relatively high rates of WDPF. Since we know that the LAD is not an ideal proxy of the LLM due to fluxes of labour

women mothers of a baby, prop. non-UK-born); and proxies for gender egalitarian practices (ratio of cohabiting to married couples, diff. in care hours between men and women, prop. of adult women divorced/separated, prop. of married couples with 0 or 2 carers, prop. of women working PT, prop. of adult women never married and not cohabiting, prop. of women who are the reference person in the household).

²⁰ Women with higher education are those holding Level 4 or Level 5 educational qualifications. It is not possible to disentangle these two in CAMs data.

exchange which cut across administrative boundaries, variables capturing commuting flows are expected to be important in predicting WDPF. However, the impact of the proportion of the population who works in a different LAD on WDPF is small and not statistically different from zero, though controlling for this allows us to estimate less biased coefficients for other independent variables. In contrast, the ratio of in-commuters to the population in the LAD has a negative and statistically significant effect on WDPF ($b=-0.098$), which indicates that LADs which receive more commuters have rates of occupational sex-segregation more similar to those of the nation as a whole. Thus, it seems that commuting across LADs is a stabilizing mechanism. Finally, occupations have considerable different rates of sex-segregation in London compared to the UK for reasons not controlled for in this model ($b=0.228$). The latter may include mechanisms related to its capital city status, the prevalence of flows of positively selected migrants, or less discriminatory employers.

On the whole, results in this section indicate that being in London, deprivation, unemployment, migration, women's education, and a traditional gender division of labour are factors associated with high WDPF among LLMs, while women's share of the labour force, in-commuting, and occupational sizes are associated with low WDPF. In the next section we examine which LLM characteristics explain rates of occupational dissimilarity across LADs.

Which LLMs are more gender integrated and which more gender segregated?

Map 2 offers a visual representation of the distribution of occupational dissimilarity, measured as D , across LADs in England and Wales. The plot indicates that D is spread unevenly across different parts of England and Wales. Large values of D are found in the North, Yorkshire, and the Midlands. This may be due to more traditional gender-role institutional arrangements in the central-northern part of England, and to a male-dominated industry-based economic structure (Duncan, 1991). Conversely, low values of D are present around London and in the South West, possibly due to more progressive gender-role attitudes in London and its surroundings. Interestingly, LADs across the Thames mouth are the only districts among those situated around London for which high values of D are recorded, which may be explained by these areas being

‘bedroom communities’ which supply -mostly male- workers to the LADs in London (e.g. there may be an overrepresentation of male managers living in them who may commute to work in the City).

We explore the predictors of occupational dissimilarity in column 2 in Table 8, which presents standardized coefficients from an OLS model in which the dependent variable is D and the independent variables are those used to predict WDPF. R^2 is 0.921, which suggests that our predictors explain almost all the variance of D. Industrial dissimilarity has the strongest association with occupational dissimilarity of all regressors. This relationship is positive and statistically significant ($b=0.459$), and indicates that LLMs in which men and women are more separated across employment sectors, are those in which men and women are more separated across occupations. This suggests that the sex-segregation of occupations is consistently different across sectors of the economy (e.g. managers in ‘public administration’ would be more often women than those in the ‘electricity, gas and water supply’ industry). D is significantly lower in LADs which have higher deprivation rates ($b=-0.220$), a higher proportion of highly qualified women ($b=-0.418$), more migrants ($b=-0.103$), and a higher share of non-white population ($b=-0.126$). The negative relationship between IMD and D may be driven by the occupational structure of deprived LLMs, which may draw heavily from low-skilled more-androgynous lines of work. The inverse relationship between the proportion of women in the LAD who are highly qualified and D can be explained by a higher ability of women to compete with men for high-status jobs. The negative association between rates of net-migration and the dependent variable is in line with the interpretation in the previous model that slack labour markets facilitate movement into occupations non-traditional for the worker’s sex. A reason why D may be negatively associated to the share of non-white population may be that ethnic minority women are less qualified and less able to cross gender-boundaries into traditionally male-dominated lines of work. We also find evidence that LADs with a higher proportion of families with dependent children have higher rates of occupational sex-dissimilarity, which is consistent with human capital theories arguing that women but not men change jobs to accommodate family care, presumably by moving into female-dominated occupations (Polachek, 1979). Our results also indicate that the higher the difference in the number of hours men and women dedicate to caring for relatives in a given labour market is, the higher

occupational dissimilarity will be. As women do more caring than men in 371 out of 374 LADs, this finding suggests that caring duties constrain occupational choice, or that an underlying unobserved factor such as ‘institutionalized traditional gender-role attitudes’ produces both. Finally, rates of out-commuting are significantly and positively associated with D, which hints at inefficiencies in using LADs to proxy LLMs.

Overall, results in this section indicate that most of the variance in D is explained by the regressors included in our model. Industrial dissimilarity, traditional gender-role attitudes, and the prevalence of families with dependent children are associated with high occupational dissimilarity in LLMs, while deprivation, women’s education, and large shares of ethnic minorities and migrants are associated with low occupational dissimilarity.

