Segregation and Gender Gaps through the UK’s Great Recession

by Giovanni Razzu and Carl Singleton
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Abstract

Gender gaps in work respond to the business cycle. Although there are many potential explanations, this paper tests the simplest. Is this because of the extent of gender segregation in work? A counterfactual-type analysis is constructed which can account for the specific role of combined gender segregation across industry sectors and occupations that existed at the onset of the Great Recession in the UK. Gaps in employment, pay and hours worked are all studied. After accounting for the gender segregation of work at the broad sector and occupation group level, the results contradict the existing narrative that men’s employment has been more harshly affected by the recession than women’s employment: gender segregation accounts for over two and a half times the actual fall in the gender gap between 2007 and 2011. Results for pay and hours are more mixed. Gender segregation accounts for some of the fall in the pay gap, but does not explain the decline in the hours gap, nor the relatively greater rise in part-time work among men since 2007.

Key words: gender, employment, hours, gender pay gap, gender segregation, business cycle

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*For associated data and replication files see http://carlsingletoneconomics.com/research. We would like to thank members of the Labour Force Survey team at the Office for National Statistics for answering our queries promptly and thoroughly.

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1 Introduction

Over the last four decades, the employment rate gap between working age men and women in the UK has narrowed by almost thirty percentage points. Roughly half of this narrowing is attributed to a rise in the female rate, and the other half to a fall in the male rate (figure 1). However, alongside this trend there is another prominent pattern. The gender employment rate gap is pro-cyclical. The jobs growth of men appears to be more sensitive to the economic cycle than for women (Peiro et al., 2012; Razzu & Singleton, 2014). The Great Recession has certainly reminded us of the importance of understanding the behaviour of labour markets over the business cycle. Moreover, achieving gender equality, especially in work, has been a stated priority of UK Government policy for decades, leading to the gradual build up of legislation and institutions aimed at achieving this, beginning with the 1970 Equal Pay Act, and continuing with more recent interventions aimed at facilitating women’s participation into the labour market, such as those addressing the costs of childcare and sharing of parental leave. Therefore, it is not surprising that significant attention was paid to gender outcomes during and following the 2008-09 recession. However, in an area of policy making which can be relatively reactionary, it is worth reflecting that greater reductions in male jobs growth during a downturn is not atypical for the UK. It is also not obviously clear that changes in gender gaps over a recession, including in hours and pay, necessarily reflect that men or women in work are experiencing an unfair share of economic misfortune. Instead, a likely candidate to explain such patterns is the degree of gender segregation in work.

Figure 1: UK employment rates by gender, 16-64, SA, 1971-2014

Source.- ONS Labour Market Statistics. Shaded segments represent UK recessions defined as at least two consecutive quarters of negative GDP growth.

1Polly Toynbee, Guardian columnist: “My fear is that we will look back on this time of the deepest recession since the war, and see it as a period when women’s lives took a step backward, at home and at work” (10/2014). In two years of economic recovery, women lost jobs, men found them, Pew Research Centre (7/2011). Are women bearing the brunt of the recession?, Fawcett Society, (3/09). The Impact of Austerity on Women, Fawcett Society, (3/12).
Table 1 shows the extent of gender segregation in both industry and occupation at the onset of the Great Recession; more specifically, the share of those employed in the various economic sectors (manufacturing, construction etc.) and occupations (manager and senior officials, professionals, elementary occupations etc.) who are women. Regardless of occupational status, women were outnumbered by men in every sector except in the public administration, education and health sectors, where seventy per cent of employed individuals were women, and to a lesser degree in the distribution, hotel and restaurant, and other services sectors. On the other hand, only fourteen per cent of those employed in the construction sector were women in 2007. In terms of occupations, those working in personal services, administrative and secretarial work and sales and customer service were far more likely to be female. Moreover, this representation also demonstrates the extent of the segregation of work within industries and occupations, and the notable heterogeneity of segregation across both dimensions. For instance, although only fourteen per cent of those working in the construction sector in 2007 were female, eighty-four per cent of the administrative and secretarial occupations in that sector were filled by women, a greater share than in any other sector. In the public administration, health and education sector, which is highly female dominated, the proportion of women working in senior and managerial occupations falls to only fifty-seven per cent. Although the occupational groups and industry sectors described here are broad and contain significant heterogeneity of jobs, nonetheless these definitions still allow us to highlight the striking differences in where men and women find themselves in the labour market.

Table 1: Gender segregation in industry and occupation in the UK, 2007 - share in employment type who are women

<table>
<thead>
<tr>
<th>Occ. groups (SOC2000)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-B</td>
<td>0.26</td>
<td>0.39</td>
<td>0.55</td>
<td>0.81</td>
<td>0.13</td>
<td>0.78</td>
<td>0.52</td>
<td>0.08</td>
<td>0.19</td>
<td>0.28</td>
</tr>
<tr>
<td>C-E</td>
<td>0.24</td>
<td>0.18</td>
<td>0.29</td>
<td>0.71</td>
<td>0.02</td>
<td>0.80</td>
<td>0.55</td>
<td>0.01</td>
<td>0.17</td>
<td>0.25</td>
</tr>
<tr>
<td>D</td>
<td>0.23</td>
<td>0.15</td>
<td>0.35</td>
<td>0.77</td>
<td>0.05</td>
<td>0.68</td>
<td>0.60</td>
<td>0.22</td>
<td>0.28</td>
<td>0.26</td>
</tr>
<tr>
<td>Ind. sectors (SIC1997)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>0.15</td>
<td>0.11</td>
<td>0.22</td>
<td>0.84</td>
<td>0.01</td>
<td>0.36</td>
<td>0.63</td>
<td>0.01</td>
<td>0.05</td>
<td>0.14</td>
</tr>
<tr>
<td>G-H</td>
<td>0.36</td>
<td>0.37</td>
<td>0.53</td>
<td>0.74</td>
<td>0.17</td>
<td>0.82</td>
<td>0.70</td>
<td>0.15</td>
<td>0.52</td>
<td>0.52</td>
</tr>
<tr>
<td>I</td>
<td>0.27</td>
<td>0.15</td>
<td>0.28</td>
<td>0.65</td>
<td>0.03</td>
<td>0.67</td>
<td>0.59</td>
<td>0.04</td>
<td>0.17</td>
<td>0.26</td>
</tr>
<tr>
<td>J-K</td>
<td>0.34</td>
<td>0.26</td>
<td>0.44</td>
<td>0.78</td>
<td>0.05</td>
<td>0.65</td>
<td>0.59</td>
<td>0.14</td>
<td>0.43</td>
<td>0.46</td>
</tr>
<tr>
<td>L-N</td>
<td>0.57</td>
<td>0.63</td>
<td>0.64</td>
<td>0.81</td>
<td>0.36</td>
<td>0.87</td>
<td>0.76</td>
<td>0.19</td>
<td>0.74</td>
<td>0.70</td>
</tr>
<tr>
<td>O-Q</td>
<td>0.41</td>
<td>0.41</td>
<td>0.43</td>
<td>0.79</td>
<td>0.09</td>
<td>0.76</td>
<td>0.67</td>
<td>0.08</td>
<td>0.47</td>
<td>0.52</td>
</tr>
<tr>
<td>Total</td>
<td>0.35</td>
<td>0.45</td>
<td>0.52</td>
<td>0.78</td>
<td>0.08</td>
<td>0.84</td>
<td>0.68</td>
<td>0.14</td>
<td>0.45</td>
<td></td>
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</tbody>
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The objective of this paper is to assess the role gender segregation across industry and occupations has in explaining differential labour market outcomes during the Great Recession. To what extent can the observed short-term changes in gaps in employment, pay and hours worked be explained by the
industry sectors and occupations in which men and women work?

