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Regional characteristics of the gender employment gap: A spatio-temporal approach

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Abstract
There is a substantial body of research that recognises the importance of analysing regional characteristics in employment and labour relations that occur in a given geographical context. However, this phenomenon has been scarcely studied from a spatial approach. This article uses a spatio-temporal panel data model to examine the spatial interactions between the gender employment gap and, some labour and socioeconomic characteristics of 727 municipalities of Andalusia, Spain, for the period 2012–2016. The results show that due to spatial diffusion mechanisms, a spatial spillover effect occurs in both the gender gap in employment and in some of the labour and socioeconomic characteristics considered. These findings may be extended to other geographic areas and can be of use for the implementation of regional policies aimed at narrowing the gender employment gap.

JEL Codes: R10, J16, E24

Keywords
Employment, gender gap, labour market, policy diffusion, spatial model

Introduction

Numerous studies have shown that the spatial distribution of male and female employment is not purely random, but rather they show spatial interaction (Elhorst and Zeilstra, 2007; McGrath-Champ et al., 2010; Hudson, 2001; Rainnie et al., 2011). These investigations highlight that the geographical context is not simply a geographical area formed

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by regions in which there is a set of common characteristics that affect the labour market, but that there is also spatial interaction between these regions (Rainnie et al., 2011). Having estimates of these interactions would be of interest not only to scholars, but also to policymakers who seek to mitigate the problems arising from the labour gap. However, these interactions are not always easy to observe. For this reason, this work tries to quantify these spatial interactions with the help of spatial econometric methods. These methods allow estimating to what extent a region's employment gap may be affected not only by its own labour and socioeconomic factors, but also by the employment gap and labour and socioeconomic factors of neighbouring regions. The results shown in this work correspond to the region of Andalusia, Spain, but these spatial interactions can occur in other geographic areas (countries, states, etc.), regardless of whether they may have their own particular characteristics (Hudson, 2001). In this line, much of the literature has identified the main labour and socioeconomic characteristics of regions that influence women's and men's labour market participation (Bettio et al., 2013; Castellano and Rocca, 2019; Olivetti and Petrongolo, 2014; Noback et al., 2013).

This phenomenon has been scarcely studied from a spatial approach and even less so from a spatio-temporal approach. Classical econometrics does not take into account spatial interactions that can occur between regions belonging to the same geographical area, since they are considered isolated entities (Anselin, 1988). However, in line with Tobler's law (1970) – which establishes that everything is related to everything else, but what is close is more related than what is distant – some studies have shown the existence of a series of diffusion mechanisms in adopting local and regional policies through which regions close to others make similar decisions (Shipan and Volden, 2008). This can cause a spatial spillover effect in employment levels between neighbouring regions. Other works have also highlighted the importance of introducing spatial interactions between the regions of a geographic area to capture the effect that common regional characteristics can have on the presence of a spillover effect (Haining, 2003).

The classical regression model can be used to quantify direct effects, that is, to measure to what extent the labour gap in regions is affected by some labour or socioeconomic aspects of those regions, without considering what occurs with their neighbouring regions. In this article, we argue that to properly understand the gender employment gap in a geographic area, it is necessary to analyse not only the regional characteristics that explain this gap in those regions, but also those of their neighbours. This work studies the gender gap in 727 Andalusian municipalities (Spain) for the period 2012–2016 and sets out three main objectives. The first consists of determining whether the gender gap in employment is spatially distributed in a random way or not, and whether this behaviour persists over time. The second objective is to analyse whether endogenous spillovers, possibly due to spatial diffusion mechanisms, have occurred which cause the gender employment gap, in a given municipality, to be influenced by that of its neighbouring municipalities. The third objective is to identify which labour and socioeconomic characteristics affect the gender employment gap of the municipalities (direct effects) and of their neighbouring municipalities (indirect effects). To achieve the first objective, the presence of spatial autocorrelation in the gender employment gap has been analysed for each of the years considered, using a classical univariate method such as the Moran's I statistic. To achieve the second and third objectives, a multivariate method such as the

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regression model has been used; specifically, a spatial econometric model known as the spatial Durbin model (SDM) was estimated. The SDM uses spatio-temporal data and also identifies endogenous spillover, as well as direct and indirect effects.

This study is structured as follows. The theoretical foundation of our work and the hypotheses are presented in the following section. The data and variables used in the study are then presented, followed by a discussion of the results of the econometric models. Finally, conclusions are drawn.

Literature review and hypothesis

The geographic context and regional characteristics

Social, economic and political life is embedded in particular spatial structures (Herod et al., 2007). Places are constituted by and through factories, offices, landscapes and houses, and are a continuous mixture of meanings that are affected by shared social practices which construct a particular context (Hudson, 2001; McGrath-Champ et al., 2010). According to Hudson (2001), a territory, understood as a geographic context, shapes the employment and labour relations that occur within that territory. Therefore, geographic space is not understood simply as a spot on a map where things 'take place', but that there are a number of labour, social and economic features common to a territory that condition the nature of the employment and work that takes place in that particular context (Rainnie et al., 2011). For this reason, analyses of labour relations and other socioeconomic aspects within a geographic space are of interest since they inquire into how a given geographic distribution conditions or influences these phenomena (Sánchez-Peña, 2012).