An application using the BHPS: the impact of occupational feminization on wages

Effects of occupational and geographical disaggregation of the feminization indicator

One of the reasons why a geographically-sensitive operationalization of occupational sex-segregation is desirable are the potential implications of misclassifying individuals in analyses of the relationships between occupational sex-segregation and labour market outcomes. In this section, we explore the degree to which the sex-composition of individuals’ occupations is misspecified when using indicators of sex-segregation defined at the national level rather than indicators specified at lower geographies, on the assumption that the latter are more accurate. We then test how much such misclassifications affect estimates of existing research by means on a case study, namely the impact of occupational sex-segregation on wages. The wage effect of occupational sex-segregation is probably the most prominent research area within the occupational sex-segregation literature, with a high number of studies devoted to it (e.g. Treiman and Hartmann, 1981; England et al, 1994; Tam, 1997; see Perales, 2010 for a review). A common finding among these is that occupational feminization has a negative effect on wages: the higher the proportion of workers who are women in individuals’ occupation, the lower their wages are *ceteris paribus*. Theoretical explanations for this include the devaluation of the work typically done by women

(England, 1992) and the existence of mediating mechanisms such as human capital assets (Polachek, 1979), compensating differentials (Filer, 1989), and skill specialization (Tam, 1997).

In the literature on occupational sex-segregation is common to separate occupations into occupational sex-types. Occupations in which between 0% and 30% of workers are women are male-dominated, those in which between 30%-70% of workers are women are integrated, and those in which between 70% and 100% of workers are women are female-dominated.²¹ Table 9 shows which percentage of all workers are misclassified when using indicators of the percentage of workers in the occupation who are women at different levels of geographical and occupational disaggregation, relative to the most disaggregated measure (4-digit occupations within LADs). Focusing first on occupational (dis)aggregation, results indicate that the percentage of cases which are miscoded increases by around 10 points for each digit of occupational aggregation, from 10% at 4-digits to 40% at 1-digit. Therefore, in line with arguments in Reskin (1993) the occupational sex-type of almost half of the individuals is coded wrongly when using highly aggregated occupational classifications. Results on geographical disaggregation indicate that the percentage of individuals whose occupation is miscoded is very similar at the UK, GOR, and LAD levels. The exception is the 4-digit occupational classification, in which about 10% of all individuals are placed in the wrong occupational sex-type when indicators of occupational feminization are defined at the national or regional level. This indicates that disaggregating geographically only pays if a highly disaggregated occupational classification is also used.

Table 10 show coefficients on the effect of a continuous measure of the *proportion* of workers in the occupation who are women constructed at different levels of occupational and geographical disaggregation on the log of men's and women's hourly wages.²² Using the most disaggregated indicator, the models indicate that a man who

²¹ The exact points of the occupational feminization distribution in which the divisions between categories are placed vary across studies, but the 30% and 70% cut-points are the most frequently used.

²² These are pooled OLS regression models which use data for years 2001 to 2007 from the BHPS, and in which standard errors are clustered at the level of the individual. Controls in these models include year, age, marital status, education, job tenure, contract type, hours of work, establishment size, industry, on-the-job training, managerial duties, gender-role attitudes, hours of housework, caring duties, accident rates in the occupation, shift work, and unpaid overtime. We do not include dummy variables for regions to avoid confusing their effect with the changes in the model coefficients from defining occupational feminization at different levels of geographical disaggregation, although results are similar when such

works in a fully male-dominated occupation has wages which are around 30% lower than those of a similar man working in a fully female-dominated occupation. For women, this figure is approximately 26%. When more aggregated occupational classifications are used to calculate the percentage of women in the occupation, the effect of occupational feminization on wages is underestimated for men, and overestimated for women. However, the impacts of occupational feminization on wages are not sensitive to using more or less geographically-aggregated classifications. This suggests that disaggregating occupations is more important than disaggregating LLMs for the analysis of the effect of occupational sex-segregation on wages.

On the whole, results in this section indicate that the risk of misclassifying individuals into the ‘wrong’ occupational sex-type when defining occupational feminization at a geographical level other than the district is negligible, except for when occupational classifications are highly disaggregated. Also, indicators of occupational feminization derived at different levels of geographical disaggregation had very similar impacts on wages, while the degree of occupational disaggregation matters more.

Geographical variation in the impact of occupational sex-segregation on wages

Another intersection between occupational sex-segregation and geography is the potential heterogeneity in the association between occupational feminization and labour market outcomes across geographies. In this section, we use MLMs (Goldstein, 1987) to test whether there is geographical variation in the effect of occupational feminization on wages using data for the 2001 wave of the BHPS.²³

MLMs are regression techniques useful to model data which has a hierarchical structure, (i.e. observations are nested within groups or contexts), and allow for the incorporation of contextual-level information when estimating observational-level associations. In our case, the lower level units are individuals (level 1) nested within LADs (level 2). The simplest MLM is the random intercept (RI) model, where the

dummies are added. For a more exhaustive analysis of the effect of occupational sex-segregation on wages using similar data, controls for skill specialization, and panel-data models see Perales (2010).

²³ Estimating MLMs which use the seven BHPS waves for which SOC2000 is available would be complicated in this context: individuals do not always live in the same district, and therefore observations are not fully nested within LADs. Estimating a single model with this data structure would require a highly complex cross-classified model outside the scope of the present article.

intercept in the regression is allowed to vary across level 2 units (i.e. LADs).²⁴ These RI are differences between the cluster-specific means (i.e. mean wage in the LAD) and the population mean (i.e. mean wage at the national level), and are reported as a variance term indicating the amount of heterogeneity across clusters. More complex random slopes (RS) models allow the coefficients of given independent variables to differ across level 2 units. In some of our models, we will allow the effect of occupational feminization on wages to vary across LADs.²⁵

Results from naïve RI and RS models with only one independent variable -the proportion of workers in the occupation who are women- are presented in Table 11. In naïve RI models, random intercepts for men (0.017) and women (0.022) are statistically different from zero, indicating that average hourly wages vary across regions. Results also show that between 8% and 10% of the total variation in wages for men and women is explained by differences across LADs, and that the effect of occupational feminization on wages is statistically significant, negative, and larger for women ($b=-0.37$) than for men ($b=-0.13$). In naïve RS models, the random slopes are statistically different from zero, suggesting that the effect of occupational feminization on wages varies across LADs, and are larger for women (0.126) than for men (0.013), which indicates that such variation is greater among women. Interestingly, the coefficient for occupational feminization for men ($b=-0.08$) does not remain statistically significant in the RS model, suggesting that there is no main effect, but a combination of both positive and negative effects across districts.