Section two begins by discussing the existing evidence and various explanations that have been put forward to understand the way gender gaps in labour market outcomes evolve over the business cycle. This paper focuses on employment, pay and hours worked, extending the existing literature which has tended to focus only on the former and unemployment. In section three an analysis of the role of segregation during the UK Great Recession is constructed. This adds to similar studies, which use a shift-share type analysis of changes in UK gender gaps (Rubery & Rafferty, 2013; Perivier, 2014), by suggesting a decomposition of changes in relative gaps in employment, hours and pay, accounting for the initial extent of segregation in work for men and women across occupations and industries at the onset of the downturn. This is represented relative to a counterfactual whereby both men and women were instead distributed across job types identically to the whole workforce. As such, this method accounts for a more specific role of segregation in the evolution of the gaps, and allows us to draw more specific conclusions on the role it plays in explaining the gender dimension of the business cycle. Accounting for segregation at the industry and occupation level together allows stronger conclusions than when considering only each in turn. This combined segregation accounts for all of the initial fall in the employment rate gap from 2008, but, by the end of 2011, for over two and a half times its actual decline, with this contribution subsequently declining by the end 2014. As such, after accounting for where men and women work, the business cycle still does not appear gender neutral, but it is women’s employment instead which is then more sensitive to the economic cycle. However, this picture is less clear for the other outcomes analysed here. Segregation by 2010 can account for around eighty per cent of the fall in the hourly pay gap, but not the greater reduction in male weekly hours worked, nor the relative rise in male part-time work. Thus, to explain why gender outcomes might differ over the cycle, factors which can explain the initial segregation of work are the likely candidates, such as subject choice in education, societal stereotyping of jobs, availability of flexible working patterns and so on. However, for employment especially, there must also be additional factors specific to the cycle which can explain worse jobs performance for women.

In section four we offer some concluding remarks and the appendix presents details of the data and methodology used throughout.

2 Describing gender gaps and the business cycle

Although some studies have noted or analysed the possibility that the business cycle is not gender neutral, the majority of these have described or estimated this indirectly or with limited attention to the UK. Peiro et al. (2012) estimate directly a relationship between changes in unemployment rates and a cyclical component of GDP for the UK and US, finding that the business cycle extends its influence on unemployment rates over several quarters, and does so more intensely for men than women. Razzu &
Singleton (2014) extend this analysis further by decomposing a gendered output gap identity, and estimate an implied vector autoregression (VAR) model comprising cyclical components of GDP and labour market outcomes for the US and UK from 1948 and 1971 respectively. The cumulative response to the business cycle of the male unemployment rate is shown to be significantly stronger in both countries over this period.

Whilst the focus of these studies has mostly been on the unemployment rate, there has nonetheless been some recognition that there could be gender patterns in other aggregate labour market outcomes. As our main objective is to assess the role played by gender segregation, here we focus only on patterns over the cycle within work, focusing on employment rates, pay and hours worked.

2.1 Employment

The natural first step to describe the business cycle properties of gender employment rates is via their unconditional cross-correlation statistics with GDP growth (Burns & Mitchell, 1946). We begin with the most simple identity relating output and employment,

\[ Y_t = \frac{Y_t}{E_t} \left( \frac{E^m_t + E^f_t}{N^m_t + N^f_t} \right) N_t, \]  

where \( Y_t \) is real GDP, \( \frac{Y_t}{E_t} \) is output per employee, \( N_t \) is the total population, and \( \{m, f\} \) denote male and female levels respectively. To express this as a tractable additive function of employment rates we take a first order log approximation around \( t - 1 \) values,

\[ \Delta y_t = \frac{E^m_t}{E_{t-1}} \Delta [e^m_t - n^m_t] + \frac{E^f_t}{E_{t-1}} \Delta [e^f_t - n^f_t] + \nu_t, \]  

where lower case values represent logs. Thus, \( \Delta [e^m_t - n^m_t] \) gives the log change in the male employment rate. \( \nu_t \) captures the contribution of changes in output per worker, population and an approximation error. Equation (2) could also be re-written as zero sample mean log point cyclical deviations if instead approximated around some identifiable trend in the series.

Following (2), the first columns of table 2 give cross-correlation statistics of log GDP changes and gender employment rates weighted by their shares in total employment. Although the weighting does not significantly alter the results, it nonetheless compensates for the markedly changed gender composition of employment in recent history, as depicted in figure 1. For completeness, we also present unconditional statistics using detrended series.\(^3\) Both sets of results show that male employment rate changes are more strongly related to the business cycle than female changes. Considering the correlation of employment rates ten quarters after a GDP change, there is also some suggestion that the female response is more

\(^3\)For comparability with the general literature we use the most common Hodrick Prescott filter with standard quarterly smoothing parameter of 1600, despite the noted limitations when this is applied to non-US macro time series. See Canova (1998) for a thorough outline of how common detrending methods affect the estimated business cycle properties of US macroeconomic time series.
persistent.\footnote{Peiro et al. (2012) also suggests that the female unemployment response is more persistent for the UK.} However, as seen from (2) these statistics will be unsatisfactory in so far as they do not condition on the behaviour of other variables in the output identity, and so ignore potentially valuable information. The method of Den Haan (2000) provides a workable solution, without needing to make restrictive assumptions on the data generating process. This involves estimating a VAR based on (2), and correlation statistics are then computed using the derived forecast errors (see appendix for discussion of the data and methodology used here). The final columns of table 2 give comparable results using this approach with ten step ahead forecast errors. Male employment rates remain marginally more responsive to the economic cycle than female, and there is no difference in persistence. Notably, the unconditional statistics tend to over-estimate the responsiveness of employment to the cycle (see also figure 10 in the appendix).

Table 2: Correlation statistics of changes/deviations from trend in log GDP (1981q3-2009q3, UK) with forward employment rates

<table>
<thead>
<tr>
<th></th>
<th>Unconditional</th>
<th></th>
<th>Conditional</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time changes</td>
<td>HP-1600</td>
<td>10 step fcast err.</td>
</tr>
<tr>
<td>Forward qtrs</td>
<td>0 Max.† 10</td>
<td>0 Max. 10</td>
<td>0 Max. 10</td>
</tr>
<tr>
<td>Male</td>
<td>0.44 (2) 0.58 (2) 0.07 (2) 0.67 (2) 0.85 (2) 0.01 (2) 0.44 0.49 0.13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>0.44 (1) 0.46 (1) 0.17 (1) 0.56 (3) 0.75 (3) 0.12 (3) 0.40 0.42 0.11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note.- Forecast errors are obtained by estimating (12) with no trend terms, thirteen lags, and a sample period of 1971q2-2014q3 (see appendix for details). The male and female employment rate log changes/deviations from trend used to calculate the statistics here are weighted by their shares in total employment as implied by (2).

† Values in parentheses give the number of quarters forward for the employment rate with the highest cross-correlation statistic.