In this vein, numerous studies have analysed regional-level labour and socioeconomic characteristics that may influence female and male labour force participation (Goodchild et al., 2000; McGrath-Champ et al., 2010). Some authors have examined job characteristics in a geographic area to determine labour market inequalities using factors related to the regional structure of employment opportunities, such as the sectoral structure or labour supply and demand (Azmat et al., 2006; Castellano and Rocca, 2019; Goldin, 1995; Olivetti and Petrongolo, 2014). Other authors have analysed the sectoral structure of regions using industrial specialisation indices and indicators of the sectoral composition of activities (Bowen and Finegan, 1969; Elhorst and Zeilstra, 2007; Noback et al., 2013), or labour supply and demand in a given region based on unemployment rates (Elhorst, 1996; Euwals et al., 2007; Van der Veen and Evers, 1984; Van Ham and Büchel, 2006).

A considerable body of literature has also included factors related to regional socioeconomic characteristics to analyse the level of female and male employment in a territory (Cotter et al., 2001; Fitzenberger et al., 2004; Bettio et al., 2013; Cha, 2013). In this regard, some studies have shown the negative effect that the presence of dependents in the household has on female labour participation (Cukrowska-Torzewska, 2016; Moen and Yu, 2000) using the dependency ratio as one of the indicators (Abellán et al., 2011; Noback et al., 2013). In their analyses, Buzar et al. (2007) and Haase et al., (2009) included variables related to population structure, such as the percentage of young women or population density to determine labour market participation in a given region.

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Other studies have examined factors related to retirement pensions to measure gender inequalities in working life and the greater monetary poverty suffered by women in certain territories (Blackburn et al., 2016; Möhring, 2015; Vara, 2013; Zhao and Zhao, 2018). Finally, a part of the literature has also incorporated variables related to access to political power to analyse the employment gap between men and women in a territory (Arceneaux, 2001) or variables related to income or the economic dimension in reports on the gender gap (Hausmann et al., 2013).

Therefore, based on the literature review, we have selected a set of observable factors related to the employment and socioeconomic characteristics of regions, in order to quantify the effects that these characteristics have on the gender employment gap, in a given geographic context.

The importance of spatial interaction

Classical econometrics considers regions as independent entities without taking into account the spatial interaction between them (Anselin, 1988), while, on the contrary, according to Tobler's law (1970) the presence of spatial autocorrelation or spatial interaction is expected (Anselin, 2001). Spatial autocorrelation refers to the correlation of georeferenced observations of a single variable measured at different locations, which can sometimes be due to spatial spillover (Fischer and Griffith, 2008). The spatial autocorrelation of a single variable can be analysed intuitively by observing the behaviour of the variable on a choropleth map that displays the spatial clusters and analytically by means of some statistical tests such as Moran's I test (Anselin, 1988). This test determines the degree of spatial autocorrelation of the variable of interest (Morton et al., 2018) in a univariate way, that is, without considering the effect of other variables. However, spatial econometrics models consider not only other observable explanatory variables, but also the spatial autocorrelation by including a spatially lagged dependent variable in the model (Morton et al., 2018). This variable controls for endogenous spillovers (Fageda and Olivieri, 2019) or the global spatial effect (Elhorst, 2014). In addition, it is also possible to take into account exogenous spillovers by including spatially lagged explanatory variables (Fageda and Olivieri, 2019). Normally, these spillover effects are not directly observable as they are difficult to measure and hence to quantify. However, spatial econometrics models permit obtaining the estimates of these effects.

Spatial interaction and endogenous spillovers in the gender employment gap may be due to the existence of policy diffusion between regions, that is, when public policies adopted by a regional government are influenced by the public policies of neighbouring governments (Gilardi, 2010; Simmons and Elkins, 2004). Policy diffusion occurs through mechanisms of diffusion, such as coercion, imitation, competition and learning (Simmons et al., 2006). Policy diffusion can lead to the emergence of spatial autocorrelation and spatial clustering between regions, such that an increase in the employment level in a region *i* influences the employment level of neighbouring regions (Niebuhr, 2003). This may be due to an imitation mechanism, which occurs when decisions taken by regional administrations imitate those of other regions, regardless of whether, or not, the decisions are effective (Shipan and Volden, 2008). Another mechanism that can lead to spatial autocorrelation is economic competition. This occurs when regional administrations

compete to adopt certain policies due to the outcomes of applying policies implemented by other regions. Thus, the economic impact of adopting active employment policies in order to reduce the gap can serve as a benchmark for regions in the same geographical area (Ruiz-Villaverde et al., 2018). Finally, the learning mechanism refers to the process by which a region adopts the decision of other regions once those decisions have been proven to be successful (Berry and Baybeck, 2005). Thus, if one region significantly decreases the gender employment gap, this may lead to a contagion effect, causing the gap in neighbouring regions to decrease as well (Overman and Puga, 2002).

