An analysis of London Borough in 2018 about comprehensively measuring the Economic Gender Fairness and its spatial pattern

19161032
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Word count: 2939

RPub link
https://rpubs.com/amberyli/GISappendix
Github link
https://github.com/amberyli/Final-Assessment-GIS-

1. Introduction

In recent years, gender fairness has gradually evolved from a policy concern to something that is on everyone's mind. One goal under Sustainable Development Goals is "Achieve gender equality and empower all women and girls" (United Nations 2015). Based on a research (Maceira 2017), improving gender equality would have a massive positive effect on economic. However, according to the report of World Economic Forum (WEF), it would take 257 years to close the gender gap in economic participation and opportunity (2019). In other words, it is known to all that gender equality is important, but the overall situation is not ideal.

2. Research Question

The UK, one of the richest countries in the world, and London, its capital, is known for its advanced economic level. The focus of this article is not on these familiar things, but rather, on the level of economic gender equality in this prosperous place. In specific, there are two main research points. One is how to obtain a parameter that allows comparison of gender fairness in economic across London boroughs. The other one is whether these parameters of different boroughs have spatial correlations.

3. Literature Review

3.1 Measure the Economic Gender Fairness

Monitor Gender Gap

The monitor report published by the UK government (Great Britain. Government Equalities Office and The Rt Hon Penny Mordaunt MP, 2019), divide the economic gender gap into two broad components, one for economic participation and progression, the other for attitudes and leadership. The first part consists mainly of pay gap, employment rate gap, unpaid work gap. And the second contains gaps in job orientation gap and senior executive.

The published legislation (The Equality Act 2010 (Gender Pay Gap Information) Regulations, 2017), which states organizations employing 250 or more employees must publish and report specific figures about their gender pay gap, is enough to express the importance of gender pay gap.

But there are 2 limits to follow its idea for quantitative research. The first one is that it lacks comprehensive view. All comparisons of gender differences are made for individual aspect. There is no conclusion for these two key parts. In actual, there is no way to draw an objective overall conclusion, because using words alone for such complicated issue is not sufficient. It is necessary to use extra statistical methods to manage these indicators aggregately. The other one is that some indicators are too subjective. The unpaid work time is already very vague and ambiguous as everyone has different definition of it. Even if the time lost in caring for family or children could be accurately calculated, it is still unknown what would people spend that time on if they would not do the caring job. Besides, the job orientation is the similar, its accuracy is too complicated to set.

Economic Fairness in London

While in London, a researcher (Leeser 2018) introduces three parts to measure economic fairness in London. For "labor market that works for everyone", the goal is to narrow pay gap and achieve fair employment for a different group of people. For "equal opportunities", it is to decrease the unemployment rate and provide more equal life chances, especially in education. The last one is "raising living standards", which consists of increasing the disposable income by lowering different costs of living, reducing poverty and supply more inclusive financing services.

The report is meaningful and thorough for the recognition of discrimination and inequalities. However, there are 3 gaps if follow its idea to analysis. The first one is its classification is not clear. Employment rate and unemployment rate have conflict each other. The second one is the indicator should be related to economic. The topic of more equal life chances is closer to a sub-topic of education. Besides, while taking away the emotional part and objectively thinking about the third division, "raising living standards", all of these issues are highly linked to personal income. After transforming them into figures, they are repetitive descriptions of the unfairness caused by income level.

Global Gender Gap Report

The 2020 Global Gender Gap Report (2019) is published by World Economic Forum (WEF). Under the Economic Participation and Opportunity, there are five indicators, employment rate gap, similar work wage gap, earning gap, senior official gap and professional gap.

While carefully considering about these indicators, there are two overlaps. While calculating the impact of earning gap, the influence of the similar work wage gap is already included. For senior officials and professionals, they basically describe the advancement space for female in their careers. This is not the discussion about whether female executives are more willing to promote women. Rather, it is measuring whether there are more and more women occurring in these high-level positions. Thus, it is better to consider these two gaps together as individual interest varies.