Again using (2), we also account for how changes in the gender employment rate cumulatively contribute to recessions. Figures 2a and 2b use ten step ahead forecast errors from the estimated VAR to decompose deviations from trend GDP for the 1990 and 2008 recessions respectively. During the former, reduced male jobs growth accounts for approximately forty per cent of the fall in output. Female employment however accounts for less than twenty per cent at the deepest point of the recession. In the most recent downturn, the male employment rate contributes less than 20 per cent of the decline in output from trend, and the female rate contributes nothing.
2.2 Hours and pay

There is also some evidence that outcomes within employment can differ by gender over the UK business cycle. Using the Annual Survey of Hours and Earnings, Elsby et al. (2013) provide a thorough description of real wage changes over the last four decades. They confirm that both male and female real wages are pro-cyclical, and their patterns across recessions are similar. However, in the same study they show for the US that gender differences can emerge, with a particularly adverse effect of the Great Recession on women’s real wages. In the UK, as the unemployment rate increased from 5.2 to 7.8 per cent between 2008 and 2011, men’s mean real wages declined by approximately ten per cent, but only
six per cent for women. For both genders this represents a striking reduction against a long-term upward trend in real wages, and is the only sustained reduction in the last four decades.\(^5\)

The response of hours of work to the Great Recession in the UK has been extensively documented by Borowczyk-Martins & Lalé (2014). They find that increases in part-time work can account for almost all of the fall in average hours worked during this period. Borowczyk-Martins & Lalé (2014) also describe a more significant increase in part-time employment, by their preferred definition, for men than women during the latest economic downturn: the share of all in employment working part-time, between the fourth quarters of 2007 and 2010, for men increased from 11.1 to 13.1 per cent, as opposed to an increase from 42.1 to 42.9 per cent for women. To understand patterns in the gap in hours worked, it is important to start with the distribution of part-time employment across industry sectors and occupations. Given the greater tendency of women to work part-time, it is no surprise then that female dominated industries and occupations also tend to be those with shorter average hours of work.

Unlike for the employment rate, comparable historical series of gender hours worked and pay are relatively brief. Figures 3a and 3b plot the annual log change on the previous year in average real hourly pay and basic usual hours in work since 2005, and the associated change in the log gender gaps. During the downturn, male hourly pay faced greater downwards pressure than female. In 2009, the gender pay gap fell by approximately one per cent, and in each of the subsequent two years it declined by a further half per cent. However, these changes are not substantial, and they most likely can partly be explained by the general trend in the UK of a narrowing pay gap. Hours of work at the individual level, including within continuous employment relationships, are cyclical, but over the economic cycle this manifests in only small observable changes in moments of the economy-wide hours distribution. Nonetheless, there is some suggestion that male hours in work over the whole period had a more pro-cyclical response to the Great Recession than female hours. However, as per the pay gap, this could be accounted for, at least in part, by an overall trend of a narrowing gender gap in hours worked.

2.3 Candidate Explanations

There are several potential reasons as to why business cycles could lead to different aggregate labour market outcomes for men and women. It could in some part be explained by gender related differences in individual economic agents’ responses, both on the demand and supply side of the labour market. For example, discriminatory firms’ negative perceptions of women’s relative productivity might change during economic recessions, perhaps as a consequence of the increased need to minimise costs such as maternity leave, therefore leading to substitution of women for men in work (Rubery, 1988). Various complex and interacting factors could theoretically account for a different response of labour supply decisions over the cycle: the level of attachment to the labour market and exposure to macroeconomic shocks, levels of job tenure and human capital accumulation, institutions, and how households pool

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\(^5\) Real wages for men and women fell on the previous year during 1977, though this was a time of high and volatile inflation and curbs on nominal wage increases negotiated between the Government and trade unions. Wage growth remained relatively constant in the 1980s, and slowed somewhat in the 1990s, becoming negative in the Great Recession.
resources, income and risk. One way in which these factors might theoretically manifest during a recession is the so-called ‘added worker effect’. An increase in labour supply might be prompted by the need to compensate for the loss of a partner’s, and therefore household labour income. The evidence on the significance of the added worker effect is however mixed. Most studies consider a micro-level analysis of married individuals’ labour supply decision. Bryan & Longhi (2013), comparing the Great Recession to the boom period before, find that both men and women substantially increased their job search activity from 2008-2011 if their partner lost a job compared with the years previously. This would imply that an added worker effect could be important in explaining gender patterns in employment over the cycle. However, the authors also find that this job search activity did not tend to increase the likelihood

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6See Stephens, 2002 for a detailed overview of the earlier literature.
of these individuals moving into employment. Razzu & Singleton (2014) also consider the possibility of an added worker effect at the macro level, using labour market flows data for the UK, and conclude that there is scope for an added worker effect to explain some of the gender pattern in outcomes. The likelihood of rejoining the labour market through unemployment is generally higher for women than men. Comparing the recessionary period of 2008-2012 with the preceding years, the average flow probability to unemployment for women looking after family and home increased by almost forty per cent, but only twenty per cent for similar men. Similarly, inactive married women were a third more likely to start looking for work compared with pre-recession, whereas married men saw almost no rise in their likelihood of doing so. Outside the UK, using US time use survey data, Berik & Kongar (2013) also report evidence consistent with an added worker effect. The 2007-2009 recession narrowed the gender gap in both paid and unpaid work. Married mothers reduced their hours of time devoted to housework, shopping and childcare, replacing it with paid work. Fathers on the other hand saw reduced paid hours but no additional unpaid work.

Another possibility is that female employment relationships simply differ from male. For example, job tenure is typically longer for men (Booth et al., 1999), and employees with relatively shorter tenures may be fired more quickly than those who have been with the firm longer and accumulated more experience, job specific skills or potential redundancy costs. Similarly, women more commonly work part-time or in temporary positions, and these forms of employment tend to be more sensitive to the cycle. However, Borowczyk-Martins & Lalé (2014) document that during the Great Recession part-time employment has been counter-cyclical, and that increases in this type of work tended to favour men. This increase though was driven by transitions within employment, both by movements from full-time work and lengthened spells in part-time work. As such, although this dampened the relative fall in the gender employment gap, it was nonetheless symptomatic of worsening relative outcomes for men. Men and women also differ in their likelihood of being affected directly by the minimum wage. Women are fifty per cent more likely than men to be in minimum wage jobs, and such jobs are further concentrated into specific sectors. This potentially places a limit on wage flexibility for some roles during recessions, and thus could partially explain the greater reduction in the average real wage observed during the Great Recession for men.

Much recent attention has also been given to the importance of career changes in determining wages. As outlined by Carrillo-Tudela et al. (2015), job moves to different occupations or industries have been strongly pro-cyclical over the last two decades in the UK, and women are significantly more likely to make a career change upon a new hire, particularly in job to job transitions. It follows that when the economic climate restricts these movements, whether this be through risk aversion on the part of the employee, or lack of opportunity, this is likely to affect women more adversely. This provides another potential channel for how the pay gap could be affected by the business cycle, though this would move in the opposite direction to the observed changes during the last downturn.