In considering the presence of spatial interactions, it is possible to draw a more complete picture of how places and their attributes interrelate with each other (Haining, 2003). These spatial interactions may be the product of economic, social or political forces that tend to group populations with shared traits together in certain areas (Voss et al., 2006) or, as Manski (1993) explains, the presence of common factors and social networks affects neighbouring regions and causes the behaviour of the regions to be similar. In other words, these common regional characteristics, generated by geographic context, can lead to the presence of spatial autocorrelation. Therefore, in a geographic context marked by specific labour and socioeconomic characteristics, it is necessary to incorporate the spatial analysis approach (Corrado and Fingleton, 2012).

Few investigations have examined spatial interaction in the labour market. For instance, Elhorst and Zeilstra (2007) showed that employment in a given region is influenced by that of neighbouring regions. This spatial behaviour has also been studied using cross-sectional data for the case of the gender employment gap in Dutch municipalities (Noback et al., 2013).

Hypotheses

In line with the above, our first hypothesis (H1) aims to identify the existence of spatial autocorrelation in the gender employment gap between the municipalities of Andalusia, without considering the effect of other variables, and whether this autocorrelation has persisted over time. The aim of our second hypothesis (H2) is to determine whether endogenous spillovers have occurred between the municipalities (H2). And, finally, we are interested in quantifying the direct and indirect effects of regional factors that influence this gap (H3). That is, we want to determine whether some of the characteristics related to the region's employment opportunity structure and certain socioeconomic characteristics not only explain the gender employment gap in a municipality (direct effects), but also affect the gap in neighbouring municipalities (indirect effects). To this end, we have formulated three hypotheses as follows:

Hypothesis 1 (H1). The spatial distribution of the gender employment gap in Andalusian municipalities is not random but formed by spatial clusters.

Hypothesis 2 (H2). The gender employment gap of municipalities tends to be affected by neighbouring municipalities.

Hypothesis 3 (H3). Regional labour and socioeconomic characteristics affect the gender employment gap in a municipality (direct effects) and the gender employment gap in its neighbouring municipalities (indirect effects).

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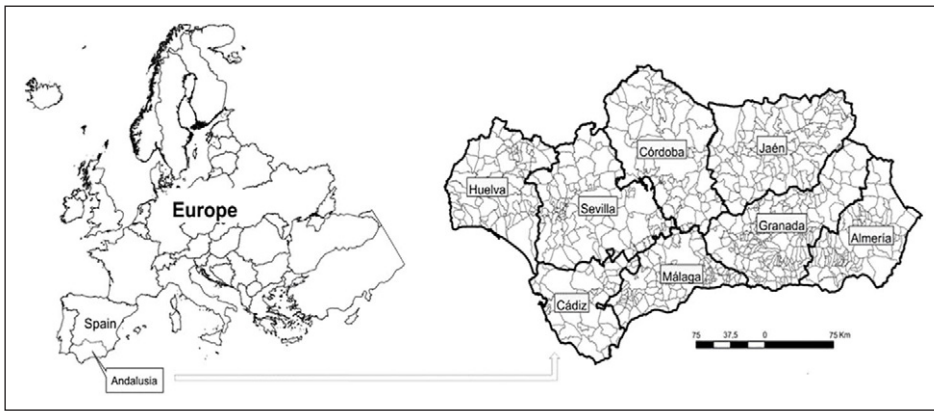

Figure 1. Study area.
Source: Own elaboration.

Study area, data and variables

The study area comprises the autonomous community of Andalusia, Spain, which is located in the most southwestern part of Europe (see Figure 1). Andalusia is the second largest region in the entire Iberian Peninsula, covering an area of 87,268 km². It is also the most populated region in Spain with 8,426,405 inhabitants, of whom 4,159,637 are men and 4,266,768 are women (Instituto Nacional de Estadística (INE), 2019). The population of Andalusia accounts for nearly 2% of the total European Union (EU) population, exceeding the population of more than half of EU countries. Andalusia is made up of eight provinces (Almeria, Cadiz, Cordoba, Granada, Huelva, Jaen, Malaga and Seville) with a total of 786 municipalities (Junta de Andalucía, 2009). Several specific areas can be distinguished in Andalusia, each of which has its own labour and socioeconomic characteristics depending on the geographic context of the area.

The years selected for the analysis are 2012–2016, a period in which Spain began to leave behind the economic recession caused by the international financial crisis. This crisis strongly affected the region of Andalusia, but according to some studies it was also one of the regions that recovered most quickly (Reig, 2017).

Table 1 shows the variables used in the analysis and their sources of information. The dependent variable is the gender employment gap (*gender_gap*), defined as the percentage difference between the male employment rate and the female employment rate. The female and male employment rates have been calculated by dividing the number of women and men affiliated to the Spanish social security system by the total population of women and men aged 15–65 years.

Two indicators have been used to examine the degree to which the structure of industrial activity in a region influences male and female labour participation: *mix* (Bowen and Finegan, 1969; Elhorst and Zeilstra, 2007) and *servicesector*. The variable *mix* predicts the expected proportion of female employment in a municipality according to the regional-level industrial specialisation, combined with the expected proportion of female employment in the region of Andalusia as a whole

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Table 1. Descriptive statistics.