From those passages, the gender gap in economic is mainly embodied in the different level of earning profits. The profits are divided into tangible and intangible. The tangible part means money. It includes how many of them get paid and how much is it. These could be simply measured by the pay gap and the employment gap. The intangible profits are the power they have. In other words, how much of the influence they can make. It is widely measured by the gap of the number of people in the higher position.

4. Methodology

4.1 Study Area

Figure 1. Base map of London including borough boundaries

The study area of this report is based on the Greater London which is one of the 9 Government Office Regions of the UK. From the official definition, it consists of 32 boroughs and the City of London, which is 33 subareas in total. The City is not a borough in actual, but for clear presentation in the analysis, it is treated as a borough. Besides, it is obvious that the River Thames is omitted in the map. Although in the strict geographic division, those regions are not adjacent due to the separation of the river. While calculating the spatial autocorrelation, they are neighborhood. Thus, the base map should only contain the geographic information of the boroughs.

4.2 Subindex Calculation

The main idea of this analysis is to capture the gap between female and male and make preparation for further comparisons between gender to measure fairness. So, all data would use female-to-male ratios as the format to do the calculation. Notice the employment datasets are all collected based on workplace. The earning data should also use the one based on workplace rather than home place.

4.2.1 Pay Gap (GPG)

The original dataset stores the mean of the gross weekly earnings by gender for full-time worker in 2018. The formula is:

$$GPG_i = \frac{FemaleFT_i}{MaleFT_i}$$

where:
- $FemaleFT_i$ and $MaleFT_i$ are the earnings of female and male in the borough i

4.2.2 Employment Gap (EG)

The raw dataset has the employment rate of female and male who aged from 16 to 64 in 2018. The formula is:

$$EG_i = \frac{FemaleEmployment_i}{MaleEmployment_i}$$

where:

- $FemaleEmployment_i$ and $MaleEmployment_i$ are the employment rate of female and male in the borough i

4.2.3 Advancement Gap (AG)

It is to measure the employment rate gap in the high-level jobs. The occupation type in the raw data is classified based on Standard Occupation Classification published in 2010 (SOC 2010 - Office for National Statistics, 2016). The first division is the same as the WEF version, which is "managers, directors and senior officials". The division in WEF report is "professional and technical workers", while in the source dataset published in 2018, they are listed respectively. The formula is:

$$AG_i = \frac{(\sum_{a=1}^{3} Female_a)_i}{(\sum_{a=1}^{3} Male_a)_i}$$

where:

- a is the 3 division in dataset
- $Female_a$ and $Male_a$ are the total number of the people in those jobs for female and male in the borough i

4.3 Economic Gender Fairness Index (EGFI or INDEX)

The way to calculate the weight is firstly introduced by Lopez-Claros and Zahidi (2005). Its key idea is to weight each indicator contributing to the same relative impact. The formula is:

$$INDEX_i = w_1 GPG_i + w_2 EG_i + w_3 AG_i$$
$$w_b = \frac{\delta_b}{\sum_{b=1}^{3} \delta_b}$$
$$\delta_b = \frac{0.01}{sd_b}$$

where:

- b is the 3 subindexes (GPG, EG and AG)
- w_b is the weight of each subindex
- δ_b is the standard deviation per 1% point change
- sd_b is the standard deviation of each subindex for all boroughs

The value of GPG, EG, AG and EGFI are definitely non-negative. If there is missing value of either female or male in the subindex, the result is set to be 0. If all the subindexes are 0, then EGFI is 0. Otherwise, they should always be positive. When it is equal to 1, that means there is no gender gap. Otherwise, the gap exists. If it is lower than 1, men have the advantage. It is bigger than 1, women take the advantage.