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However, before considering whether there are intrinsic and more complex differences in how men and women interact with labour markets over the business cycle, which are typically challenging to identify, we should be sure we are not more simply observing the effects of labour market composition. Can the patterns described above be accounted for by where men and women work? By different concentrations in occupations and industry sectors? Furthermore, although the observed cyclicality of aggregate gaps for the UK may be modest, it is possible that the role of composition has an offsetting effect on actual differences in gender responses, such that the business cycle is less neutral than it would at first appear. Of course, that is not to say that some of the potential factors outlined above are not also related to the gender segregation of the labour market. As a further example, Arestis et al. (2013) explore the possibility that the financialisation of the US economy since the 1980s has created identity preference effects by linking managerial and financial occupations to high earnings, and in turn high earnings to the dominant demographic group in the labour force, namely men.\(^8\) So-called stratification effects of the Great Recession, through the declining importance of the financial services sector in the economy, could then in part be explained by the fact that the financialisation of the economy in recent decades has not been gender neutral. In keeping with this observation, although where men and women work at the start of the recession is not strictly exogenous to other candidate explanations above, if segregation can account for changes in subsequent gaps it nonetheless shows that this is the likely channel through which men and women might have different labour market experience during a recession. As such, factors which can explain the segregation of work, such as education subject choices, would also most likely explain why business cycles are not gender neutral, as opposed to other hypotheses, such as the added worker effect.

The gender segregation of work in the UK is a commonly reported fact (Blackburn et al., 2000, 2002; Bettio & Verashchagina, 2009). To assess whether this is relevant to the cyclical gender pattern, Rubery & Rafferty (2013) conduct a shift-share analysis of employment changes over the Great Recession, holding constant 2007 gender industry shares. They find that differences can mostly be accounted for by patterns of jobs loss and growth across sectors, rather than gender differences within. Although, overall and in some sectors women were disproportionately affected. Perivier (2014) undertakes a similar study of the variation of employment by industry and gender over the same period and concludes that female employment loss in the UK was relatively greater than male, accounting for the initial industry segregation of the labour market. Albanesi & Sahin (2013) construct a counterfactual employment rate change over past US recessions for women if they had the same distribution of work across industry sectors as men. They find that differences in the initial distribution of work entering a recession can account for around half of the greater male unemployment rate rise. Likewise, for employment changes, for recent recessions they find that the industry distribution accounts for over two-thirds of higher male employment losses.

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\(^8\)Individuals with a similar identity develop preferences in the sense that they engage in behaviour that reduces negative externalities generated by the identity of other individuals. For instance, a white male employer will consider certain jobs appropriate for white men only and others for women.
The role of gender segregation in the Great Recession

The shift-share analyses of employment changes described above, and in the appendix, do not capture the explicit role of there being initial differences in the distribution of work by gender at the start of a recession. Instead, they only capture a partial role that composition could be having in the evolution of the gender gap. Here we consider a decomposition which accounts for the greater scope that composition could have in explaining employment patterns. Moreover, we consider the role of segregation across industry sectors and major occupation groups, as well as their intersection, in explaining the change in the gender gaps during the Great Recession. Finally, we add evidence by looking not just at the employment gap but also the evolution of gaps in pay and hours worked.

3.1 Methodology

We decompose the change in the gender employment rate gap as follows.

Let $E_{i,j}^t$ refer to the level of employment in some mutually exclusive type $i$ (e.g. occupation, industry sector, or their intersection) by person type (e.g. gender) $j$ at time $t$. Let $N_j^t$ be total population of type $j$. Total employment for type $j$ is given by $E_j^t = \sum_i E_{i,j}^t$. Taking a first order log approximation of the employment rate for some group $j$ around $t-1$ values gives

$$\Delta \left[ e_j^t - n_j^t \right] \approx \sum_i \lambda_{i,j}^{t-1} \Delta e_{i,j}^t - \Delta n_j^t,$$  \hspace{1cm} (3)

where $\lambda_{i,j}^{t-1} = \frac{E_{i,j}^{t-1}}{E_j^{t-1}}$, i.e. the share of all type $j$ in employment working in occupation or industry $i$. If $j \in \{m, f\}$, denoting male and female respectively, then we can re-write the change in the logarithmic gender employment rate gap as a sum of factors,

$$\Delta E_{\text{Gap}}^t \approx \sum_i \left( \lambda_{i,m}^{t-1} \Delta e_{i,m}^t - \lambda_{i,f}^{t-1} \Delta e_{i,f}^t \right) - \Delta \left[ n_m^t - n_f^t \right].$$  \hspace{1cm} (4)

We then consider an approximate counterfactual change in the employment rate gap if, at the onset of some period, the distribution across types of work had been the same for men and women, given by

$$\tilde{\lambda}_0^t = \frac{E_0^t}{E_0^t},$$  \hspace{1cm} (5)

and define as follows the change in the employment rate gap had that distribution remained that way throughout the period,

$$\Delta E_{\text{Gap}}^t \approx \sum_i \tilde{\lambda}_0^t \Delta \left[ e_{i,m}^t - e_{i,f}^t \right].$$  \hspace{1cm} (6)
Ignoring the negligible gender difference in population growth rates over the short time periods studied here, we can re-write (4) as

$$\Delta \text{EGap}_t \approx \overbrace{\Delta \text{EGap}_t}^{\text{Counterfactual - no segregation}} + \sum_i \left( (\lambda_{0,m}^{i,m} - \lambda_{1,m}^{i,m}) \Delta e_i^{i,m} - (\lambda_{0,f}^{i,f} - \lambda_{1,f}^{i,f}) \Delta e_i^{i,f} \right)$$

$$+ \sum_i \left( (\lambda_{1,m}^{i,m} - \lambda_{0,m}^{i,m}) \Delta e_i^{i,m} - (\lambda_{1,f}^{i,f} - \lambda_{0,f}^{i,f}) \Delta e_i^{i,f} \right),$$

where the second term on the RHS can be interpreted as the additional contribution of allowing employment shares across types of work to differ before the start of a recessionary period, i.e. the initial degree of segregation, and the third term the added contribution of allowing gender shares in industry sectors to not only differ, but change over time. Thus, if we believe where men and women work is significant, we would expect the initial segregation effect to cumulatively account for the majority of the fall in the gender employment gap over the Great Recession.

As a further way of understanding patterns in gender employment, we might ask which types of work can account for the variation in the gender gap over a longer period of time. Note that we can simply rewrite (4) as

$$\Delta \text{EGap}_t = \sum_i X_i^t - \Delta \left[ n_i^m - n_i^f \right] + \eta_t,$$

where $$X_i^t$$ represents the contribution of changes to employment of type $$i$$ among men and women to the logarithmic employment rate gap, and $$\eta_t$$ is the approximation error. Then given this additive representation we simply define the statistic

$$\beta^i = \frac{\text{covar}(X_i^t, \Delta \text{EGap}_t)}{\text{var}(\Delta \text{EGap}_t)},$$

giving the fraction of the variance in the gender gap accounted for by changes to employment of type $$i$$. By definition, these $$\beta$$'s, and the equivalent statistics for population changes and the approximation error will sum to one. Where these are substantially greater than employment’s overall share in some industry sector or occupation, we could conclude that employment variation here is relatively important in explaining changes in aggregate gaps over some period of time.

