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Changing Determinants of Low Fertility and Diffusion: a Spatial Analysis for Italy

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ABSTRACT

Italy is a case study in lowest-low fertility. Its internal heterogeneity is substantial and changing over time. The paper has two main aims. First, it aims at investigating whether the theoretical framework offered by the diffusionist perspective to fertility transition could still be relevant in explaining fertility changes in contemporary advanced societies. Second, the paper aims at investigating if and how the associations between fertility and a series of indicators of secularisation, female occupation, contribution of fertility of immigrants, and economic development change across space and over time. We make use of geographically weighted regressions and spatial panel regressions to model explicitly spatial dependence in fertility among Italian provinces over the period between 1999 and 2010. Results show that spatial dependence in provincial fertility persists even after controlling for standard correlates of fertility, consistently with a diffusionist perspective. Further, the local association between fertility and its correlates is not homogeneous across provinces. The strength and in some cases also the direction of such associations vary spatially, suggesting that the determinants of low fertility change across space. Finally, the associations between fertility and its correlates change over time. Copyright © 2015 John Wiley & Sons, Ltd.

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INTRODUCTION

The emergence of low and lowest-low fertility has triggered crucial research puzzles, which have to deal with fertility differentials across societies, that is, variation across space, and historical trajectories, that is, fertility variation over time. Related to these puzzles, further research has tackled the question of which factors are associated with fertility variation and whether there are changes in this association over time and, although this has not been extensively dealt with, across space.

In this paper, we reconcile the literature on the factors associated with fertility variation over time and across space with the literature on the 'diffusionist' perspective of fertility change. We analyse recent sub-national data from Italy, one of the countries where lowest-low fertility levels first emerged at the national level and where fertility has been below replacement for decades. More specifically, the paper has two main aims. First, we document the relevance of a diffusionist perspective in the study of fertility change in contemporary advanced societies. Second, we investigate if and how the associations between fertility and its correlates change over time and across space by applying statistical models that allow analysis of actual birth data at the sub-national level both cross-sectionally and over time, also including covariates.

Our results are suggestive that the diffusionist perspective might still be helpful in explaining fertility differentials, and they show the potential biases in estimating the relevance of factors associated with fertility in contexts characterised by sub-national heterogeneity.

DIFFUSION AND LOW FERTILITY

In this section, we review the theoretical framework of the 'diffusionist' perspective on fertility decline and discuss the potential relevance of such a framework for studying contemporary low fertility societies by pointing to a variety of diffusion mechanisms that could come into play.

The Princeton European Fertility Project (Coale & Watkins, 1986; Watkins, 1987; Bongaarts & Watkins, 1996) studied historical fertility decline across European provinces. Fertility decline was shown to spread beyond what was predicted by socio-economic differentials across provinces. Rather, areas that shared the same language, ethnicity and religion – that is, the same cultural characteristics – experienced similar fertility transitions (Knodel & van de Walle, 1979; Coale & Watkins, 1986). These considerations are directly linked to the 'diffusionist' perspective on fertility decline. In all definitions, diffusion is different from the other types of communication because it is driven by new ideas (Bongaarts & Watkins, 1996; Rogers, 1995; Casterline, 2001).

In a diffusionist perspective, fertility decline results from the diffusion of new attitudes and ideas towards the value and cost of children and of new behaviours because of acquired knowledge and information regarding birth control techniques (Cleland & Wilson, 1987; Casterline, 2001). Attitudes and behaviours are 'new' as long as they were absent or rare in the past. For this reason, the spread of new ideas and behaviours is akin to 'innovation diffusion' and 'behavioural innovation', as opposed to an 'adjustment process', which responds to changed economic circumstances (Carlson, 1966). The spread of new ideas and knowledge is curvilinear and dynamic and acts through social interaction, that is, a process of social influence and/or social learning at the individual level through kinship, social and communication networks, and the mass media (Retherford & Palmore, 1983; Montgomery & Casterline, 1996; Kohler, 2000; Casterline, 2001). Characteristics of innovations, of innovators and of the environmental contexts, all influence the diffusion of innovations (Wejnert, 2002).

The diffusionist perspective on fertility change has been mainly applied to historical settings in studies of the first demographic transition (FDT) (Tolnay, 1995; Bocquet-Appel & Jakobi, 1998; Van Bavel, 2004). In particular, Goldstein and Klüsener (2014) found that the fertility decline in Prussia between 1980 and 1910 is consistent with the diffusionist perspective of fertility transition. The validity of this approach has also been tested on the contemporary fertility decline in developing countries (Watkins, 1987; Weeks *et al.*, 2000; Bocquet-Appel *et al.*, 2002). However, the diffusionist perspective can be applied in general to demographic change. In particular, diffusion mechanisms can be in place whenever there is an innovation in demographic behaviours. The 'Ready, Willing, and Able' model for innovation and diffusion (Coale, 1973; Lesthaeghe & Vanderhoeft, 2001) offers an explanation for the successful diffusion of new demographic behaviours, while social interaction effects play a decisive role for the success, timing, and pace of diffusion of the innovative demographic behaviour (Montgomery & Casterline, 1996).

The diffusion process in the second demographic transition (SDT) (Van de Kaa, 1987) involves ideational change and the spread of new demographic behaviours (i.e. the diffusion of non-marital cohabitation, divorce, illegitimate childbearing, and single parenthood). In accordance with the SDT framework, spatial patterns of family formation and their socioeconomic, cultural, and political correlates are found in several developed countries. Areas that were forerunners in the FDT were found to be forerunners also in the SDT (Lesthaeghe & Neels, 2002; Valkonen *et al.*, 2008; Lesthaeghe & Lopez-Gay, 2013). Vitali *et al.* (2015) identify female educational expansion as the main driver behind the emergence of the new fertility behaviour.

The hypothesis that social interactions are important in shaping the emergence of lowest-low fertility was put forward by Kohler *et al.* (2002), and subsequent research has shown the relevance of social networks in shaping fertility choices in contemporary advanced societies (e.g. Bernardi *et al.*, 2007; Balbo & Barban, 2014).