Graph 3 offers a visual representation of naïve RI and RS models. In these graphs, each stripe represents the regression line for a specific LAD. In RI models, differences in the heights of the LAD-specific intercepts are moderate, with mean wages clustering at around £12 when occupational feminization is zero, and regression slopes being steeper for women than for men. In RS models, certain variability in LAD-specific slopes is visible, and variation in the steepness of the LAD-specific slopes is more pronounced for women than for men. In the model for women, there is evidence of ‘fanning in’, as variation in average wages across LADs is higher in occupations in

²⁴ This is identical to the random effects panel data model where observations are nested within individuals.

²⁵ Formally, the random intercepts model can be expressed as: $Y_{ij} = B_0 + B_1X_{ij} + U_{0j} + e_{ij}$. The formula for the random slopes model is $Y_{ij} = B_0 + B_1X_{ij} + U_{0j} + U_{1j}X_{ij} + e_{ij}$.

which few women work. In the model for men there is a positive relationship between occupational feminization and wages in a handful of LADs, but in most districts there is a negative association with slopes of comparable steepness. This model is an example of ‘fanning out’, since variation in average wages across LADs increases with the proportion of workers in the occupation who are women.²⁶

On the whole, results in this section suggest that the magnitude of the relationship between occupational feminization and wages observed at the national level varies across LLMs, and in some extreme cases for men it is even positive.

5. Discussion and conclusion

This article has explored the geographical dimensions of occupational sex-segregation in England and Wales, using descriptive statistics, maps, and cross-sectional and multi-level models.

Key findings indicate that the sex-segregation of occupations and occupational dissimilarity are different across regions and districts in England and Wales, with variation increasing with both geographical and occupational disaggregation and not depending on outliers. Occupations which are gender-integrated have greater variation in occupational feminization across LLMs than sex-segregated occupations, while female-dominated occupations have greater variation than male-dominated occupations. Predictors of D include industrial dissimilarity, traditional gender-role attitudes, dependent children, deprivation, women’s education, ethnic diversity, and migration, while predictors of WDPF include region, deprivation, unemployment, migration, women’s education, traditional gender divisions of labour, women’s share of the labour force, in-commuting, and occupational sizes. Other results suggest that few individuals are misclassified when defining occupational feminization at a geographical level other than the district, that indicators of the proportion of workers in the occupation who are women derived at different levels of geographical aggregation produce very similar impacts on wages, and that such impacts differ across districts (especially for women).

²⁶ Results from fully specified models which include the same covariates as OLS models in Tables 11 and 12 are similar to those from naïve models, with the only difference that the parameters on occupational feminization for men (RI=-0.297, RS=-0.273) and women (RI=-0.246, RS=-0.240) are statistically significant in all cases.

The key implication of this research is that the spatial dimensions of occupational sex-segregation are more important for policy than for analytical purposes. The finding that the sex-composition of occupations varies widely across different parts of the national territory indicates that, if evening the distribution of men and women across lines of work is a policy objective, locally-targeted approaches should complement existing nationwide initiatives. Future steps to derive specific policy measures must begin by identifying which mechanisms produce more gender-neutral occupational and wage structures in GORs and LADs which appear to be ‘pockets of good practice’. Qualitative case-study research designs may be particularly fitting for such an endeavour.

Forthcoming quantitative research studies should focus first and foremost on testing the robustness of our findings by replicating the analyses in this article using more elaborated ways to operationalize LLMs, such as TTWAs. Future research should also explore which area-level factors produce different associations between occupational feminization and wages across LLMs in Britain, extend the analyses to other labour market outcomes (e.g. promotion opportunities), and identify occupational characteristics associated with variability in sex-segregation across local LLMs (e.g. educational and skill requirements). A final worthwhile avenue for research would be to explore why nations with high levels of occupational sex-segregation have comparatively high levels of gender equality (Bettio, 2002; Blackburn and Jarman, 2005; Bettio, 2008), while LLMs in which occupational sex-segregation is high have low levels of gender equality (Cohen and Huffman, 2003a, 2003b). For all of these ventures, multi-level techniques which model the clustering of individuals within different spatial settings will surely be invaluable tools.

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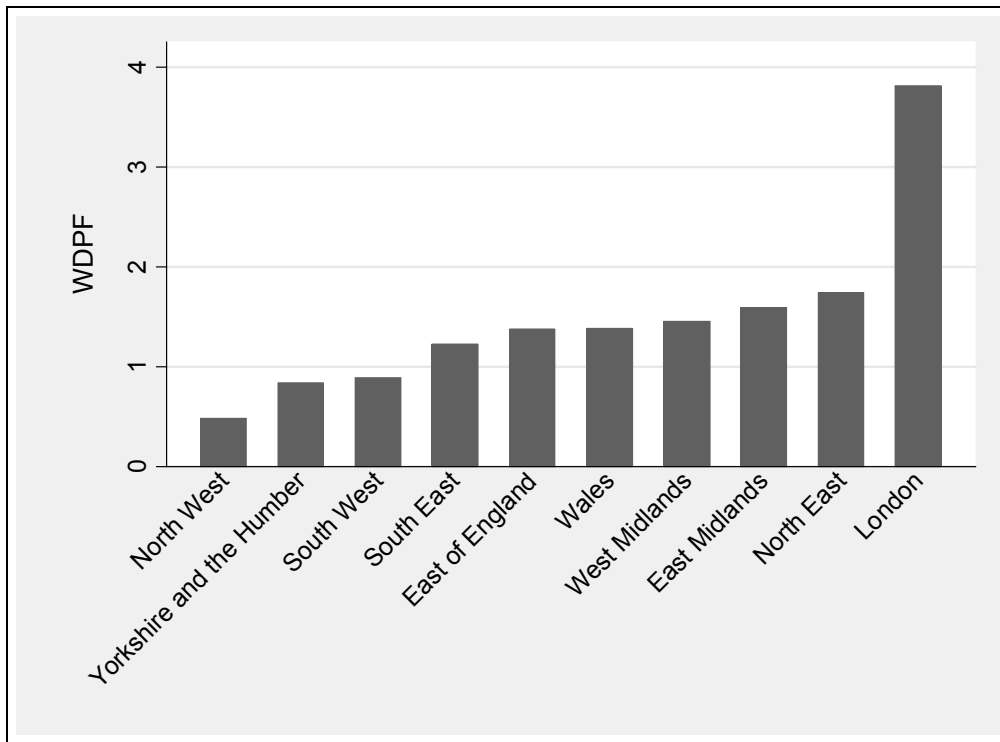
7. Graphs and tables