Variable	Mean	SD	Min.	Max.	Descriptions and sources
Gender_gap	0.210	0.071	−0.219	0.541	% male employment rate − % female employment rate (SEPE)
Unemploy women	0.244	0.108	0.008	0.638	No. of unemployed registered (women)/active population (SEPE)
Unemploy men	0.218	0.076	0.035	0.503	No. of unemployed registered (men)/active population (SEPE)
Mix	45.420	3.347	18.864	53.255	$Mix^{r,f} = 100 \times \sum_{s=1}^{4} \frac{E_s^{r,m+f}}{E_{total}^{r,m+f}} \times \frac{E^{n,f}}{E_s^{n,m+f}}$ (IECA)
Servicesector	39.472	18.756	0.000	94.144	$IE_{i,j} = \frac{\frac{E_{i,j}}{\sum E_{i,k}}}{\frac{E_{h,j}}{\sum E_{h,k}}}$ (IECA)
Dependency_Rate	0.535	0.090	0.241	1.154	No. of persons <15 + no. of persons >65/no. of persons 15–65 years age $\times$ 100 (IECA)
Young women	0.141	0.036	0.034	0.241	No. of women aged 15–30 years/population total (IECA)
Density	229.786	785.636	2.380	10,077.070	No. of inhabitants per km^2 (IECA)
Pension women	0.584	0.078	0.433	1.079	Average amount of women's pension (thousands of Euros) (IECA)
Pension men	0.845	0.163	0.478	1.594	Average amount of men's pension (thousands of Euros) (IECA)
Councilwomen	0.404	0.104	0.000	1.000	No. of councilwomen (TP)
Income	4.125	1.422	0.490	11.496	Average income per capita (thousands of Euros) (IECA)

Source: Authors' calculations based on data generated from Instituto de Estadística y Cartografía de Andalucía (IECA), Servicio Público de Empleo Estatal (SEPE) and the transparency portal of the general state administration (TP).
Note: $N = 3635$.

$$Mix^{r,f} = 100 \times \sum_{s=1}^{4} \frac{E_s^{r,m+f}}{E_{total}^{r,m+f}} \times \frac{E^{n,f}}{E_s^{n,m+f}}$$

where E is employment, calculated as the number of social security affiliations; s is the sector, for which four sectors are calculated separately (agriculture, industry, construction and services); m denotes males; f denotes females; r is the municipality; and n is Andalusia.

The variable *servicesector* is calculated as the municipal percentage of employment in the service sector, that is, as an index of industrial specialisation in the service sector

$$IE_{i,j} = \frac{\frac{E_{i,j}}{\sum E_{i,k}}}{\frac{E_{h,j}}{\sum E_{h,k}}}$$

where E is employment and is calculated as the number of social security affiliations; i is the municipality; j is the sector, for which only the service sector is calculated; k is the total sectors (agriculture, industry, construction and services); and h is Andalusia.

In addition, in order to approximate the employment opportunities structure in Andalusia, two variables were used (Broersma and van Dijk, 2002; Van Ham and Büchel, 2006:): *unemploywomen*, which measures the number of registered unemployed women over the total active population of a municipality; and *unemploymen*, which reflects the number of registered unemployed men over the total active population of the same municipality.

To analyse the regional-level socioeconomic characteristics, several variables were used. As regards the presence of dependents (children and the elderly) in Andalusia, the indicator *dependency_rate* was used (Abellán et al., 2011; Noback et al., 2013). This variable is calculated as the sum of the number of persons under the age of 14 years and over the age of 65 years divided by the number of persons aged 14–65 years and multiplied by 100

$$dependency\_rate = \frac{Number\ of\ persons < 14 + Number\ of\ persons > 65}{Number\ of\ persons 14 - 65\ years\ age} \times 100$$

To measure the presence of young women and the population density in Andalusia, the variables *youngwomen* and *density* were used (Consejo Económico y Social, 2018; INE, 2019). *Youngwomen* is calculated as the percentage of women aged 15–30 years over the total population of a given municipality. *Density* is calculated as the number of inhabitants per square kilometre of a territory (hab/km^2).

To measure gender inequalities in working life (Blackburn et al., 2016; Zhao and Zhao, 2018), the variables *pensionmen* and *pensionwomen* were used. These variables are defined as the mean retirement pension (in thousands of euros) for men and women. Other variables used to determine the socioeconomic aspects of municipalities included