This counterfactual type decomposition for the employment rate gap can similarly be described for average hours of work and for hourly rates of pay. For example, the change in the logarithmic gender
gap in hours is approximately given by

\[
\Delta H_{\text{Gap}} t \approx \sum_t \left( \hat{\lambda}^{i,m}_{k-1} \Delta h^{i,m}_t - \hat{\lambda}^{i,f}_{k-1} \Delta h^{i,f}_t \right)
\]

Counterfactual - no segregation

\[+ \sum_t \left( \lambda^{i,m}_{k-1} (\lambda^{i,f}_{k-1} - \hat{\lambda}^{i,f}_{k-1}) \Delta h^{i,f}_t \right) \left( \lambda^{i,m}_{k-1} - \hat{\lambda}^{i,m}_{k-1} \right) \Delta h^{i,m}_t\]

\[
+ \sum_t \left( \lambda^{i,m}_{k-1} (\lambda^{i,f}_{k-1} - \hat{\lambda}^{i,f}_{k-1}) \Delta h^{i,f}_t \right) \left( \lambda^{i,m}_{k-1} - \hat{\lambda}^{i,m}_{k-1} \right) \Delta h^{i,m}_t
\]

Initial segregation

\[
+ \sum_t \left( \lambda^{i,m}_{k-1} \Delta h^{i,m}_t - \lambda^{i,f}_{k-1} \Delta h^{i,f}_t \right) \left( \lambda^{i,m}_{k-1} - \hat{\lambda}^{i,m}_{k-1} \right) \Delta h^{i,m}_t
\]

Varying segregation

\[
+ \sum_t \left( \lambda^{i,m}_{k-1} \Delta h^{i,m}_t - \lambda^{i,f}_{k-1} \Delta h^{i,f}_t \right) \left( \lambda^{i,m}_{k-1} - \hat{\lambda}^{i,m}_{k-1} \right) \Delta h^{i,m}_t
\]

where \( \lambda^{i,j}_{k-1} = \frac{\lambda^{i,j}_k}{h^{i,j}_k} \).

3.2 Data and results

3.2.1 Employment gap

To generate a consistent time series of gender employment by industry sector and occupation from the period immediately before the Great Recession we make use of the micro data from the Quarterly Labour Force Survey for those aged sixteen and over (see appendix for a more detailed description of the data and methods used here and in the remainder of this section). Unless stated otherwise, by industry sectors and occupation groups we refer to the SIC1997 and SOC2000 classifications respectively as described in table 1.10

Figure 4 shows the cumulative fall in the log employment rate gap from the fourth quarter of 2007, and illustrates how the components of the decomposition in (7) contribute to this change when accounting for gender segregation across industry sectors and occupation groups. Table 3 also summarises these results. Here the counterfactual is that men and women were identically distributed across sectors and occupations in the first quarter of 2007, and that this remained the case thereafter.

When accounting for industry segregation alone, the contribution from the different distribution of men and women across sectors pre-recession is approximately twice as great as the actual fall in the employment rate gap (figure 4a). To the end of 2010 this accounts for a fall in the gender gap of 0.053 log points, as opposed to an actual fall of 0.027. Under the counterfactual, the employment gap would in fact have widened. In the downturn, job losses and reduced jobs growth were more prominent in sectors where men dominate the labour force, such as construction and manufacturing, particularly at the start of the downturn, and vice versa in female dominated sectors such as public administration and health and social work activities. The initial fall in the employment rate gap has largely persisted since 2011, as has the extent to which this can be explained by the industry segregation of work. This suggests that any

---

10 From 2009 and 2011 onwards respectively, individuals’ jobs were classified using updated SIC2007 and SOC2010 classifications. As such, we make use of conversions provided by the UK’s Office for National Statistics. However, as shown in the appendix, using instead these latter classifications for the analysis does not qualitatively affect the results here.
Figure 4: Decomposition of cumulative change in log gender employment rate gap from 2007, UK

(a) Industry

(b) Occupation

(c) Industry & Occupation

Note.- Gender employment rate gap stated as male minus female. Indexed to zero in final quarter of 2007.
Source.- Author calculations using Quarterly Labour Force Survey.
Table 3: Contributions to change in log gender employment rate gap (log points x100)

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Counterfactual</th>
<th>Initial seg.</th>
<th>Varying seg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry sectors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007q4-10q4</td>
<td>-2.7</td>
<td>2.3</td>
<td>-5.3</td>
<td>0.2</td>
</tr>
<tr>
<td>2010q4-14q3</td>
<td>-0.2</td>
<td>-1.6</td>
<td>0.9</td>
<td>0.4</td>
</tr>
<tr>
<td>Occupation groups</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007q4-10q4</td>
<td>-2.9</td>
<td>-0.5</td>
<td>-2.2</td>
<td>-0.2</td>
</tr>
<tr>
<td>2010q4-14q3</td>
<td>-0.2</td>
<td>-0.9</td>
<td>1.1</td>
<td>-0.4</td>
</tr>
<tr>
<td>Industry &amp; occupations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007q4-10q4</td>
<td>-2.7</td>
<td>2.0</td>
<td>-4.8</td>
<td>0.1</td>
</tr>
<tr>
<td>2010q4-14q3</td>
<td>-0.2</td>
<td>-4.7</td>
<td>4.6</td>
<td>-0.1</td>
</tr>
</tbody>
</table>

Note.- Gender gap given by male minus female. Columns may not sum to total due to approximation error and rounding. See appendix for details of data and methodology.

The subsequent economic recovery has not favoured jobs growth in sectors that were hardest hit during the downturn. Given that the gender segregation effect more than accounts for the fall in the employment rate gap, a simplistic interpretation of this result would be that within industry sectors, women’s employment was more harshly affected by the recession. However, the industry sectors defined at the single letter level of the SIC classification are broad. Furthermore, this fails to account for the large amount of heterogeneity and segregation of work within specific industry sectors, particularly by occupation. Occupational segregation alone accounts for the majority, around seventy-five per cent, of the fall in the employment rate gap by the end of 2010 (figure 4b). Those working in skilled trades for example, who are significantly more likely to be male, experienced slower jobs growth than other female dominated occupations such as administrative and secretarial work. There is no suggestion that women were more severely affected by the downturn within occupation groups. From 2010, it appears as though some of the jobs recovery did tend to favour the same male dominated occupations that were initially hardest hit. However, the same caveats as for how we might interpret results for industry sectors also apply to occupational groups.

To tackle in part one of these caveats, we also analyse the effect of gender segregation across the intersection of industry sectors and occupational groups. When doing so, the counterfactual component is close to zero throughout most of the period to 2010, and as such the segregation of work must account for the majority of why male jobs growth slowed more than female initially (figure 4c). By the end of 2011, the initial segregation of work accounts for over two and a half times the actual fall in the employment gap. Accounting for the composition of the workforce in this way suggests that if the reduction in jobs growth had been evenly spread between men and women, the gender gap should have narrowed significantly further. There is scope, therefore, to suggest that women’s employment, within occupation and industry, was more severely affected by the downturn than men’s. In fact, under the counterfactual, the gender employment rate gap would have risen by around a quarter in log points. However, from 2011, although the observed decline in the gender gap is persistent, the role of segregation diminishes by 2014. Thus, accounting for where men and women work still demonstrates that the business cycle
has not been gender neutral, but we might conclude differently now that, at least so far as the UK Great Recession is concerned, women in employment were more severely affected at the height of the downturn.

As a sense check, we also compare these results to what would have been obtained from a shift-share type analysis in the spirit of Rubery & Rafferty (2013). Focusing on industry sectors alone, we decompose the absolute change in the employment gap in levels over subsequent three year periods from 2004 (table 4). The ‘segregation’ effect here represents the change in the employment gap that would have occurred if the male and female shares within each sector had remained constant throughout the period. Thus, unlike under the counterfactual type decomposition above, it is not only the initial difference in employment shares which is accounted for, but also an assumption that male and female jobs growth within types was equal. Between 2004 and 2007, during which time the employment gap increased by only twenty-four thousand, the segregation effect contributed virtually nothing. However, between 2007 and the end of 2010, when the gap decreased by around four hundred thousand, the segregation effect for industry sectors accounts for a fall of eight hundred thousand. Thus the different distribution of work within industries accounts for over the twice fall in the gap. Although the two methods are only indirectly comparable, the magnitude of industry segregation’s role during the Great Recession accounted for here is similar to that found above using the alternative method.