Table 1. Percentage of workers in 1-digit occupations who are women for England and Wales by GOR

SOC 2000	Occupational title (1 digit)	England and Wales	North East	North West	Yorkshire and the Humber	East Midlands	West Midlands	East of England	South East	South West	London	Wales
1	Managers and Senior Officials	36.15	38.12	37.10	35.94	34.70	34.70	34.26	34.47	36.83	38.97	38.24
2	Professional Occupations	43.46	43.98	43.65	44.47	43.23	43.11	42.64	42.00	42.34	44.89	45.48
3	Associate Professional and Technical Occupations	48.97	46.91	49.53	48.59	49.25	50.00	47.40	48.28	48.28	50.26	50.09
4	Administrative and Secretarial Occupations	79.47	79.01	79.45	79.82	80.93	81.41	81.26	80.07	79.73	75.87	79.09
5	Skilled Trades Occupations	11.64	9.67	10.88	11.21	11.87	12.59	10.83	11.39	12.33	12.53	12.82
6	Personal Service Occupations	85.24	83.91	85.04	86.23	86.56	86.89	87.13	85.95	87.05	79.41	84.71
7	Sales and Customer Service Occupations	74.06	78.01	75.01	75.96	75.44	75.42	75.52	73.23	75.26	65.76	76.92
8	Process, Plant and Machine Operatives	21.50	20.97	21.17	20.87	27.83	24.15	19.94	17.79	20.29	17.88	23.02
9	Elementary Occupations	50.61	53.50	50.97	52.26	52.26	52.30	51.21	49.53	50.94	44.06	51.34

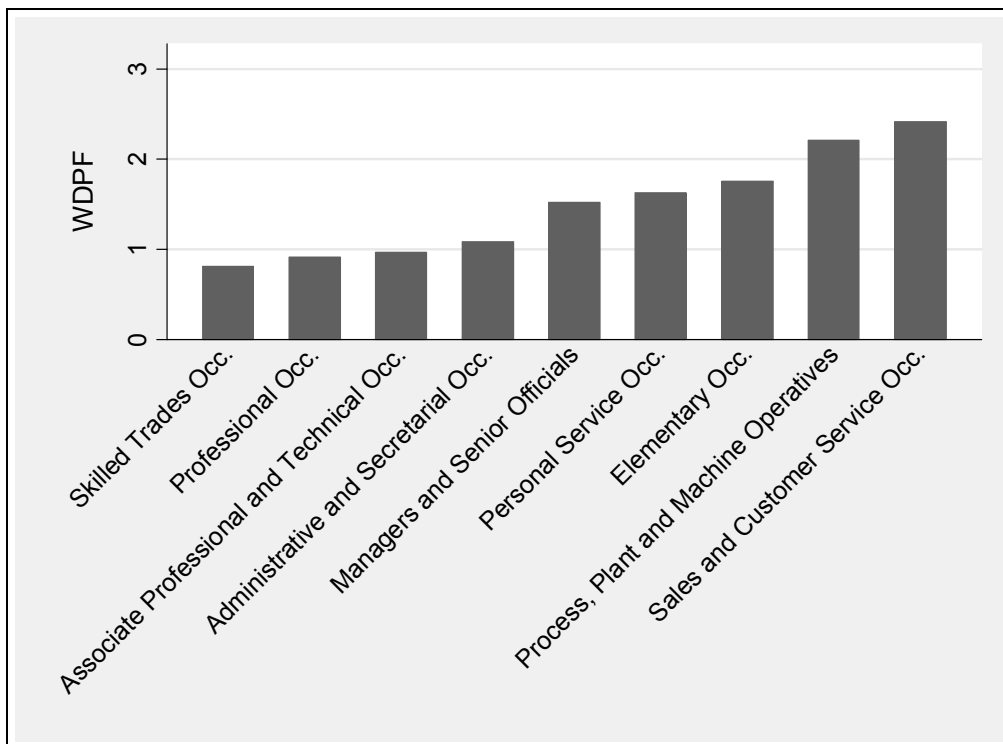
Notes: From commissioned table c0086 of the UK Census (England and Wales).

Graph 1. WDPF across 1-digit occupations by GOR



Notes: From commissioned table c0086 of the UK Census (England and Wales).

Graph 2. WDPF across GORs by 1-digit occupation



Notes: From commissioned table c0086 of the UK Census (England and Wales).