4.4 Global Moran's I

It measures the spatial autocorrelation based on both feature locations and feature values simultaneously (Moran 1950). The formula is shown as:

$$I = \frac{n \sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\left(\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}\right) \sum_{i=1}^{n}(x_i - \bar{x})^2}$$

where:
- $i \neq j$
- n is the number of boroughs
- x_i and x_j are the values of the INDEX of boroughs i and j, respectively
- $\bar{x}$ equals to the average of the INDEX of all boroughs
- w_{ij} is the spatial weight matrix corresponding to the boroughs pair i and j

Global Moran's I is between -1 and 1. Moran's I > 0 represents positive spatial correlation. When Moran's I is closer to 1, the correlation is more obvious. Moran's I < 0 represents negative spatial correlation. And the closer to -1, the correlation is more obvious. Otherwise, Moran's I = 0, the pattern is random.

4.5 Geary's C

It measures the spatial autocorrelation whether the adjacent feature values are correlated (Geary 1954). The formula is shown as:

$$C = \frac{(n-1) \sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}\left(x_i - x_j\right)^2}{2\left(\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}\right) \sum_{i=1}^{n}(x_i - \bar{x})^2}$$

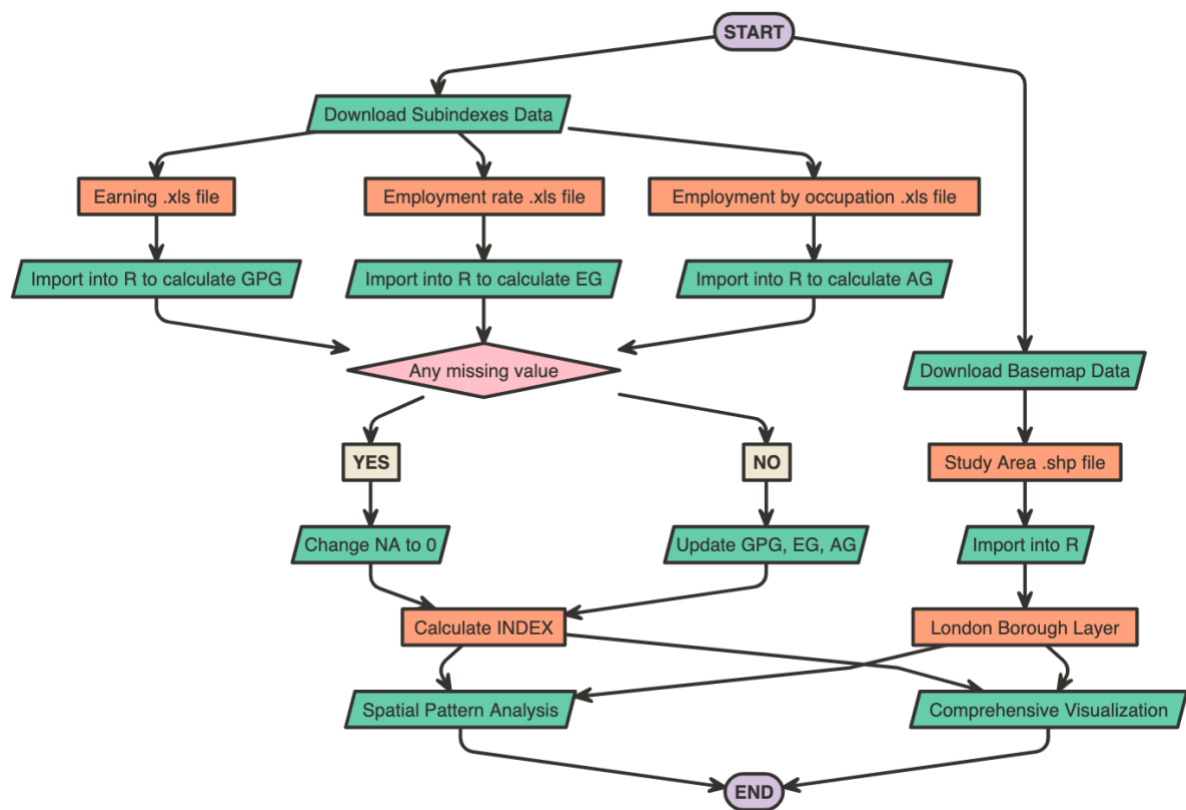where:
- $i, j, n, x_i, x_j, \bar{x}, w_{ij}$ are analogous to those of Moran's I