In addition to social influence and social learning, however, it is important to point out that other key factors that shape fertility decisions might develop through a diffusion process across space and which might be particularly important when studying advanced societies with low fertility. In particular, we refer to the diffusion of institutions and institutional practices. Such institutions and practices can influence fertility and the compatibility between work and family in modern societies. Several theories argue that institutions matter for fertility choices, for example, McDonald's (2000) gendered fertility theory

DOI: 10.1002/psp

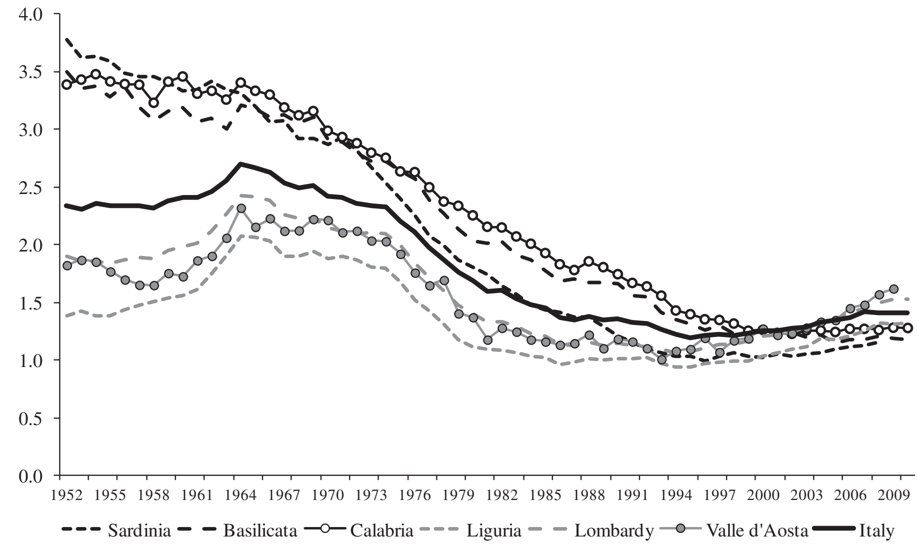
on the role of family-oriented and market-oriented institutions. Empirical results show that childcare provision matters for fertility (Hank & Kreyenfeld, 2003; Rindfuss *et al.*, 2010) and therefore the diffusion of childcare provision is indeed a diffusion of fertility change. The diffusionist perspective can be broadened to include the diffusion of institutional practices and innovation in institutions that matter for fertility choices, factors that are usually not well captured by standard socioeconomic variables. Some innovations in institutions might be directly related to fertility, for example, the diffusion of family-friendly workplaces. It is difficult to separate the role of culture (ideas) from the role of institutions in influencing fertility, as culture shapes institutions and institutions shape culture. It is however possible that the diffusion of practices within institutions that are important in shaping fertility choices nowadays might be as important as the diffusion of contraceptive practices has been for the demographic decline.

A necessary (but not sufficient) condition for a diffusionist perspective is the existence of correlation across space for a given behaviour. Geographical maps have been serving this purpose for a long time. The next step is to incorporate a diffusion process into statistical models.

SUB-NATIONAL FERTILITY PATTERNS IN CONTEMPORARY ITALY

Italy presents great intra-country variation in fertility (e.g. Kertzer *et al.*, 2009). Livi-Bacci (1977) and Watkins (1990) show that regional fertility differentials existed in Italy before the FDT. Historically, fertility was considerably higher in the south of Italy than in the centre and north. Fertility started to decline during the mid-1960s and the decline came to a halt in 1995, when a period total fertility rate (TFR) of 1.19 was recorded. From 1995 onwards, fertility has been slightly increasing at the national level, and territorial differences have emerged again, to the point that in very recent years there has been a reversal, in that it is the north that now shows the highest regional fertility.

Figure 1 shows the evolution of the TFR over the period 1952–2010[1] for three selected southern regions, Sardinia, Basilicata, Calabria and three selected north-western regions, Lombardy, Liguria, and Valle d'Aosta. Liguria had the lowest TFR in Italy for almost the whole period, which was already low at 1.39 in 1952. A very low fertility level was observed also for the north-western region of Piedmont in 1952, while the TFR in Sardinia was 3.8 and it was also above 3 in other southern regions. The northern regions of Liguria and Emilia



Source: Istat, Survey on Live Births after 2004.

Figure 1. Total fertility rate in Italy and four selected Italian regions over the period 1952–2010: Sardinia, Basilicata, Calabria (south), Lombardy, Liguria, and Valle d'Aosta (north-west).

DOI: 10.1002/psp

Romagna were the first two regions to cross the lowest-low fertility threshold of 1.3 in 1979, followed by other northern regions. The same threshold was crossed more than 10 years later in southern regions, starting in 1991 with Sardinia. In the same way as in the early 1980s they were the forerunners of lowest-low fertility, in the 2000s, the northern regions were the forerunners of fertility recuperation. By 2008, in fact, all northern and central regions, with the exception of Trentino-Alto-Adige, had exited from lowest-low fertility. Instead, the majority of southern regions continued to record lowest-low fertility levels in 2010. Italian regional data therefore suggest that the aggregate level hides great intra-country variation. Provincial-level data, which started to be collected in 1999, offer the possibility to study more carefully sub-national fertility patterns.

Figure 2 shows that in 1999, most southern provinces showed a TFR above the national average; conversely, most northern provinces showed a TFR below the national average, while the reversal holds in 2010.

DATA

We use data for 110 Italian provinces (NUTS-3) over the period 1999–2010.[2] The main dependent variable is the provincial period TFR (Source: Istat, Survey on Live Births).[3]

As correlates of fertility, we use gross domestic product (GDP) and measures of the gender gap in the labour market, migrant contribution to fertility, and secularisation.

GDP is expressed in Euros per inhabitant and is calculated at current market prices (Source: Eurostat, Regional Statistics). In regression analyses, we also consider the square of GDP in order to capture the non-linear relationship between TFR and GDP.

Gender gap in the labour market is a relative measure of women's employment. It is equal to one minus the proportion of working women aged 15 to 64 years, relative to the same proportion calculated for men, multiplied by 100 (Source: Istat, Labour Force Quarterly Survey for the period 1999–2003 and Labour Force Survey after 2003). This indicator varies between 0% (no gender gap, i.e. women's employment rate equals that of men) and 100% (greatest gender gap, i.e. women's employment equals zero).