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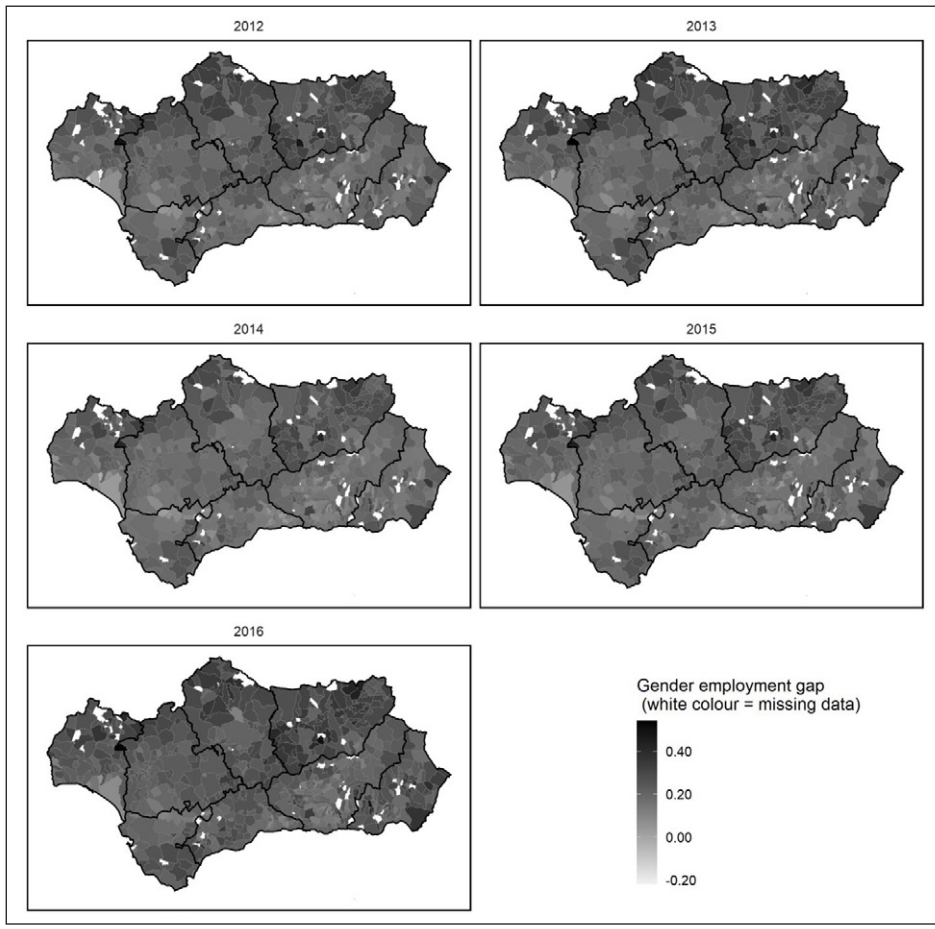

Figure 2. Spatial distribution of gender employment gap in Andalusia.
Source: Own elaboration based on data from Instituto de Estadística y Cartografía de Andalucía (IECA).

the number of political representatives (Arceneaux, 2001) by means of the indicator *councilwomen*, which is calculated as the number of councilwomen elected to each of the municipal (town or city) councils, and the indicator *income*, which is calculated as the mean income per inhabitant in thousands of euros.

Figure 2 shows the spatial distribution of the employment gap for the 5 years considered. As can be observed in the figure, municipalities located close to each other are shown in a similar colour, thus indicating strong spatial clustering. More specifically, a certain grouping can be observed in the municipalities marked in dark grey (municipalities with high employment gap percentages) and in light grey (municipalities with low employment gap percentages). Municipalities with a greater employment gap are spatially concentrated in the north and interior of Andalusia, particularly in the northern areas of the provinces of Huelva, Seville and Cordoba and in the southwestern area of the province of Jaen. These are provinces with a particular geographic context and common

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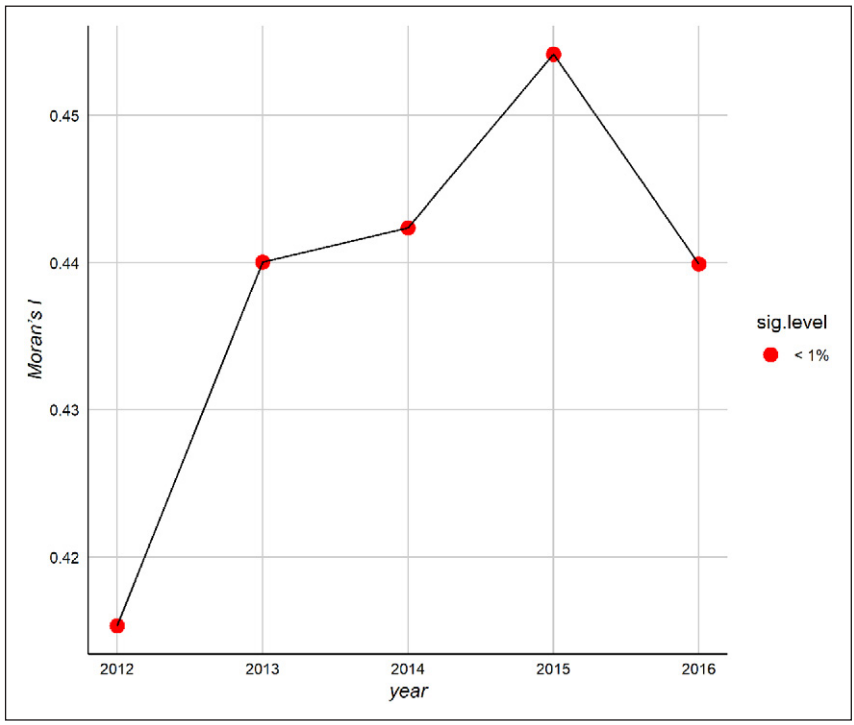