Table 2. Percentage of workers in selected 4-digit occupations who are women across GORs

SOC 2000	Occupational title (4 digits)	N	Nation	Minimum	Maximum	Range
5411	Weavers and knitters	9,648	30.14	21.42 (East Midlands)	66.53 (East of England)	45.11
3561	Public service associate professionals	22,050	64.84	50.26 (South West)	78.24 (South East)	27.98
9234	Launderers; dry cleaners; pressers	52,040	73.20	53.71 (London)	81.21 (Yorkshire and the Humber)	27.50
5434	Chefs, cooks	335,741	50.30	37.60 (London)	61.55 (Wales)	23.95
6122	Childminders and related occupations	113,566	97.57	97.02 (Yorkshire and the Humber)	98.21 (East Midlands)	1.19
5315	Carpenters and joiners	248,449	1.41	1.04 (North East)	2.22 (London)	1.18
6121	Nursery nurses	167,694	98.56	97.90 (London)	98.77 (West Midlands)	0.88
8211	Heavy goods vehicle drivers	299,106	1.64	1.29 (North East)	1.91 (South East)	0.62

Notes: From commissioned table c0086 of the UK Census (England and Wales).

Table 3. Percentage of workers in selected 4-digit occupations who are women across LADs

SOC 2000	Occupational title (4 digits)	N	Nation	Minimum	Maximum	Range
8131	Assemblers (electrical products)	38,969	52.04	5.66 (Lancaster)	85 (Wigan)	79.34
8137	Sewing machinists	98,086	87.73	24.65 (Tower Hamlets)	100 (Chester)	75.35
9111	Farm workers	72,227	22.67	3.75 (Sedgefield)	71.43 (Gravesham)	67.68
9224	Waiters; waitresses	214,569	73.28	28.46 (Tower Hamlets)	92.15 (Berwick-upon-Tweed)	63.69
4215	Personal assistants and other secretaries	496,761	96.33	90.54 (Hackney)	99.55 (Halton)	9.01
5231	Motor mechanics; auto engineers	188,905	1.67	0 (several LADs)	8.02 (Blaenau Gwent)	8.02
5241	Electricians; electrical fitters	198,841	1.43	0 (several LADs)	6.21 (Purbeck)	6.21
5314	Plumbers; heating and ventilating engineers	134,875	0.88	0 (several LADs)	5.17 (North Shropshire)	5.17

Notes: Data from commissioned table c0822 of the 2001 UK Census (England and Wales). Only occupation-LAD cells in which there were at least 50 workers and occupations with at least 50 workers in half (187) of the LADs.

Table 4. WDPF for GORs and LADs across occupations

% Female...	Mean	Minimum	p25	Median	p75	Maximum	IQ Range	Range
in the GOR (1 digit)	1.43	0.48 (North West)	0.84	1.35	1.65	3.44 (London)	0.81	2.96
in the GOR (2 digits)	1.78	0.73 (North West)	1.23	1.43	1.94	4.40 (London)	0.71	3.67
in the GOR (3 digits)	1.97	1.08 (North West)	1.34	1.73	1.93	4.26 (London)	0.59	3.18
in the GOR (4 digits)	2.18	1.42 (North West)	1.58	1.89	2.29	4.49 (London)	0.71	3.07
in the LAD (1 digit)	2.67	0.68 (Stockport)	2.02	2.52	3.17	8.33 (Richmondshire)	1.15	7.65
in the LAD (2 digits)	3.17	1.16 (Stockport)	2.46	2.97	3.56	9.23 (Tower Hamlets)	1.10	8.07
in the LAD (3 digits)	3.70	1.63 (Stockport)	2.98	3.49	4.03	9.86 (Tower Hamlets)	1.05	8.23
in the LAD (4 digits)	4.66	2.36 (Leeds)	3.89	4.51	5.06	11.04 (Tower Hamlets)	1.17	8.68

Notes: From commissioned tables c0822 and c0086 of the 2001 UK Census (England and Wales).

Table 5. WDPF for occupations across GORs and LADs

% Female...	Mean	Minimum	p25	Median	p75	Maximum	IQ Range	Range
in the GOR (1 digit)	2.10	0.99 (Skilled Trades Occ.)	1.21	1.99	2.60	3.81 (Sales and Customer Service Occ.)	1.39	2.82
in the GOR (2 digits)	2.06	0.23 (Skilled Construction and Building Trades)	1.33	1.90	2.65	5.50 (Elementary Administration and Service Occ.)	1.32	5.27
in the GOR (3 digits)	2.51	0.22 (Construction Trades)	1.52	2.28	3.40	7.14 (Housekeeping Occupations)	1.88	6.92
in the GOR (4 digits)	2.85	0.17 (Bricklayers, Masons)	1.43	2.46	3.82	12.98 (Tailors and dressmakers)	2.39	12.81
in the LAD (1 digit)	2.71	1.69 (Skilled Trades Occ.)	2.15	2.58	2.78	4.23 (Sales and Customer Service Occ.)	0.63	2.54
in the LAD (2 digits)	3.12	0.54 (Skilled Construction and Building Trades)	2.58	3.22	4.12	5.47 (Elementary Administration and Service Occ.)	1.54	4.93
in the LAD (3 digits)	4.34	0.43 (Construction Trades)	3.06	4.09	5.79	10.48 (Textiles And Garments Trades)	2.73	10.05
in the LAD (4 digits)	6.58	0.62 (Heavy Goods Vehicle Drivers)	3.73	5.90	8.63	22.47 (Elementary Cleaning Occ. N.E.C.)	4.90	21.85

Notes: From commissioned tables c0822 and c0086 of the 2001 UK Census (England and Wales).