Fertility of foreigners is the percentage of births to two foreign parents on all births (Source: Istat, Migration and calculation of yearly resident population).

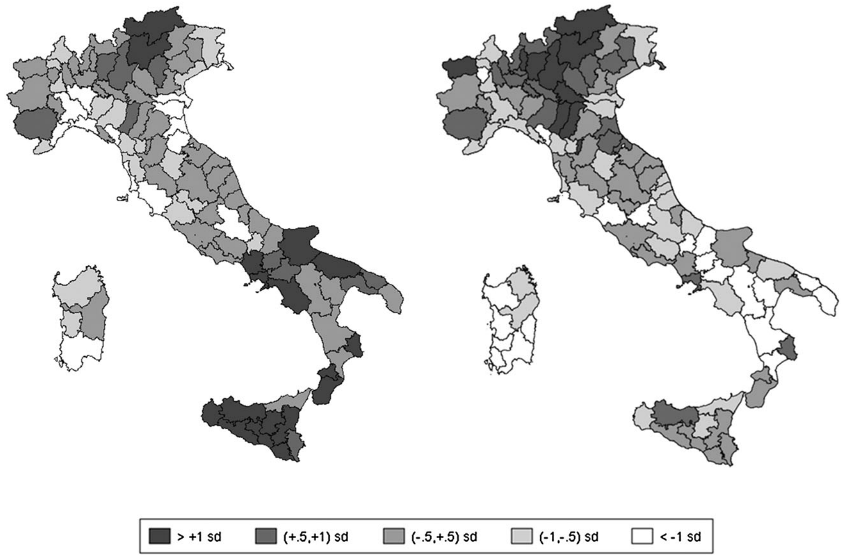


Figure 2. Total fertility rate (TFR) in Italian provinces in year 1999 (left) and 2010 (right). The legend is to be read in terms of standard deviations (SD) from the mean: ">1 SD" indicates provinces whose TFR is 1 SD above the mean; "(0.5;1)" between 0.5 and 1 SD above the mean; (−0.5;0.5) 0.5 SD around the mean; (−1;−0.5) between 0.5 and 1 SD below the mean; "<−1" 1 SD below the mean. Mean, SD, and sample size were 1.18, 0.15, and 103, respectively, in 1999 (left) and 1.37, 0.14, and 110 in 2010 (right).

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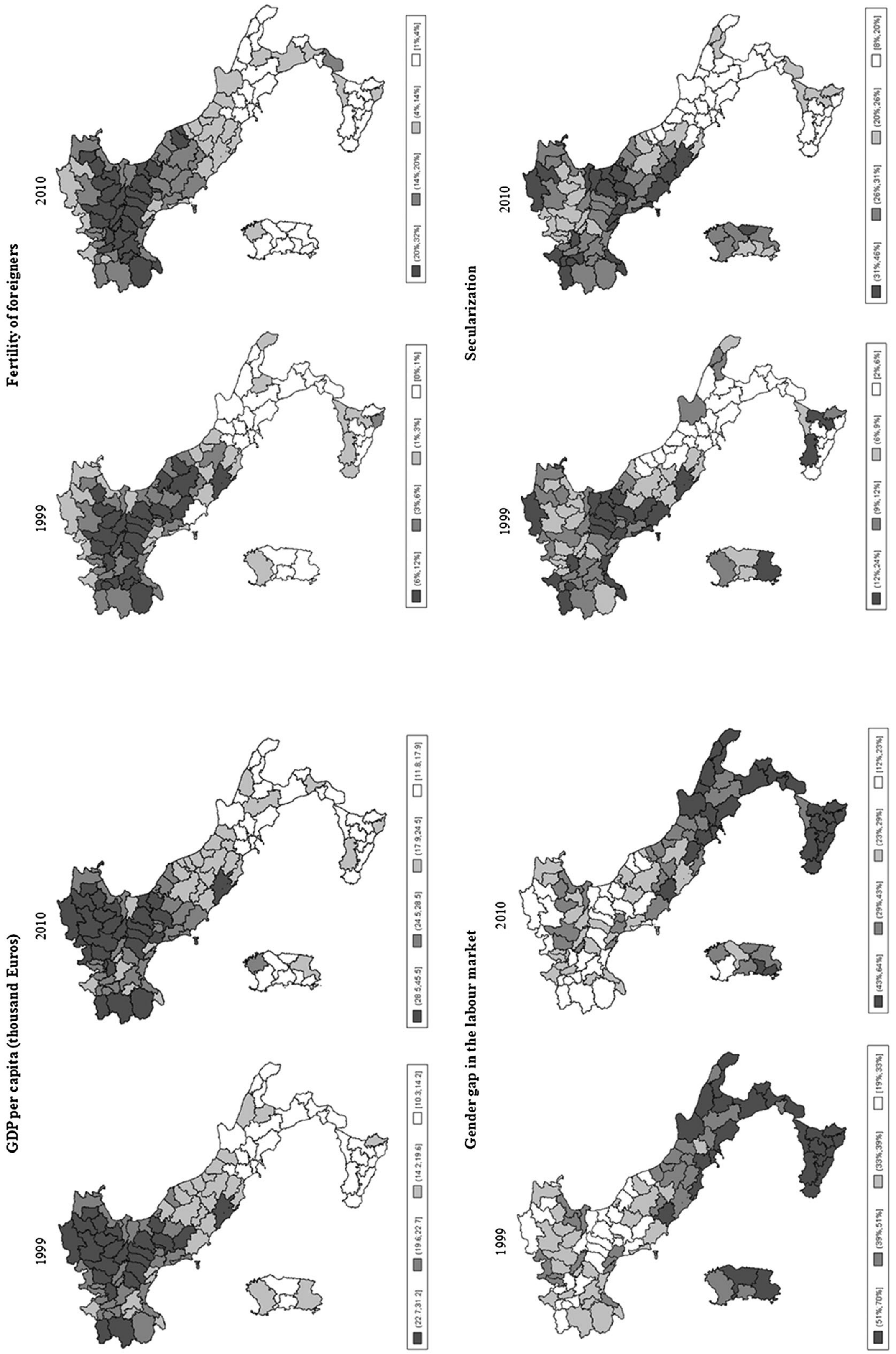

Figure 3. Observed values of indicators by quartile ranges, year 1999 and 2010. GDP, gross domestic product.