Figure 3. Spatial autocorrelation (Moran's I) for each year.
Source: Own elaboration based on data from Instituto de Estadística y Cartografía de Andalucía (IECA).

socioeconomic and employment characteristics. Specifically, they are characterised by a low population density and a strongly masculinised primary sector dedicated to agricultural and livestock production with few employment opportunities for women, who have left the area in search of work. This behaviour is also observed in southwest Almeria since horticultural production is predominant in the province and employs a considerable amount of male labour (Figure 2).

In contrast, there are spatial concentrations with low gender employment gap values in the south of the province of Huelva and in the province of Malaga and some coastal municipalities, as well as in the provincial capitals and their metropolitan areas. These two geographic areas also display particular characteristics. In the province of Huelva, strawberry production is the predominant activity and employs mainly female labour. In the province of Malaga, its capital and coastal municipalities and their metropolitan areas are characterised by an industrial and service activity that generates significant female employment. These areas also have a high percentage of young women.

It should be noted that the spatial concentration described above has generally remained unchanged over time (see Figure 2) because the socioeconomic characteristics and specific features of these Andalusian provinces persisted during the period analysed (Federación Andaluza de Municipios y Provincias, 2018). However, the gender employment gap widened each year over the period 2012–2016. This behaviour can be explained

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by the impact of the international economic crisis on male employment, which fell much more sharply than female employment. Nonetheless, following the economic recovery, male employment bounced back much more quickly than female employment, which became much more precarious (Gálvez-Muñoz and Rodríguez-Modroño, 2013).

Results

Spatial global autocorrelation

To test for the presence of global spatial autocorrelation, Moran's I test is used (Anselin, 1988; Nicolini and Resmini, 2011). This test detects the presence of spatial global autocorrelation, that is, if the gender gap in employment is distributed spatially at random or if, on the contrary, it presents spatial autocorrelation. The statistic to perform Moran's I test is given as

$$I = \frac{n}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(y_i - \bar{y})(y_j - \bar{y})}{\sum_{i=1}^{n}(y_i - \bar{y})^2}$$

where y_{it} is the observation of the gender employment gap in municipality i, $\bar{y}$ is its mean and w_{ij} are the spatial weights corresponding to municipalities i and j.

Depending on the type of contiguity between municipalities, there exist different specifications for the weights w_{ij}. Following Anselin (1988, 2002), two of the most common specifications are the queen method and the distance between the centroids of the municipalities. In the case of the queen specification, the weights take a value of 1 if the municipalities share a common edge or vertex and 0 otherwise. However, the weights of the second approach are obtained as the inverse of the distance between the centroids. The second criterion is in agreement with Tobler's principle that regions closest in space are more similar than distant ones. We have chosen the latter approach based on this principle.

Figure 3 shows the values of Moran's I statistic for each year of the period considered. As can be observed, Moran's I is positive and statistically significant for all the years. The results confirm what was previously observed in Figure 2, that is, the municipalities of Andalusia display a high degree of spatial clustering over the 5-year period. That is, municipalities in close proximity to each other, have similar employment gap values.

These results confirm H1 of our study, namely that the spatial distribution of the gender employment gap in Andalusian municipalities is not random, but formed by spatial clusters.

Models

In order to test H2 and H3, we estimated a spatial panel model. To this end, we first determined whether a pooled model, a fixed-effects (FE) model or a random-effects (RE) model was more suitable. The results of the Chow test ($F = 15.912$, $p < 0.000$) indicated

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that an FE specification was more suitable than a pooled specification. In addition, the results of the Breusch–Pagan test ($\chi^2 = 2707.4$, $p < 0.000$) indicated that an RE model was preferable to a pooled model. Finally, the results of the Hausman test (Baltagi, 2005; Elhorst, 2009) indicated that an FE model was preferable to an RE model ($\chi^2 = 1165.6$, $p < 0.000$). Hence, the FE model was the chosen specification.

We then determined whether the model perturbations presented problems of spatial autocorrelation. If the perturbations of the chosen model show spatial autocorrelation, an ordinary least squares (OLS) estimation will be unbiased, but not efficient and classical standard error estimators will be biased (Anselin, 2001). To confirm the presence of spatial autocorrelation in perturbances, two Lagrange multiplier tests and their robust versions were used (LM-lag and LM-error and RLM-lag and RLM-error, respectively) (Anselin and Rey, 1991), which would justify the use of spatial econometric methods. Table 2 shows the results of the tests, which indicate a strong presence of autocorrelation in the disturbances as they are highly significant. On the contrary, according to the likelihood ratio (LR) test (LR = 176.7856, $p = 0.000$), we can conclude that the SDM specification is appropriate.