Geary's C vary between 0 and 2. The value of C > 1 indicates dispersed pattern. And when the C < 1 indicates clustering pattern. Otherwise, Geary's C = 1, the values of one area has no spatial relation to the values of any other area.
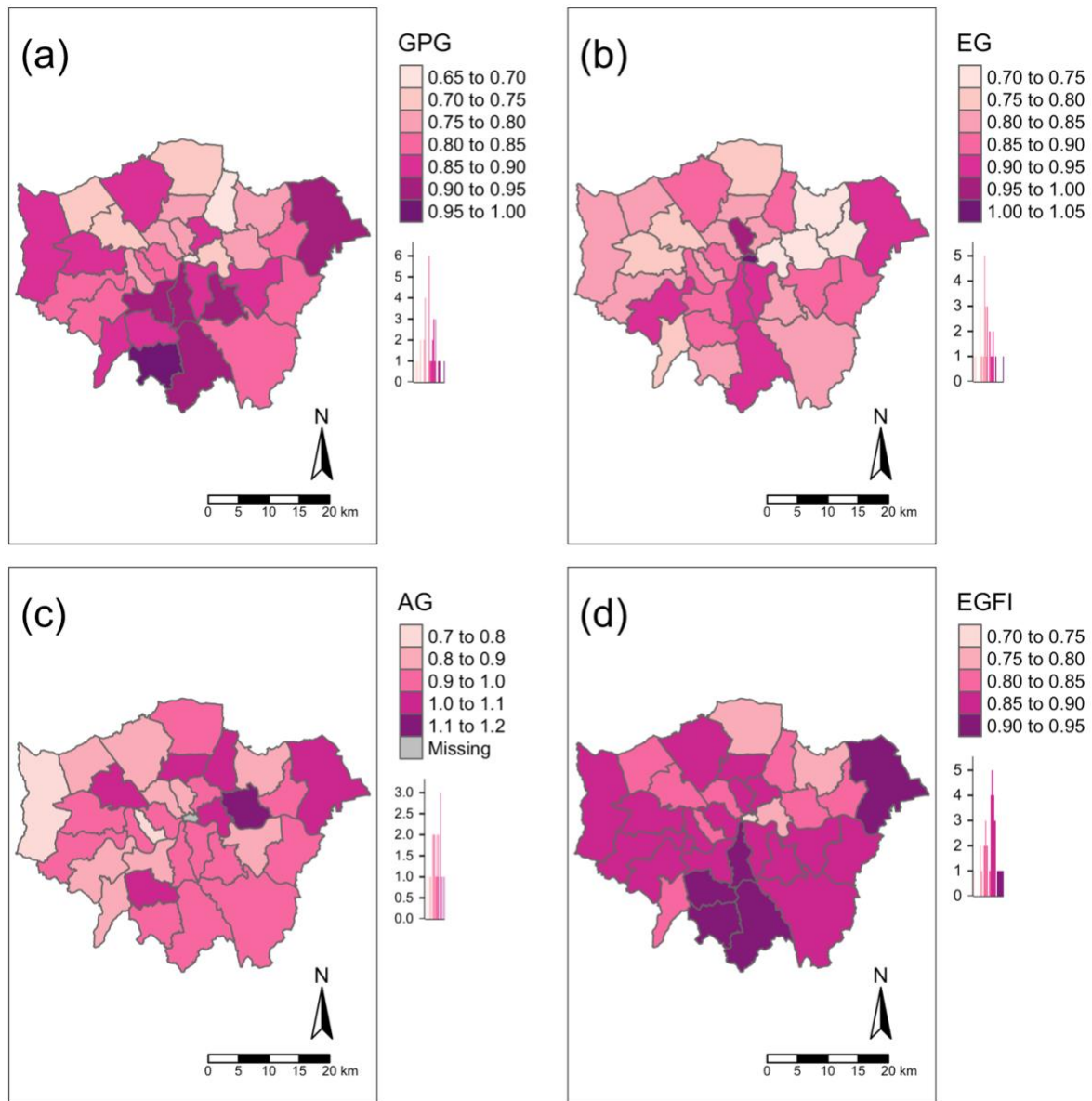
4.6 Flowchart