<table>
<thead>
<tr>
<th>Contributions</th>
<th>2004q2-07q2</th>
<th>2007q2-10q4</th>
<th>2010q4-14q3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>24</td>
<td>-394</td>
<td>39</td>
</tr>
<tr>
<td>Segregation</td>
<td>3</td>
<td>-807</td>
<td>53</td>
</tr>
<tr>
<td>Share</td>
<td>34</td>
<td>426</td>
<td>-23</td>
</tr>
<tr>
<td>Interaction</td>
<td>-13</td>
<td>-13</td>
<td>9</td>
</tr>
</tbody>
</table>

Note.- Gender gap given by male minus female. See appendix for details of data and methodology.

Given that the composition of the labour force appears to determine cyclical gender patterns of employment, we can also consider more specifically which sectors and occupations are driving this. As briefly touched on above, it is necessarily so that these will primarily be sectors and occupations with a combination of high (low) variation in jobs growth and a male (female) dominated workforce. Using the accounting identity (8), we calculate the share of the variance in quarterly employment rate gap changes determined within individual sectors and occupations, from 1997 and 2001 respectively to 2014.\textsuperscript{11} Figure 6 displays these statistics alongside shares of overall employment in each type of work for 2007. Unsurprisingly, more highly gender segregated sectors, particularly those which are female dominated, account for a relatively high share of variation in the employment gap. Looking more closely at the time series of sector contributions to the change in the gap post 2007, the ‘public sectors’ of public admin., health and education contribute to relatively better outcomes for women in the economy as a

\textsuperscript{11}For this longer time period we make use of employment series published by the Office for National Statistics as part of their monthly Labour Market Statistics release using the SIC2007 & SOC2000 classifications.
whole for the majority of this period, besides 2012 (figure 5). Thus, it is certainly the case that female dominance of these sectors relatively insulated women up to 2011. From 2012 onwards, since these are sectors most likely affected by tighter UK fiscal policy, the aggregate data overall do not suggest that this policy resulted in an increased gender employment gap. Although the pace of UK fiscal tightening was less than anticipated, it has still not led to the vulnerability of female employment that was perhaps expected. It is however important to note that the distinction between public and other sectors used here might not be the most appropriate one to capture the full impact of austerity measures on the gender gap.

Figure 5: Decomposition of cumulative change in log gender employment rate gap from 2007, UK contribution from ‘public’ sectors


For occupation groups, the picture is less clear cut. Elementary occupations, which in 2007 comprised roughly the same share of both the male and female workforce nonetheless are relatively important in explaining gender gap changes. This occupational group represents a very broad category of jobs spread across industry sectors, within which there is substantial segregation, and as such can still contribute substantially to the variance in the employment gap over the cycle.

### 3.2.2 Hours of work and pay gap

Given the patterns observed for employment rates, the natural next step is to assess whether or not these are replicated for the gender gaps in hours of work and pay. The Labour Force Survey contains various self-reported measures of hours worked. In this analysis we use basic usual weekly hours worked, excluding overtime.\(^\text{12}\) Although as seen above, the gender gap in hours does not vary much over time, it is nonetheless large, with men in 2007 usually working an average of thirty-eight hours in the week, compared with thirty hours for women. The rise in part-time work during the Great Recession was mostly driven by the transition rate from full-time work within employment relationships (Borowczyk-Martins

\(^{12}\text{Results would not be significantly altered were we to consider an alternative measure.}\)
Figure 6: Share of variance in quarterly log gender employment gap changes accounted for by employment variation within industry sectors & occupation groups, UK

(a) Industry, 1997q2-2014q3

(b) Occupation, 2001q3-2014q3

If these reductions in hours were equally likely among men and women we would expect the hours gap to fall given that men more commonly work longer hours. However, this will also be affected by the relative gender composition of the industries and occupations which experienced greater hours reductions during this time.

Using measures of average weekly hours worked for all men and women in work at an annual frequency, we carry out an equivalent decomposition of changes in the log hours gap, with the counterfactual being that men and women were identically distributed across sectors and occupations in 2007 and subsequently. Table 5 and figure 7 show results for the change between 2007 and 2010.

Figure 7: Decomposition of cumulative change in log gender hours gap from 2007, UK - sectors & occupations

Note.- Gender hours gap stated as male minus female. Indexed to zero in 2007.
Source.- Author calculations using Annual Population Survey.

Overall, the hours gap fell by approximately one per cent during this period. Focusing on results which account for the distribution of work across both industries and occupations, segregation cannot account for a large part of the fall in the hours gap. In other words, if men and women, at the onset of the recession, worked in the same industry sectors and occupations, the decline in the gender gap would be very similar to what was actually observed. Given the recent link between changes in the average hours of work in the UK and the incidence of part-time working, we can expect that the narrowing in the part-time employment gap over this period is also not explained by segregation. A similar decomposition of the log gap in share of work which is part-time, shows that neither industries nor occupations can

---

13 Given individuals are only questioned about pay and hours in the first and final of five waves in the survey, we use editions of the representative Annual Population Survey for January-December from 2007-2010. However, the time period is more limited since we were not able to obtain a consistent classification of industry and occupations for 2011-2014.
explain this change (middle panel of table 5).14

Finally, we also consider whether or not the reduction in the pay gap during the Great Recession can be accounted for by where men and women work. It is possible that downward nominal wage rigidity is more common in particular sectors which are dominated by one gender or the other. Using annual averages for hourly wage rates we decompose the log change in the gender pay gap as above. The segregation of work across neither industry sectors nor occupation groups can explain the fall in the pay gap (bottom panel of table 5 and figure 8), implying that it was not driven by the relative gender composition of some jobs. Therefore, as far as pay is concerned, it appears that male wages were more severely depressed by the downturn. However, when we look at the role of segregation across both industry and occupation, as much as eighty per cent of the fall in the pay gap can be accounted for where men and women work by 2010.

Table 5: Contributions to change in log weekly hours, part-time share & pay gender gaps, 2007-2010 (log points x100)

<table>
<thead>
<tr>
<th></th>
<th>Contributions</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Counterfactual</td>
<td>Initial seg.</td>
<td>Varying seg.</td>
</tr>
<tr>
<td><strong>Hours:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industry sectors</td>
<td>-1.0</td>
<td>-0.9</td>
<td>0.0</td>
<td>-0.1</td>
</tr>
<tr>
<td>Occupation groups</td>
<td>-1.0</td>
<td>-0.7</td>
<td>0.2</td>
<td>-0.4</td>
</tr>
<tr>
<td>Industry &amp; Occupations</td>
<td>-1.0</td>
<td>-0.6</td>
<td>-0.1</td>
<td>-0.2</td>
</tr>
<tr>
<td><strong>Part-time share:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industry sectors</td>
<td>14.5</td>
<td>11.5</td>
<td>-0.3</td>
<td>-0.3</td>
</tr>
<tr>
<td>Occupation groups</td>
<td>14.5</td>
<td>13.1</td>
<td>1.6</td>
<td>1.3</td>
</tr>
<tr>
<td><strong>Pay:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industry sectors</td>
<td>-0.7</td>
<td>-0.9</td>
<td>0.0</td>
<td>0.3</td>
</tr>
<tr>
<td>Occupation groups</td>
<td>-0.7</td>
<td>-0.6</td>
<td>-0.1</td>
<td>0.0</td>
</tr>
<tr>
<td>Industry &amp; Occupations</td>
<td>-0.7</td>
<td>-0.3</td>
<td>-0.5</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Note. – Gender gap given by male minus female. Columns may not sum to total due to approximation error. See appendix for details of data and methodology.