Table 6. Index of Dissimilarity for GORs and LADs

% Female...	Mean	Minimum	p25	Median	p75	Maximum	IQ Range	Range
in the GOR (1 digit)	.3715	.3000 (London)	.3691	.3749	.3885	.3965 (North East)	0.0194	0.0965
in the GOR (2 digits)	.4861	.3694 (London)	.4858	.4989	.5020	.5232 (North East)	0.0162	0.1538
in the GOR (3 digits)	.5115	.4096 (London)	.5176	.5211	.5252	.5459 (North East)	0.0076	0.1363
in the GOR (4 digits)	.5655	.4633 (London)	.5670	.5737	.5813	.6043 (North East)	0.0143	0.1410
in the LAD (1 digit)	.3772	.2148 (Camden)	.3635	.3832	.4018	.4789 (Barrow-in-Furness)	0.0383	0.2641
in the LAD (2 digits)	.4896	.2656 (Camden)	.4734	.5020	.5219	.5975 (Barrow-in-Furness)	0.0485	0.3319
in the LAD (3 digits)	.5205	.2999 (Camden)	.5055	.5312	.5505	.6267 (Barrow-in-Furness)	0.0450	0.3268
in the LAD (4 digits)	.5750	.3530 (Camden)	.5586	.5858	.6053	.6867 (Barrow-in-Furness)	0.0467	0.3337

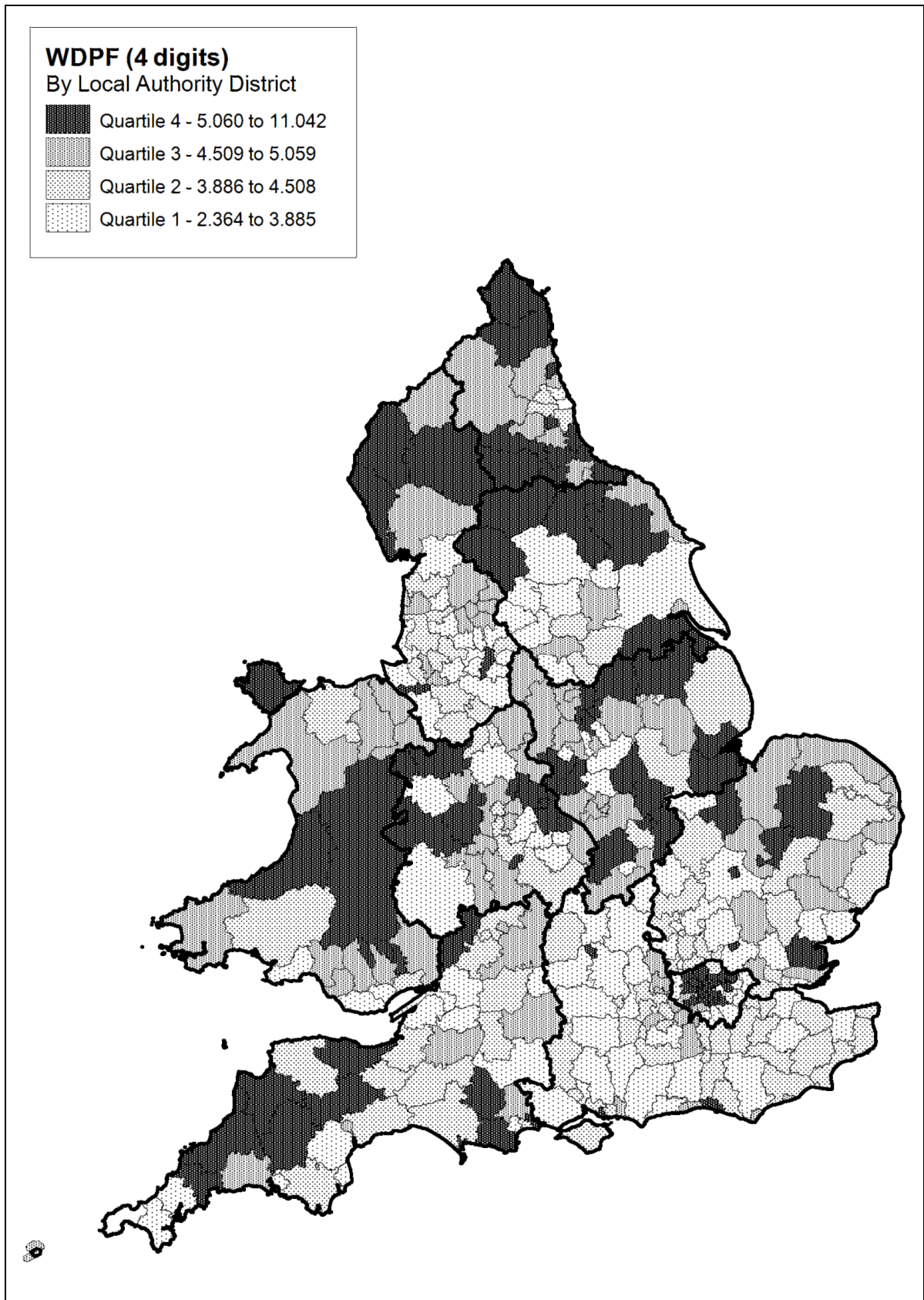
Notes: From commissioned table c0822 of the UK Census (England and Wales). Based on Duncan and Duncan (1955).

Table 7. OLS regression of WDPF on occupational sex-type and occupational size

	WDPF LAD 4 digits		
	1	2	3
Male-dominated occupation	<i>Ref. cat.</i>	<i>Ref. cat.</i>	<i>Ref. cat.</i>
Integrated occupation	0.392***		0.467***
Female-dominated occupation	0.002		0.167***
Occupation's size at national level (in 1000s)		-0.010	
Number of LADs with 50+ workers in the occupation		-0.605***	-0.655***
R ²	0.153	0.372	0.559
N	353	353	353

Notes: Data from commissioned table c0822 of the 2001 UK Census (England and Wales). OLS (standardized coefficients). Stars: + 0.2 * 0.1 ** 0.05 *** 0.01. Male-dominated = 0%-30% female; Integrated = 30%-70% female; Female-dominated = 70%-100% female.