Figure 2. Flow Chart of the Methodology

5. Results

Figure 3. Map of Pay Gap, Employment Gap, Advancement Gap and Economic Gender Fairness Index

According to the definition illustrated in Methodology, the borough with darker color has the higher level of the gender fairness.

In graph (a), the overall characteristics of the data distribution are not distinct. The relative obvious part is the smallest part of GPG subindex are concentrated in the north-west of London. In specific, the gender pay gap in this area is larger than other places.

While in plot (b), the general pattern of spatial distribution is not distinct. But for individual, Islington has an index level over 0.95. And in City of London, the female employment rate is higher than male.

However, in (c), notice City has missing value of the number of high-level jobs. Based on the logic of advancement, it is necessary to set its corresponding AG to 0 for further research. That is also the reason why the EGFI of city is the lowest and has the lightest color in the map. Besides, there are 7 boroughs that has more female executives than male. Except for Merton, all of these boroughs are in North of London, especially in North-east part.

Add the table with detailed figure to consider plot (d) in figure 3.

Figure 4. Table of the value and rank of GPG, EG, AG and INDEX

NAME	GPG	EG	AG	INDEX	GPG rank	EG rank	AG rank	INDEX rank
Havering	0.946	0.902	1.027	0.940	2	7	5	1
Croydon	0.907	0.938	0.976	0.932	5	3	12	2
Lambeth	0.935	0.927	0.919	0.929	3	4	18	3
Sutton	1.000	0.847	0.903	0.917	1	17	21	4
Merton	0.888	0.866	1.024	0.901	8	14	6	5
…	…	…	…	…	…	…	…	…
Harrow	0.747	0.832	0.878	0.806	28	21	26	29
Enfield	0.703	0.782	0.994	0.785	31	29	9	30
Redbridge	0.794	0.716	0.899	0.778	24	33	22	31
Tower Hamlets	0.727	0.730	1.020	0.777	30	31	7	32
City of London	0.688	1.037	0.000	0.725	32	1	33	33

For EGFI, the 5 boroughs with the highest INDEX/EGFI value, which are all over 0.9, are Havering, Croydon, Lambeth, Sutton and Merton in descending. Except for Lambeth, the rest 4 are all located in outer London is sometimes considered as a rural area of London. When checking the boroughs with the value of the lowest 5 EGFI, three of them (Harrow, Enfield and Redbridge) are in Outer London. And none of their corresponding subindex is outstanding. Different from them, both City and Tower Hamlets have high value in AG.

From Mace's (2011) discussion, the flexibility and adaptability of Outer London is often unremarkable, and these abilities would contribute a lot to adapting to new uses and changing economic. These figures from 2018 to some extent support Mace's opinion. In other words, the level of economic gender fairness in an area might not be indicative of the immediate economic level of the region, but it does provide some indication of the potential of the economic development in this area.