The next step was to specify the spatial panel model. Although there are different spatial econometric panel models, SDM is one of the most attractive models for empirical spatial studies (Elhorst, 2014) and can be used to test spatial interaction effects (LeSage and Pace, 2009)

$$y_{it} = \phi + \rho \sum_{j=1}^{N} w_{ij} y_{it} + \mathbf{x}_{it}\beta + \sum_{j=1}^{N} w_{ij}\mathbf{x}_{ijt}\theta + u_{it}$$

where y_{it} is the dependent variable (*gender_gap*) for municipality i ($i = 1. . .727$) in period t ($t = 1 . . . 5$); ϕ is the constant parameter; ρ is the spatial autoregressive parameter which indicates the endogenous spillover effect of the gender employment gap; $\sum_{j=1}^{N} w_{ij} y_{it}$ is the spatial lagged dependent variable and represents the average gender gap in employment in neighbouring municipalities; w_{ij} are the spatial weights; $\mathbf{x}_{it}$ represents the explanatory variables; $\sum_{j=1}^{N} w_{ij}\mathbf{x}_{ijt}$ denotes the values of the explanatory variables for the neighbouring municipalities; β and θ are the associated parameters; and u_{it} is the error. To control the endogeneity of the spatially lagged dependent variable, the maximum likelihood (ML) estimator was used (Anselin, 1988).

The SDM captures not only the spatial endogenous spillover effect caused by the employment gap, but also the spatial spillover effect of the explanatory variables (Gong, Boelhouwer, and de Haan, 2014). Table 2 shows that the SDM coefficients of the key variables (*unemploymen*, *mix*, *servicesector*, *dependency_rate* and *youngwomen*) of our analysis are significant. Moreover, the coefficient of Wy (W*gender gap) is positive and significant. This indicates that the gender employment gap of municipalities tends to be affected by their neighbouring municipalities after accounting for the other explanatory variables, thus fulfilling H2. This endogenous spillover effect is likely due to the spatial diffusion mechanisms described in the literature review, namely that decisions taken by regional administrations to reduce the gender employment gap are affected by decisions taken by administrations in neighbouring regions.

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Table 2. Estimated regression models for gender gap employment.

Dep. variable	FE individual	SDM
Intercept	–	–
Unemploywomen	0.1001***	0.1120***
Unemploymen	−0.5356***	−0.5673***
Mix	−0.0005***	−0.0003*
Servicesector	−0.0001***	−0.0001*
Dependency_rate	0.4016***	0.2656***
Youngwomen	−0.3820***	−0.1513***
Density	−0.0899***	−0.0472*
Pensionwomen	−0.0328*	–0.0428**
Pensionmen	0.0231	−0.0184
Income	0.0080***	0.0013
Councilwomen	0.0125	0.0117
Wx	–	*Included*
Wy (*W***gender gap*)	–	0.2899***
AIC	−18,694.48	−19,097.44
R^2	0.9321	0.9416
LM-lag	332.5201***	–
LM-error	211.9534***	–
Robust LM-lag	122.3604***	–
Robust LM-error	1.7938***	–

Source: Authors' calculations.
FE: fixed effects; SDM: spatial Durbin model; LM: Lagrange multiplier; AIC: Akaike information criterion.
*Statistically significant at the $p < 0.10$ level; **statistically significant at the $p < 0.05$ level; and ***statistically significant at the $p < 0.01$ level.

Classically, the coefficients of panel models only consider direct effects but not spillover effect or indirect effects. In order to test H3, we follow the analyses of Elhorst (2010) and LeSage and Pace (2009), which consider the direct, indirect and total effects. The direct effects capture the impact of the change in the explanatory variables on the dependent variable, in a given municipality, while the indirect effects capture the impact of the change in the explanatory variables on the dependent variable in the neighbouring municipalities. These impacts are the result of spatial feedback (LeSage and Pace, 2009). The sum of the two effects indicates the total effect of a change in the dependent variable. Table 3 shows the estimates of the three types of effects described. Therefore, to test H3 we look at the direct effects of the variables *unemploywomen*, *unemploymen*, *mix*, *dependency_rate*, *youngwomen* and *pensionwomen*, all of which capture factors related to the employment opportunity structure and certain socioeconomic characteristics of a municipality that affect the gender employment gap in that municipality. As can be observed in the table, the indirect effects of the variables *unemploymen*, *mix*, *servicesector*, *dependency_rate*, *youngwomen*, *pensionmen* and *income* are significant. This indicates that factors related to a municipality's labour and socioeconomic characteristics also affect the gender employment gap in neighbouring municipalities.

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Table 3. Direct, indirect, and total effects.

	Direct	Indirect	Total
Unemploywomen	0.1118***	−0.0020	0.1098***
Unemploymen	−0.5620***	0.0961*	−0.4658***
Mix	−0.0004**	−0.0025***	−0.0029***
Servicesector	−0.0001	−0.0003***	−0.0004***
Dependency_rate	0.2721***	0.1166***	0.3886***
Youngwomen	−0.1681***	−0.3364***	−0.5045***
Density	−0.0520*	−0.1074	−0.1594*
Pensionwomen	−0.0436**	0.0108	−0.0328
Pensionmen	−0.0109	0.1598***	0.1488***
Income	0.0021	0.0140***	0.0160***
Councilwomen	0.0108	−0.0148	−0.0040

Source: Authors' calculations.
*Statistically significant at the $p < 0.10$ level; **statistically significant at the $p < 0.05$ level; and ***statistically significant at the $p < 0.01$ level.