Map 1. WDPF (4 digits) by LAD



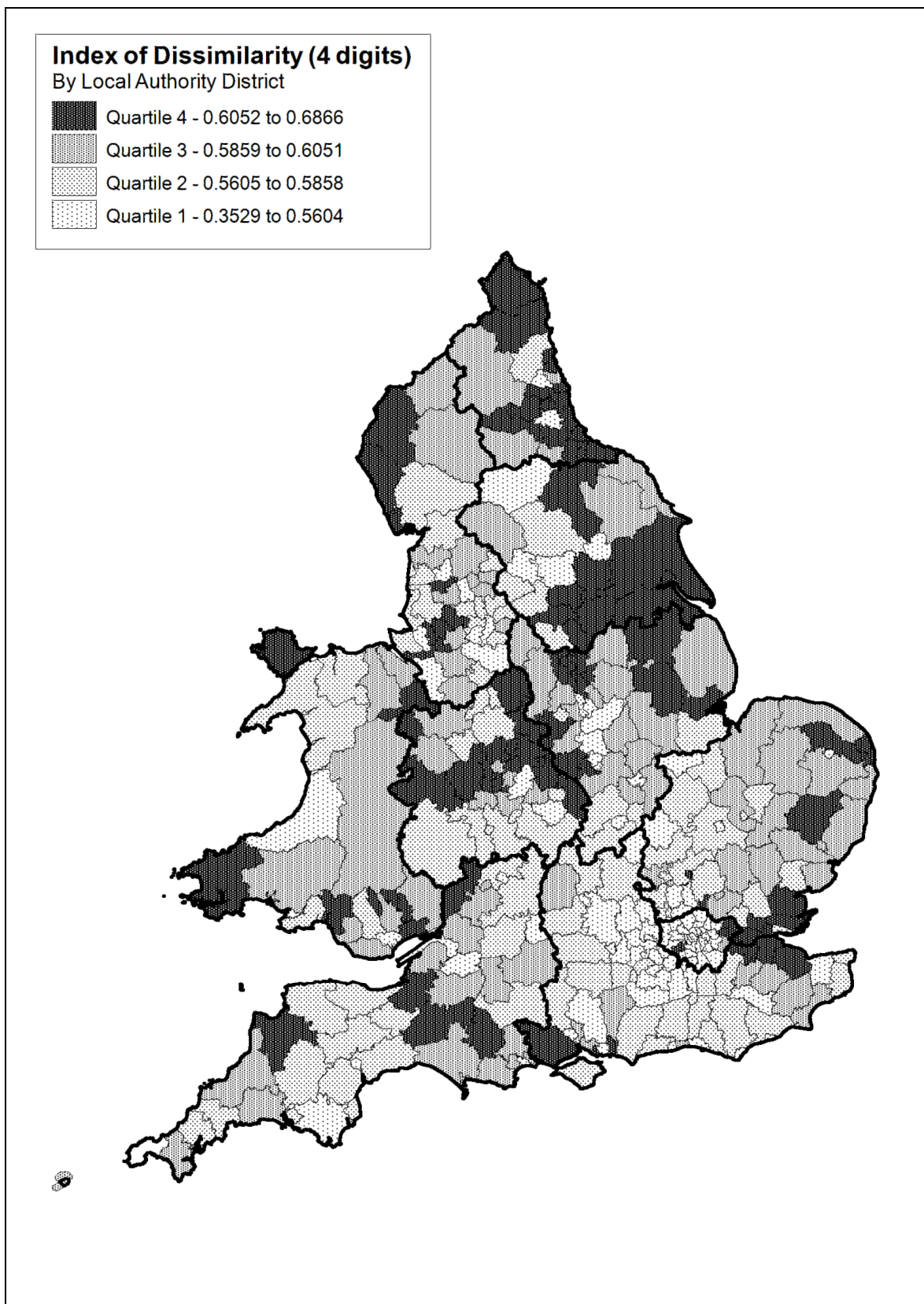
Notes: Produced with MapInfo Professional software (version 11.0).

Table 8. OLS regression of WDPF and D on LAD characteristics

	WDPF	ID
Population size (in 10,000s)	-0.032	0.000
Proportional population change 1991-2001	-0.004	-0.009
Proportion of population living in an urban area	-0.070	-0.002
Mean IMD	0.181**	-0.220***
Proportion of women with higher education	0.177***	-0.418***
Women as a percentage of labour force	-0.078**	-0.018
Unemployment rate	0.193***	0.057
Index of Dissimilarity across industries	0.012	0.459***
Proportion of adults in families with dependent children	-0.024	0.057**
Differences in care hours between men and women employees	-0.033	0.032*
Proportion of women aged 25+ who never worked	0.284**	-0.055
Proportion non-white	-0.046	-0.126***
Ratio of net-migration	0.095**	-0.103***
Ratio of in-commuters to population	0.034	0.001
Ratio of out-commuters to population	-0.098***	0.101***
London	0.228***	-0.009
Number of occupations with 50+ workers in the LAD	-0.655***	-0.020
R ²	0.711	0.921
F	52	243
N	374	374

Notes: OLS (standardized coefficients). WDPF and D (LAD 4 digits) derived from commissioned table c0822 of the 2001 UK Census. All regressors come from CAMs data except population size and number of occupations with 50+ workers in the LAD (CT), proportional population change 1991-2001 (NOMIS), and ratio of in-commuters to population (WICID). Stars: + 0.2 * 0.1 ** 0.05 *** 0.01.