Figure 5. Line graph of Rank Comparison among Indexes
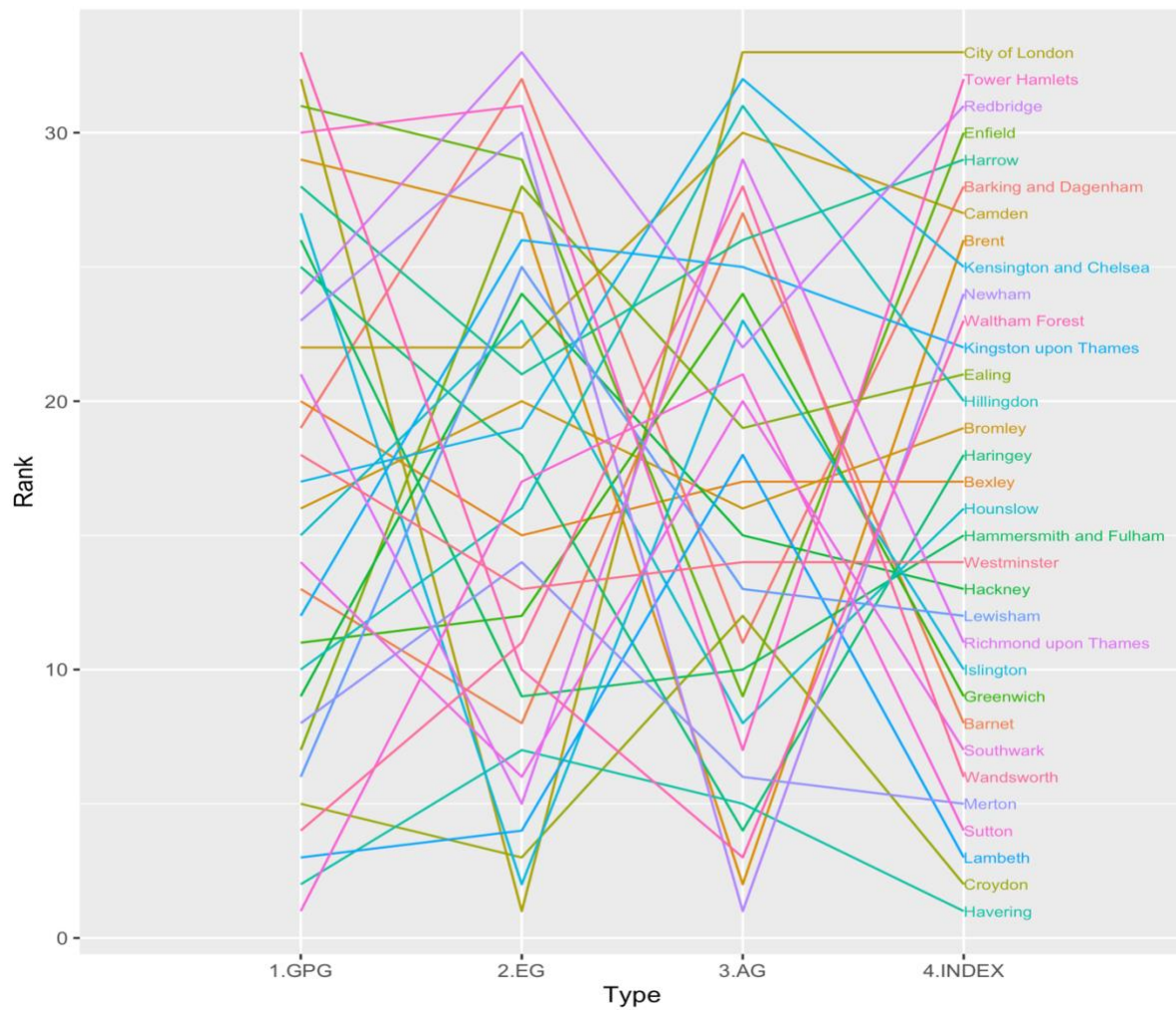
The line graph shows the changes of city ranks in different indexes. Note the rank is from the largest value of GPG, EG, AG and INDEX/EGFI to the smallest. From this, it can be seen that each borough varies considerably in terms of ranking. In other words, there is no one subindex that can be used to measure the overall level when considering the economic gender fairness of boroughs in aggregate. The results of the combined ranking are not similar to the ranking under any of the individual subindex. This is also an explanation of the need for a comprehensive analysis.