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Secularisation is the percentage of out-of-wedlock births on all births (Source: Istat, Survey on Live Births).

The spatial distribution of independent variables for the years 1999 and 2010 is reported in Figure 3. The highest values for all indicators, except gender gap, are observed in the north, intermediate values in the centre, and the lowest values in the south. The spatial distribution of our indicators remains stable over time between 1999 and 2010. North-eastern provinces are the richest, with GDP values in the top quartile of the distribution. Instead, GDP ranges in the lowest two quartiles for all southern provinces. The contribution of fertility of foreigners to the total fertility is quite low in southern provinces, while it becomes more important in central and northern provinces. Importantly, the percentage of children with foreign parents has been rising during the period of observation. In 1999, gender gap in the labour market is below 40% in most northern and central provinces, meaning that in these areas, although the employment rate is higher for men than it is for women, gender gap in the labour market assumes the lowest values observed for Italy. This same indicator ranges between 50% and 70% in most southern provinces, that is, the percentage of working women is less than half that of men in these provinces. The figure for 2010 shows that gender gap in the labour market has been decreasing all over Italy between 1999 and 2010, that is, the percentage of working women is growing. The percentage of out-of-wedlock births (secularisation) has increased substantially in most Italian provinces. Marriage is still regarded as a prerequisite for childbearing in southern provinces, where the percentage of out-of-wedlock births ranges between 8% and 20% in 2010. On the contrary, in most northern provinces, it ranges between 31% and 46%, while values for central regions lie in between. In regression analyses, all variables are standardised to ease comparisons.

FERTILITY CORRELATES OVER TIME

This session reviews the literature on the factors associated with fertility change and reconcile this literature with the theoretical framework offered by the diffusionist perspective on fertility change.

The existing international literature suggests a wide range of factors which could, to some extent, explain cross-country fertility differentials in contemporary advanced societies. One of the most cited factors is female employment. A well-known finding is that in advanced societies, the cross-country correlation between TFR and female employment reversed its sign, from negative to positive, by the late 1980s. Consequently, at a cross-sectional level, two distinct equilibria can be discerned: northern-European countries, characterised by high female employment and high fertility and southern-European countries, characterised by low female employment and low fertility (Ahn & Mira, 2002; Engelhardt & Prskawetz, 2004; Engelhardt *et al.,* 2004). A sign reversal in the cross-country correlation with fertility has also been observed for other indicators such as marriage propensity, cohabitation, divorce, extramarital births, and GDP (Billari & Kohler, 2004; Bryant, 2007). The contribution of fertility of foreigners on total fertility is another crucial correlate in low-fertility contexts (Coleman, 2006).

Figure 4 shows the evolution over time of the cross-provincial correlation coefficient between the period TFR and our four correlates of fertility: GDP, gender gap in the labour market, secularisation, and fertility of foreigners. Between 2002 and 2004, the correlation of GDP and fertility of foreigners with the TFR approaches zero. The same happens between 2004 and 2006 for the gender gap in the labour market and secularisation. One can then conclude that in those years, none of the indictors is correlated with fertility. A change in the correlation coefficient between fertility and each of its correlates over time is an indication that something is changing. Emerging values, norms, ideas, and alteration in the socio-economic context might be driving the change. Of course, such changes do not occur uniformly in all sub-national areas of the country. As it is clear from Figure 1, at the beginning of the 2000s, some provinces were experiencing increasing fertility and some others declining fertility. As explained by the diffusionist perspective on fertility decline, changes in fertility are the result of innovation diffusion and behavioural innovation spreading through social interaction processes causing new behaviours to diffuse among the population (and hence across different areas of the country) over time. Whenever there is a sign reversal in the cross-country correlation

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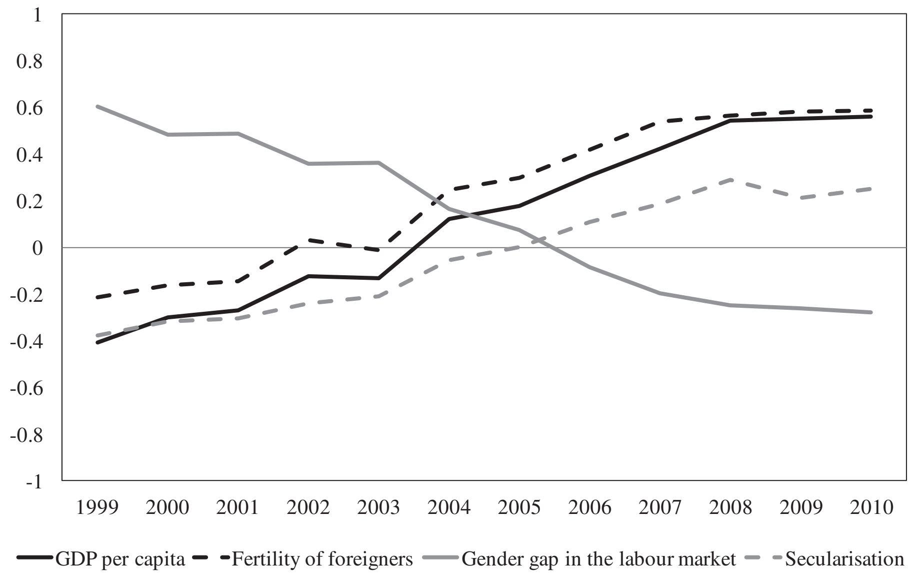

Figure 4. Correlation between total fertility rate and four indicators, Italian provinces, 1999–2010. The sample used to produce the figure refers to 110 Italian provinces (103 up to 2006).

between two variables, obviously there is a time period when the correlation crosses zero. Intuitively, the co-existence of opposite trends at the local level might well lead to a lack of global association. Thus, the cross-sectional correlation between fertility and its correlates starts to decline when a change in the association occurs in given areas. As the new ideas and behaviours that have caused such a change diffuse across space, the cross-country correlation lowers even further and reaches zero at a stage when the change is endorsed by approximately half of the areas. The correlation then changes its sign when other areas assimilate to the change. We argue that the observed change in correlation between fertility and the four indicators does not involve provinces that are randomly scattered across the country, but rather emerges in selected areas and diffuse across neighbouring provinces.