Map 2. ID (4 digits) by LAD



Notes: Produced with MapInfo Professional software (version 11.0).

Table 9. Percentage of misclassified workers

	4-digits	3-digits	2-digits	1-digits
UK	10.6%	23.2%	31.5%	41.2%
GOR	9.32%	22.2%	31.2%	41.1%
LAD	-	19.3%	29.4%	40.6%

Notes: BHPS data. Misclassification with respect to occupational sex-type: male-dominated (0-30% of workers in the individual's occupation are women), integrated (30%-70%), and female-dominated (70%-100%).

Table 10. The effect of occupational feminization on wages

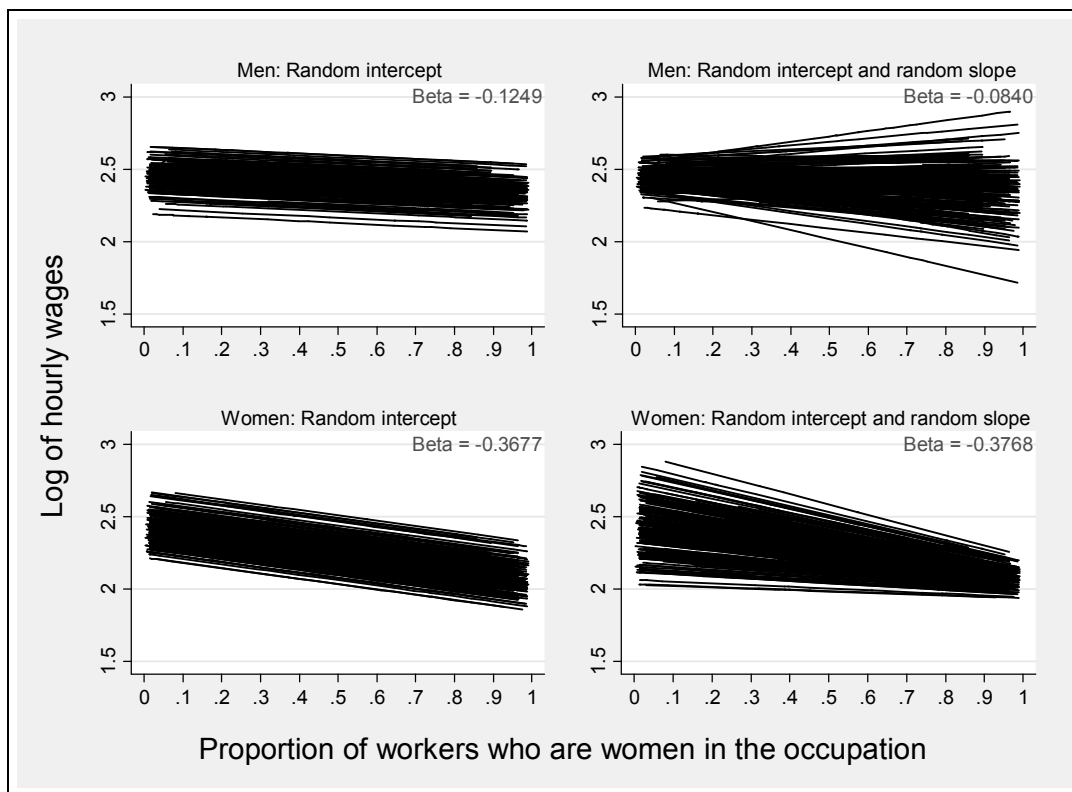
	Men				Women			
	4-digits	3-digits	2-digits	1-digits	4-digits	3-digits	2-digits	1-digits
UK	-0.294***	-0.278***	-0.239***	-0.206***	-0.254***	-0.229***	-0.224***	-0.320***
GOR	-0.291***	-0.278***	-0.240***	-0.221***	-0.278***	-0.256***	-0.250***	-0.340***
LAD	-0.271***	-0.273***	-0.237***	-0.215***	-0.251***	-0.237***	-0.234***	-0.326***

Notes: BHPS data (2001-2007). OLS models with standard errors clustered at the level of the individual. $Y = \log$ hourly wages. $X =$ Proportion of workers in the occupation who are female. Control variables: year, age, marital status, education, job tenure, contract type, hours of work, establishment size, industry, on-the-job training, managerial duties, gender-role attitudes, hours of housework, caring duties, accident rates in the occupation, shift work, and unpaid overtime. Significance levels: *** 0.01, ** 0.05, * 0.1, + 0.2.

Table 11. The effect of occupational feminization on wages: MLMs

	Men		Women	
	Random intercept	Random slope	Random intercept	Random slope
Occupational feminization	-0.125***	-0.0840	-0.368***	-0.377***
Constant	2.463***	2.454***	2.442***	2.448***
Individual-level constant	0.017***	0.086***	0.022***	0.035**
Random intercept	0.205***	0.200***	0.200***	0.199***
Individual-level residual		0.013***		0.073***
Random coefficient	7.8%	30%	9.8%	15%
N	1,701	1,701	1,773	1,773

Notes: BHPS data (2001). Naïve MLMs. $Y = \log$ hourly wages. $X =$ Proportion of workers in the occupation who are female (UK 4-digits). Level 1: Individuals (observations), Level 2: LADs. Significance levels: *** 0.01, ** 0.05, * 0.1, + 0.2.

Graph 3. The effect of occupational feminization on wages: Naïve MLMs

Notes: BHPS data (2001). MLMs. Y = log hourly wages. X = Proportion of workers in the occupation who are women. Level 1: Individuals (observations), Level 2: LADs.