14Due to small sample sizes of part-time workers in some combinations of occupations and industries, the approximation error becomes large for the combined decomposition. Therefore, we do not present results here, although they also conform to the view that the segregation hypotheses is not relevant to explain the change in this gap.
4 Concluding remarks

This paper considers the role that gender segregation in work has had in explaining the impact of the Great Recession on women and men in the UK. Our analysis extends and updates the existing evidence. This literature suggests that men’s and women’s experiences of the economic cycle could differ substantially, and that most recently men’s outcomes were disproportionately affected. Although various explanations have been put forward to potentially explain these cyclical gender differences, observed not only in the UK, the most common of these is also perhaps the simplest: men and women work in different industries and occupations, and jobs dominated by men are more sensitive to the cycle.

Gender segregation in industry sectors, by accounting for more than twice the fall in the employment rate gap from 2007 to 2010, contradicts the existing narrative that men’s employment was more harshly affected by the recession than women’s employment. Furthermore, the initial degree of segregation in both industry sectors and occupations can explain over two and a half times the decline in the employment gap. As such, if segregation were the only factor affecting gender outcomes over the cycle, the gap ought to have declined significantly further during this period. Although differences between men and women that shape the segregation of work, such as educational subject choices, must account for the pro-cyclical employment rate gap overall, there is nonetheless room for more cycle specific factors, such as the discriminatory firm practices theorised by Rubery (1988), to explain why within industry sectors and occupations, women could be more severely affected. These results would also suggest that a cyclical added worker effect, which tended to relatively increase female participation, is not a significant aggregate factor since segregation alone more than accounts for the fall in the employment gap since 2007. This is consistent with other recent evidence that suggests the UK added worker effect is
specifically an unemployment issue Bryan & Longhi (2013).

For hours and pay gaps we observe a different story. For the former, as well as for the narrowing of the part-time employment gap seen in recent years, it does not appear as though segregation has a significant role to play. The relatively greater reduction in male hours worked seen over the downturn was not explained by where men and women work. For pay, the picture is more mixed, with some suggestion that from 2007 to 2010 the narrowing of the pay gap could be attributed to work segregation.

Finally, although the limited consistent time series for pay and hours changes within job classes, and reliance on annual measures of change, limit somewhat the strength of our results, this analysis does suggest that we should be careful in drawing conclusions on the impact of gender segregation on labour market outcomes by looking solely at the distribution of work in industry sectors or occupations. A fuller assessment should include the combination of sectoral and occupational segregation.
References


Appendix

Data & methodology

Tables 1 & 5 and figures 3, 7 & 8

The UK Labour Force Survey (LFS) has a rotating five wave structure for respondents, interviewed each quarter. However, questions are only asked regarding pay and hours of work in the first and fifth waves. This substantially reduces the sample size. However, the Annual Population Survey (APS) combines responses from waves one and five of the LFS, for the whole year, as well as incorporating boosts to the sample to match its aim of providing representative data at the local authority level. Therefore, to obtain more reliable estimates of employment across industry sectors and occupations, as well as measures of average pay and hours worked within these, we prefer this aggregated data source. We use the January to December editions for each year, obtained from the UK Data Service, for individuals aged sixteen and over. An indicative reference for the 2007 survey we use is as follows: Office for National Statistics. Social Survey Division. (2015). Annual Population Survey, January - December, 2007. [data collection]. 4th Edition. UK Data Service. SN: 5989. For measures of hours worked we use the variable \textit{bushr}, which measures the total usual hours worked in the main job excluding overtime, and is derived from respondents’ answers to their usual total hours and unpaid overtime they work. For measures of pay, we use the variable \textit{hourpay}, which is derived as an hourly pay rate using responses to gross weekly earnings, \textit{bushr}, and usual hours of paid overtime. To generate a series of real average pay rates by gender we apply the HM Treasury published GDP deflator series as last updated 31/05/2015. For the designation of whether work is full or part time we use the self-response variable \textit{ftptwk}. For analysis using the APS we use classifications of industry sectors according to the Standard Industrial Classification (SIC) 1992, with variable name \textit{indsect}. However, from 2008 onwards, interviewers in the Labour Force Survey would classify occupations using the SIC2007. Details of how this differs from previous classifications can be found on the ONS website. To generate a consistent time series of employment by industry sector we make use of the conversion variable in the ONS \textit{in0792em}. This was generated by the ONS by matching SIC2007 sub-class to a higher level of aggregation, i.e. division, in SIC1992. For major occupation groups we make use of the consistent Standard Occupational Classification (SOC) 2000 classification, given by variable \textit{sc2kmmj}. Despite contact with the ONS to obtain conversions for the SOC2010 classification to 2010 for editions of the APS from 2011, we were unable to use these and so we are restricted to a limited time series. Differences between the classifications are not insubstantial. In carrying out the decomposition of changes in gender gaps we condition our levels of employment in each category of industry and occupation on their being positive values for \textit{bushr} or \textit{hourpay}. When deriving levels and means we use the survey population weights. When considering the intersection of industry sectors and occupation groups, by gender, frequencies in some categories can be very small, and in a few cases/years zero. However, we make no allowance for this since the decomposition method will give these cases very little weight/importance in the generation of the results. Zero values are however problematic since the logarithm is undefined, and where these occur, we impute values based on the previous year.
Table 3 and figure 4

Since for employment status we have available responses for every wave of the LFS we make use of editions of the Quarterly Labour Force Survey (QLFS) for individuals aged sixteen and over. An indicative reference for the January to March 2007 edition we use is as follows: Office for National Statistics. Social and Vital Statistics Division, Northern Ireland Statistics and Research Agency. Central Survey Unit. (2015). Quarterly Labour Force Survey, January - March, 2007. [data collection]. 6th Edition. UK Data Service. SN: 5657. We use the SIC1992 classification of industry sectors where available, and the associated conversion as described above for the APS from 2008. We also again use the SOC2000 classification for occupation groups, though in this case there is also an available conversion from 2010, so we are able to consider a consistent time series to July-September 2014. The LFS SOC2010-SOC2000 mapping available in the QLFS is probability-based (on an individual respondent basis), with the relative probabilities being based on the results of two dual-coded LFS datasets and a one per cent economically active sub-sample of the 2001 census. Using the estimated frequency distributions for the two classifications the probability of a SOC2000 code occurring given a SOC2010 code at the 4-digit unit group level could be calculated. The qualitative results we find using these classifications however are not altered were we to use the SIC2007 and SOC2010 classifications as our basis (see below). The sample size of the QLFS is smaller than the APS, therefore when we carry out the decompositions by both industry and occupation we combine the smaller primary sectors A-B and C-E. Likewise, to handle the few empty cases, if a frequency for some combination of industry and occupation returns zero in any period we exclude this case from the decomposition in all periods for each gender in turn. For both men and women, from seventy-two cases, this excludes three from the decompositions. To account for seasonality we apply a backward looking four quarter moving average on the derived employment levels, i.e. $\hat{E}_{ij}^t = \frac{1}{4} \sum_{k=0}^{4} E_{ij}^{t-k}$. As such, and since the aggregate employment levels do not include those whose main job could not be assigned to one of the nine major occupation groups or sectors, the derived change in the employment gap will not match exactly with that which one can readily obtain from National Statistics.