INCORPORATING SPACE INTO REGRESSION ANALYSES

The importance of spatial heterogeneity is recognised in cross-national studies of fertility in which cross-country differences are alternatively modelled through separate analyses by country, through dummy variables identifying groups of countries, country fixed effects, or random effects. Spatial heterogeneity is frequently considered also in sub-national studies of fertility in Italy (e.g. Dalla Zuanna & Righi, 1999; Caltabiano *et al.*, 2009; Castiglioni & Dalla Zuanna, 2009).

The concept of spatial dependence or spatial autocorrelation, instead, is less commonly considered, although spatial contiguity generally induces dependence in demographic behaviours, and it is an element for the successful diffusion of innovations. A number of studies called for attention on the existence of spatial patterns and the need to take these into account when studying demographic behaviours (Boyle, 2003; Goodchild & Janelle, 2004; Goodchild & Janelle, 2004; Castro, 2007; Voss, 2007; Chi & Zhu, 2008; Lesthaeghe, 2010). Although geographically referenced data have become increasingly available, it is still uncommon for demographers to explicitly account for spatial dependence. In particular, very few studies model spatial dependence in fertility (Weeks *et al.*, 2000; Waldorf & Franklin, 2002; Işik & Pinarcioglu, 2006; Muniz, 2009; Potter *et al.*, 2010; Goldstein & Klüsener, 2014).

Figure 2 shows that closer provinces have more similar TFRs than provinces that are far apart for all years in the time series. Therefore, it cannot be assumed that fertility observed in a given province is independent from fertility observed in a neighbouring province. Not only we observe a spatial pattern in fertility, we find

DOI: 10.1002/psp

similar patterns also for the correlates of fertility (Fig. 3). However, independence among observations is the main assumption of traditional regression models.

In what follows, we do not superimpose a geographical structure, which would a priori generate clusters of regions, as it would, for example, the inclusion of control dummy variables identifying the three macro regions of south, north, and centre. Rather, we explicitly take into account spatial dependence among provinces by the means of spatial modelling, which allows for the introduction into regression models of spatial (and social) interactions among neighbouring observations in space. The idea is to include in the statistical model a function of neighbouring observations through a spatial lag operator generating a new variable, which is a weighted average of the neighbouring observations. Besides the features of cross-sectional spatial regressions, panel data with spatial interaction also allows accounting for the dynamics of the process being studied.

Diffusion processes during fertility transitions have been studied empirically in only few contributions. Existing studies have modelled diffusion using an autocorrelation coefficient on fertility – the dependent variable – via the spatial lag model (Montgomery & Casterline, 1993; Tolnay, 1995; Palloni, 2001; Muniz, 2009; Goldstein & Klüsener, 2014). The spatial lag model represents a diffusive process in the dependent variable, and as such, it is appropriate for modelling social networks as well as diffusion processes, including the diffusion of behavioural innovations and new ideas, because such processes spread among individuals over space. This is essentially the idea behind the diffusionist perspective about fertility transitions and in fact, the spatial lag model was proposed by Casterline (2001) for modelling the dynamics of innovative fertility behaviours.[4]

However, explanatory variables also show a spatial pattern. Following Vitali *et al.* (2015), this paper employs a spatial Durbin model that introduces a spatial lag for the explanatory variables, in addition to the spatial lag for the dependent variable. In so doing, we allow for spatial autocorrelation not only in fertility levels but also in the levels of all the explanatory variables. Importantly, our approach is able to identify the drivers of fertility change, that is, to identify which characteristics measured in the own province matter for fertility change (direct effect) and which characteristics of the neighbouring provinces matter for diffusion (indirect effect).

A SPATIAL CROSS-SECTIONAL PERSPECTIVE

Geographically weighted regression (GWR) techniques are local regressions that allow the estimation of heterogeneous associations between the dependent and independent variables when the observations are measured at different locations (Brunsdon *et al.*, 1998, 1999; Fotheringham *et al.*, 2002).

For a given cross-section and for each location, the GWR model employed in this paper fits a single linear regression equation of the form

$$y_i = \beta_0(u_i, v_i) + \Sigma_k \beta_k(u_i, v_i) x_{ik} + \varepsilon_i \tag{1}$$

where y_i denotes the response variable in province $i = 1, \ldots, N$, x_{ik} the k-th independent variable measured in province i, (u_i, v_i) the coordinates (longitude and latitude) of the centroid of the i-th province, $\beta_k(u_i, v_i)$ the parameter associated to the k-th variable in the i-th province, and ε_i the error term (Fotheringham *et al.*, 2002). For each observation (i.e. province) i, GWR estimates an intercept term and a vector of parameter estimates using a modification of the weighted least squares model. Each regression equation (one for each province) is calibrated using a different weighting scheme on the basis of spatial dependence among neighbouring provinces. Provinces can be thought of as (irregular) spatial polygons, and it is possible to calculate their centroids' geographic coordinates on the basis of which geographical distances can be computed. Weights are inversely proportional to the distance between provinces' centroids.[5]

Geographically weighted regressions account for spatial heterogeneity, allowing the effect of covariates to vary spatially, and for spatial dependence, allowing the effect of explanatory variables in neighbouring locations to have more influence than those further away. However, spatial dependence only works through the association between the explanatory variables and the dependent variable. We apply GWR methodologies cross-sectionally to the years 1999 and 2010.

Işik and Pinarcioglu (2006) and Muniz (2009) have used GWRs to explain fertility differentials

DOI: 10.1002/psp

in Turkey and Brazil, respectively. Here, we study 110 Italian provinces (103 in 1999). In order to compare the marginal effect of the different indicators on fertility, that is, in order to assess which indicator has more explanatory power on fertility, we run a regression model, which simultaneously includes the following independent variables: GDP and its square, fertility of foreigners, gender gap in the labour market, and secularisation. In order to investigate if and how the cross-provincial association between fertility and its correlates changed over time, we run two GWR models, for 1999 and 2010. All variables are standardised according to their mean and standard deviation.[6]

A SPATIAL PANEL PERSPECTIVE

The next step in the analysis is the inclusion of the time dimension. The interaction between provinces is modelled through a spatially lagged dependent variable allowing the TFR in a given province to depend on the TFR observed in neighbouring provinces. Spatial panel methodologies are one of the most promising tool to analyse the spatial and the temporal dimensions simultaneously.