To interpret the results of Table 3, we have selected the variable *dependency_rate*. This variable has a direct positive and significant effect on the gender employment gap. This finding indicates that municipalities with a high proportion of underage children and elderly individuals have a higher percentage of gender gaps. Thus, if the variable *dependency_rate* increases by 1% in a municipality, the gender employment gap will increase by 0.27% in that municipality. Moreover, the indirect effect is also positive and significant, indicating that if the variable *dependency_rate* increases by 1% in one municipality, the gender employment gap in neighbouring municipalities will increase by 0.12%. As indicated above, the indirect effect represents the spatial spillover effect of the explanatory variables (Gong et al., 2014). Hence, it can be concluded that this variable shows significant spatial spillover. The sum of the two effects (direct and indirect) indicates that if the proportion of underage children and the elderly increases by 1%, the total effect on the gender gap will be an increase of 0.39%. The results obtained for the rest of the significant variables are the expected ones in line with the literature review (Manski, 1993; Voss et al., 2006). The importance of distinguishing between direct and indirect effects is evidenced by the spatial spillover effects of certain explanatory variables (indirect effects) which, in our case, highlight the need to account for certain regional characteristics when analysing the gender employment gap.

Conclusion and discussion

Spatial interaction has been scarcely addressed in the literature on the gender employment gap and the regional characteristics that influence it. This article has examined spatial interaction in the gender employment gap due to endogenous and exogenous spillovers. These spillovers can be caused by diffusion mechanisms and the labour and socioeconomic characteristics found within a given geographic context. However, these spatial interactions can occur in other contexts and geographic areas, thus lending a general character to the results obtained.

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Three hypotheses were formulated and tested in the results section. First, it was shown that the gender employment gap in Andalusia is distributed in spatial clusters and that this distribution has persisted over time (H-1). These results are in line with the literature which highlights that labour relations are not randomly spatially distributed, but that there are spatial interactions which cause municipalities nearby in space to have similar employment levels (Hudson, 2001; McGrath-Champ et al., 2010), which can sometimes be due to spatial spillover (Fischer and Griffith, 2008) and policy diffusion processes.

The existence of an endogenous spatial spillover effect on the gender employment gap between municipalities was also analysed (H2). This spatial interaction can be caused by policy diffusion mechanisms. According to Ruiz-Villaverde et al. (2018), when adopting certain policies, regional governments are not geographically isolated. Therefore, these results might confirm that the adoption of an employment policy in one region of Andalusia could have a significant influence on neighbouring regions due to mechanisms of imitation, competition and learning (Shipan and Volden, 2008). In other words, if a measure is promoted to reduce the gap in one municipality in Andalusia, the measure will not only influence that municipality, but its neighbouring municipalities as well.

The findings reveal that certain factors related to the labour and socioeconomic characteristics of a region exert an effect on the gender employment gap in a municipality and its neighbouring municipalities (H3). This information is important in order to guide public policy efforts towards factors that affect the employment gap in a municipality (direct effect). Specifically, these factors are male and female unemployment rates (which highlight the discouraged worker and added worker effects) and a sectoral composition that is favourable to women, both of which are related to regional labour characteristics, as well as the dependency rate, the percentage of young females in the population and women's pensions, which are related to the socioeconomic characteristics of a municipality.

H3 also provides information about which factors policymakers should take into consideration to reduce the gender gap in neighbouring municipalities (indirect effect). Thus, for example, if a measure is implemented in a municipality to promote an industrial mix favourable to women, the measure will reduce the gap both in that municipality and in its neighbouring municipalities due to a spillover effect. This result is in line with Voss et al. (2006) and Manski (1993), who indicated that due to the presence of common factors and social networks, regions tend to behave in a similar manner to their neighbouring regions, hence the importance of incorporating spatial analysis in the study of gender employment.

By taking into account the presence of spatial interactions in the gender employment gap, we were able to obtain a more complete picture of how territories and their characteristics are interrelated. In this sense, our study provides information on the spatial patterns of the employment gap in Andalusia caused by both observable and unobservable factors. These unobservable factors, the spillover effect, can be determined by diffusion mechanisms, which are difficult to measure. Both types of factors will be present in other geographic areas, although the observable factors present their own specific characteristics.

In this regard, our study provides information on employment gap patterns in Andalusia according to the region's characteristics and spatial interactions. This information can be

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of use for implementing public policies to reduce gender inequalities in the labour market, not only in the area analysed, but in other geographic areas as well.

To conclude, the strategic decisions that public institutions must make in order to successfully address the gender employment gap can be supported by the analysis presented in this study. However, the regional scale (municipalities of Andalusia) of the analysis limits the scope of this work to a certain extent since it precludes collecting data on variables that could provide more information, such as level of training, time use or salary levels, among others.

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