Table 4 and figures 5 & 6

As part of the monthly Labour Market Statistics (LMS) release by the ONS, a longer non-seasonally adjusted series for employment at the industry section (one letter) and at the major occupation group levels are published by gender for those aged sixteen and over, classified using SIC2007 and SOC2010, with the back series derived using the reverse of the methods described above. Using again a moving average to reduce seasonality we use these series as published for the January 2015 LMS release to consider over the longer term which employment types tend to explain variation in the gender employment rate gap. We can also use these series to check that our results for the employment decomposition using the QLFS as described above were not dependent on the use of the SIC1992 and SOC2000 classifications and their conversions. Figure 9 below shows qualitatively that we would have obtained the same results had we used these published statistics and the alternative classifications as our base.
Similarly as in Rubery (1988) a shift-share decomposition of the difference in employment change between men and women can be described as

$$\Delta(E_t^m - E_t^f) = \sum_{i} (1 - 2\alpha_{i-1}^f) \Delta E_t^i + \sum_{i} -2E_{i-1}^f \Delta \alpha_{i-1}^f + \sum_{i} -2E_{i-1}^i (1 - 2\alpha_{i-1}^f) \Delta E_t^i \Delta \alpha_{i-1}^f,$$

where \(i\) denotes mutually exclusive finite work types. \(\alpha_{i-1}^f\) gives the share of workers of type \(i\) who are female. The first sum on the RHS represents the employment or ‘segregation’ effect: this gives the change in the employment gap had the gender share within industries or occupations remained constant, and both men and women experienced the same change in employment within that type of work. The
second term is the ‘share’ effect, and accounts for the changing composition of work within industries and occupations. Finally, the third term is the so-called ‘interaction’ effect, which is by design small and has no relevant interpretation. For ease of replication of these results, and so as to match National Statistics for this exercise since it is a precise decomposition method, we use the published Labour Market Statistics series.

**Table 2 and figure 2**

The only requirement of the estimated VAR model in applying the result of Den Haan (2000) is that the error term for each equation is serially uncorrelated, which is achieved through inclusion of sufficient lags. One advantage of this method is that it is robust even for non-stationary variables, which is not the case for the unconditional statistics. In particular, since the forecast errors themselves are in effect the outcome of a trend-cycle decomposition, we need not focus on the question of how best to estimate cyclical components of the time series.\(^{15}\) Even so, in what follows we retain the implicit restrictions in (2) that the series are likely to be \(I(1)\) as this potentially increases the efficiency of forecasts in a finite sample setting. Thus, we estimate

\[
A_t = \alpha + \beta t + \gamma t^2 + \delta t^3 + B(L)A_{t-1} + \epsilon_t, \quad (12)
\]

where \(A_t\) is a 3x1 vector containing the first three terms of (2), \(\alpha, \beta, \gamma, \delta\) are 3x1 vectors, \(B(L)\) is 3x3, and each \(i, j\)th element is the lag polynomial \(b_{ij}(L) = (\beta_{i,j,0}L^0 + \beta_{i,j,1}L^1 + \cdots + \beta_{i,j,p}L^p)\). The lag length \(p\) is sufficient that (12) is correctly specified, i.e. the 3x1 white noise process \(\epsilon_t\) is not integrated.\(^{16}\)

Using the estimated VAR we then derive the \(K\) period ahead forecast errors for each variable using the maximum possible sample period. For each value of \(K\) we can then construct the conditional cross-correlation statistics for the variables in the model.

To construct the cross-correlation statistics we use quarterly and seasonally adjusted measures of GDP and employment rates for those aged 16-64 from 1971 to the third quarter of 2014.\(^{17}\) For the sake of robustness, we estimate (12) under alternate specifications (see table 6), though here we focus on a model with no trend terms, thirteen lags, and a sample period of 1971q2-2014q3.

Figure 10 compares the unconditional cross-correlation statistics of both log time changes and deviations from logarithmic trend in GDP and forward gender employment rates with equivalent statistics obtained using the ten step ahead forecast errors from the VAR estimation. The pattern is consistent across all three measures that the UK business cycle is more strongly positively correlated with lagged

\(^{15}\)Canova (1998) gives a thorough outline of how common detrending methods affect the estimated business cycle properties of US macroeconomic time series. Also, as shown by Harvey & Jaeger (1993), the most common detrending method, the Hodrick-Prescott (HP) filter with standard quarterly smoothing parameter matches almost exactly the less restricted Unobserved Components Model (UCM) decomposition, within which the HP filter can be nested, for US output and employment series, but this is not the case for the UK. See also Razzu & Singleton (2014) for a demonstration of this.

\(^{16}\)The criterion we use to select lag length is therefore that it is the lowest number at which there is no significant autocorrelation at the five per cent level in the residuals up to and including the eighth order. The inclusion of a trend, up to and including cubic, is decided using the Akaike information criterion.

\(^{17}\)GDP data obtained from ONS Quarterly National Accounts, and labour market data obtained from ONS Labour Market Statistics; accessed 15/02/2015.
Table 6: Description of VAR models estimated

<table>
<thead>
<tr>
<th>Sample period</th>
<th>No. lags</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>1971q2 - 2014q3</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>1971q2 - 2014q3</td>
<td>13</td>
<td>cubic</td>
</tr>
<tr>
<td>1971q2 - 2005q4</td>
<td>7</td>
<td>cubic</td>
</tr>
<tr>
<td>1980q1 - 2014q3</td>
<td>13</td>
<td>cubic</td>
</tr>
</tbody>
</table>

changes in male employment than female in at least the following four quarters.

This suggests that the immediate greater effect of the business cycle on male employment outcomes drives the UK gender cycle, and that cumulatively a recessionary period will have a larger negative effect on male outcomes (see also Razzu & Singleton, 2014). In figure 11 we compare the results using forecast errors at a ten quarter horizon from our main specification with estimations using restricted sample periods. We see that excluding data from the Great Recession or the 1970s from the estimation does not qualitatively affect the gender patterns we observe.

We could also show how the cross-correlation results with specific lagged and forward employment rates might differ while varying the forecast horizon. To calculate these we use in each case the maximum possible sample period, and thus when we compare with the unconditional measures we also adjust the sample period accordingly, meaning that these latter measures also vary. Although for brevity we exclude these results here, unsurprisingly, given what we know about the frequency of the business cycle, the patterns we discuss above tend to disappear at shorter forecast horizons. However, once we look beyond a frequency which is able to extract business cycle features of the data (approximately a five quarter forecast horizon), the pattern we describe above of male outcomes being initially more sensitive to the cycle is consistent as we increase the forecast horizon. This is also the case with regards the lack of gender difference in persistence.
Figure 10: Comparison of conditional and unconditional cross-correlation statistics for changes/deviations from trend in log output and gender employment rates

Note.- Forecast errors are from specification over full sample without trend terms, and correlation period is for GDP fixed at 1981q3-2009q3
Figure 11: Conditional cross-correlation statistics for changes in log output and gender employment rates with alternate specifications of VAR model

Note.- Forecast errors are from specifications with trends and restricted or full estimation windows as per table 6. Series labels denote the time periods of GDP changes (fixed) at which the correlation statistics are calculated.