Following Vitali *et al.* (2015), we estimate the spatial panel Durbin (SDM) model with spatial fixed effects (Anselin, 1988) which, using the notation in Elhorst (2010), takes the form

$$y_{it} = \delta \sum_{j=1}^{N} w_{ij} y_{it} + \boldsymbol{x}_{it}\boldsymbol{\beta} + \sum_{j=1}^{N} w_{ij} \boldsymbol{x}_{ijt}\boldsymbol{\gamma} + \mu_i + \varepsilon_{it} \qquad (2)$$

where i and j index the provinces ($i, j = 1,\ldots,N$) and t the time periods ($t = 1,\ldots,T$). For each time period t, the dependent variable y_{it} is the TFR observed in province i in year t, y_{jt} is the TFR observed in province j, δ is a scalar parameter, $\boldsymbol{x}_{it}$ is the vector of independent variables measured in province i, $\boldsymbol{x}_{ijt}$ is the vector of independent variables measured in province j, both of dimension $1xk$, while $\boldsymbol{\beta}$ and $\boldsymbol{\gamma}$ are matching vectors of fixed unknown parameters. Finally, w_{ij} represents the weight assigned to province j. The introduction of the spatial lag ($\sum_{j=1}^{N} w_{ij} y_{jt}$) on the dependent variable allows the TFR in a given province (y_{it}) to depend on the TFR observed in neighbouring provinces (y_{jt}). The parameter δ allows testing the assumption that fertility in each province is related to fertility observed in neighbouring provinces, and it measures the average strength of this relationship. This parameter is often referred to as spatial autocorrelation coefficient. A positive and statistically significant estimate of δ has to be interpreted as spatial autocorrelation in the TFR or, in other words, that provinces with similar TFR tend to cluster together in space, which is evidence in favour of spatial diffusion of fertility. When $\boldsymbol{\gamma} = 0$, the model reduces to the spatial lag or spatial autoregressive (SAR) panel model. The advantage of the spatial Durbin model is that it allows fertility in each province i to depend on a set of explanatory variables measured in the same province ($\boldsymbol{x}_{it}\,\boldsymbol{\beta}$), as well as on an average of the same independent variables measured in neighbouring provinces ($\sum_{j=1}^{N} w_{ij}\,\boldsymbol{x}_{ijt}\,\gamma$). The vector parameter $\boldsymbol{\gamma}$ allows testing the assumption that fertility in each province i is affected by characteristics averaged over its neighbouring provinces.[7]

LeSage (2008) and LeSage and Pace (2009) show that in a spatial Durbin model, the total average effect of a change in an independent variable on the dependent variable is the combination of the average direct and the average indirect effects. In our case, the average direct effect measures the impact of a change in a given independent variable in province i on fertility in the same province. Because each municipality is considered its neighbours' neighbour, a change in a given independent variable in municipality i affects fertility in municipality i also through an effect going from municipality i to neighbouring municipality j, and then back to i through spatial autocorrelation (δ) in fertility. The average direct effect also takes into account these feedback loops. The average indirect effect, instead, measures the average impact on fertility in province i ($i \neq j$) of a change in a given independent variable in neighbouring provinces. We can think of the indirect effects as a measure of the social interaction process occurring among people living in different provinces. Finally, the average total effect, that is, the sum of the direct and indirect effect, measures the impact of a change in a given independent variable on fertility taking into account both own-province and spatial spillover effects.[8] For a detailed explanation of the computation and interpretation of direct, indirect, and total effects, see Vitali *et al.* (2015).

The sample used for longitudinal analyses refers to the period 1999–2008 and to 99 provinces.[9]

DOI: 10.1002/psp

RESULTS FROM THE SPATIAL CROSS-SECTIONAL MODELS

Results from GWRs show two main characteristics of the association between fertility and its correlates in Italy. First, these associations are geographically heterogeneous, being positive in some areas, and negative or not statistically significant in others. Second, notwithstanding some important continuities, most associations change in magnitude and in sign between 1999 and 2010.

Figures 5 and 6 plots the local parameter estimates by quartile ranges together with their relative *t*-values for the years 1999 and 2010, respectively. Results from GWRs are a series of local parameter estimates, which measure the associations between each independent variable and the TFR for each province, controlling for the other independent variables included in the model. To ease interpretation, parameter estimates are reported on a map. In this way, it is possible to detect spatial non-stationarity in the association between variables.

In both 1999 and 2010, provincial fertility is negatively associated with GDP in the central provinces. As one moves from the centre to the north, the association first becomes weaker, that is, closer to zero, and then turns positive. Conversely, in southern provinces, the association between fertility and GDP is not statistically different from zero. Compared with 1999, in 2010, more and more provinces in the north start showing a positive association between fertility and GDP, while this association gets close to zero or is not statistically significant in most central and southern provinces. Non-linearity in the association between fertility and GDP is captured by the positive parameter estimates for GDP^2 (results not shown). Fertility is higher in the most economically developed areas of the country (northern provinces), which confirms that 'advances in development reverse fertility declines' (Myrskylä *et al.*, 2009).

Fertility of foreigners is positively and significantly associated with fertility in Italian provinces. The spatial distribution of fertility of foreigners mapped in Figure 3 shows a great variability across Italian provinces, with high contribution in the north and low contribution in the south. This is due to the fact that foreigners are concentrated in northern and, to a lesser extent, central provinces. For most immigrants, the south of Italy represents a transit place for reaching their final destination in northern Italy or continental Europe, and therefore foreigners in southern provinces tend to have lower fertility than in the rest of Italy.