Figure 6. Spatial Autocorrelation Analysis

Statistic Name	Statistic Value	Expected Value	p-value
Moran's I	0.06931420	-0.03125000	0.1645
Geary's C	0.90303349	1.00000000	0.1773

The table is the result of spatial autocorrelation analysis between economic gender fairness index of each borough and the corresponding geographical location. The global Moran's I statistic equals to 0.069, which means a positive spatial pattern. There exists some clustering. The Geary's C statistic equals to 0.903, which is less than 1. It means that similar values clustering.

6. Discussion

Figure 7. Confidence Interval of Spatial Analysis Test

Statistic Name	Statistic Value	p-value	Confidence Interval of Statistic
Moran's I	0.06931420	0.1645	(-0.07390803, 0.2125364)
Geary's C	0.90303349	0.1773	(0.7617004, 1.044367)

The p value is defined as a significance level of probability that Type 1 error exists, which is wrong rejection of the null hypothesis. Typically, it is better to be less than 0.05. But it is not the golden rule to follow in all research and it is necessary to think about confidence interval (Grabowski 2016). The p value of the Moran's test equals to 0.16. The confidence interval is between -0.07 and 0.21. The risk is the negative part, as it would illustrate the opposite pattern. According to its definition, the significant level of correctly rejecting null hypothesis is 84%. For the Geary's C test, its p value is 0.17. Its confidence interval is between 0.76 and 1.04. The worry is the part lower than 1. The possibility of wrongly reject null hypothesis is 17%. It is right to reject the null with the probability of 83%. Therefore, the conclusions made before are acceptable.

The confidence interval can reflect the results at the level of data measurement (Altman, 2000). If the confidence interval is wide, the sample size might be small (Du Prel *et al.*, 2009). In this report, there are just 33 samples. It only includes the full-time workers in the pay gap calculation. For the employment rate, only the people aged from 16 to 64 are taken into account. The raw dataset of employment by occupation uses the sample values rather than the census data. When the condition is appropriate, they should be enlarged to include larger range of people. Actually, it is not a rare case. In one research (Rettig, Fick and Hijmans, 2020), due to the smaller sample size of employment, it also produces a relatively high p value of the Moran's I test, which is 0.13.

To create a comprehensive measurement is to catch the balance between the breadth of the data and its quality. Because an improvement in the gender equality should be an increase considering as more aspects as possible. However, everyone has their own feelings about the gender gap. And these subjective results are made up of countless unquantifiable details. It cannot be calculated easily like a figure. As there is no direct way to measure it, it is popular to find a substitution which could describe the feature well and is subjective. For example, use the number of seniors to represent the influence of people. There are also other choices, such as the upper bound of salaries of different occupations. It is worth exploring the proper way to guarantee the quality of the substitution of the intangible things.

7. Conclusion

The aim of this report is to find the proper indicators to measure the economic gender fairness in London and study its geographic property. It attempts to use the weighted GPG, EG and AG to calculate the EGFI. From the view of maps, the EGFIs of Outer London are polarized. Through the interpretation of the tests of Moran' I test and Geary's C, they tend to cluster geographically, as well as the similar values. However, those trends are not strong. After discussing the p value and the confidence interval of the tests, the results are reliable. If possible, it is suggested to increase the sample size and consider more indicators with the quality assurance in mind.

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9. Declaration of Authorship

I, [YUE LI], confirm that the work presented in this assessment is my own. Where information has been derived from other sources, I confirm that this has been indicated in the work.

[YUE LI]

Date of signature:
Assessment due date