Fertility is found to be positively associated with gender gap in the labour market in all provinces in 1999. In other words, at the end of the 90s in Italy there was an inverse relationship between women's employment and fertility in that an increase in women's employment compared with men's would have led to a further fertility decline. In 1999, the strength of the association between fertility and gender gap in labour market is lowest in the centre-north (0.11) and highest in the southern island of Sicily and the so-called 'Triveneto' (0.90), comprising the north-eastern regions of Veneto, Trentino-Alto Adige, and Friuli-Venezia Giulia. Interestingly, in 2010, for some provinces in the north and in the island of Sardinia, the association between fertility and gender gap in labour market becomes negative, meaning that in these provinces, women's employment (with respect to men's) is positively associated with fertility, while this association remains negative in all provinces in the south and in the island of Sicily. Previous studies documented that in a cross-country perspective, Italy, together with the other Mediterranean countries, maintains a negative association between fertility and female employment (Ahn & Mira, 2002). However, our results show that today such a negative association holds only for the south of Italy. Therefore, for southern provinces in 2010, we observe the traditional negative association between fertility and female employment. Such association is less important in the north of Italy, once the other variables are controlled for. Therefore, northern provinces are in between the traditional association observed in the rest of Italy and northern European countries, where high female employment is associated with high fertility. Though far from Scandinavian standards, northern Italian provinces allow an easier combination of work and children with respect to other areas of the country. Female labour force participation is in fact higher than in southern regions, and part-time work and childcare facilities are now more widespread.

The indicator chosen to represent secularisation is the proportion of out-of-wedlock births, therefore provinces where such indicator assumes high values are provinces with low religiosity. It is expected that these provinces will also show

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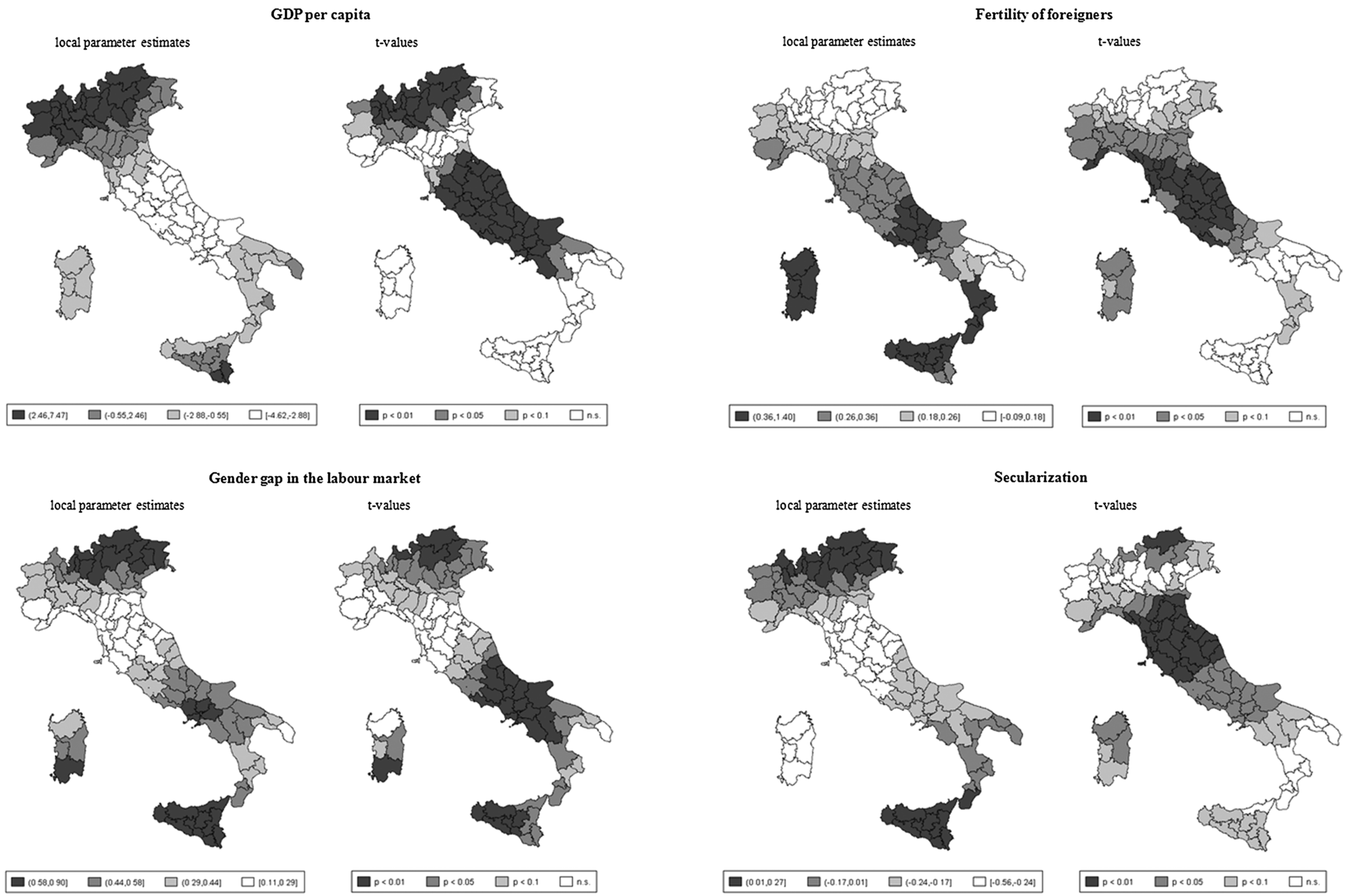

Figure 5. Results from geographically weighted regressions on total fertility rate: local parameter estimates by quartile ranges and *t*-values, year 1999. GDP, gross domestic product.

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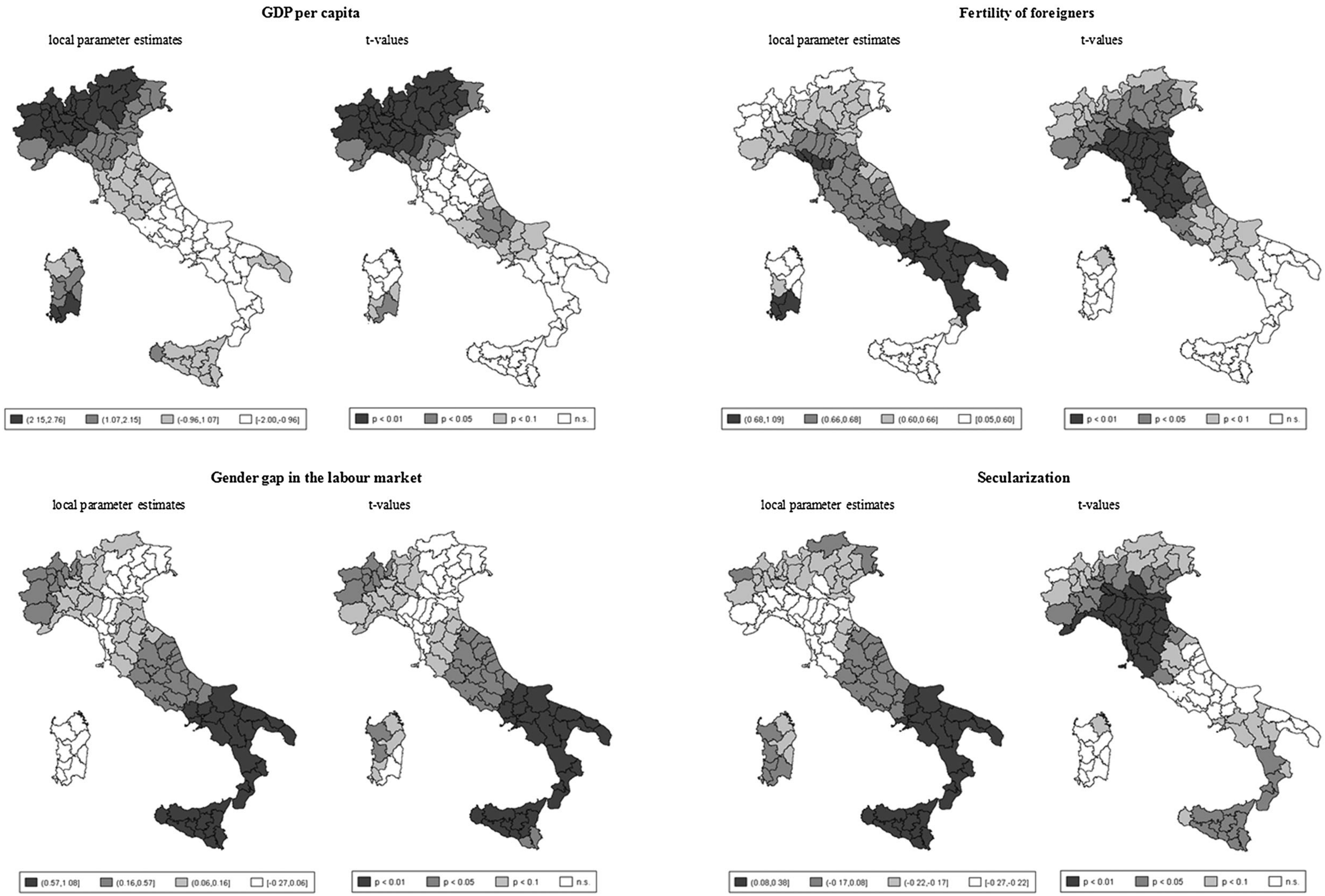

Figure 6. Results from geographically weighted regressions on total fertility rate: local parameter estimates by quartile ranges and *t*-values, year 2010. GDP, gross domestic product.

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high rates of divorces and legal separations, non-marital cohabitation, and civil marriages. In 1999, the association between secularisation and fertility is positive in two areas, Sicily and 'Triveneto' (one of the areas in Italy and Europe where the influence of Catholicism was most pervasive), while it is negative or not statistically significant in all other provinces. In 2010, the areas characterised by a positive association between fertility and secularisation has broadened to include, in addition to Sicily, most of the other southern provinces, whereas all other Italian provinces are characterised by a negative association between fertility and secularisation. The highest values of secularisation are found in the north of Italy, while southern provinces are more traditional in this respect.

RESULTS FROM SPATIAL PANEL MODELS

Table 1 reports coefficient estimates for the traditional panel model with provincial fixed effects and the SDM model. The estimated spatial autocorrelation coefficient of the TFR (δ) is equal to 0.3, indicating a positive spatial dependence of fertility across provinces.

In order to correctly measure the sign and magnitude of the impact of a change in a given independent variable, we compute the average direct, indirect, and total effects (Table 2).

Table 1. Estimates of the regression of fertility (TFR) on selected indicators, panel, and spatial panel Durbin (SDM) models with provincial fixed effects, 1999–2008.

	Fixed-effects panel model		Fixed-effects SDM model	
	β	s.e.	β	s.e.
GDP	−1.321***	0.129	−0.410*	0.172
GDP^2	1.363***	0.123	0.457**	0.143
Fertility of foreigners	0.645***	0.032	0.337***	0.040
Gender gap	0.008	0.037	0.011	0.033
Secularisation	0.244***	0.029	0.084**	0.031
W * GDP			−0.925***	0.227
W * GDP^2			0.670**	0.203
W * fertility of foreigners			0.157*	0.063
W * gender gap			−0.099	0.059
W * secularisation			0.158**	0.053
ρ			0.302***	0.038

Note: All variables are standardised. The sample refers to 99 Italian provinces (Sardinia excluded).
***$p < 0.001$.
**$p < 0.01$.
*$p < 0.05$.
GDP, gross domestic product; s.e., standard error.

Table 2. Average effects of changes in selected indicators on fertility from spatial panel Durbin models with provincial fixed effects, 1999–2008.

	Total effects		Direct effects		Indirect effects	
	Mean	s.e.	Mean	s.e.	Mean	s.e.
GDP	−1.881***	0.253	−0.495**	0.141	−1.385***	0.262
GDP^2	1.582***	0.260	0.526***	0.130	1.056***	0.250
Fertility of foreigners	0.712***	0.067	0.361***	0.042	0.351***	0.065
Gender gap	−0.126	0.091	0.003	0.032	−0.129	0.080
Secularisation	0.346***	0.069	0.105**	0.029	0.241***	0.067

Note: All variables are standardised. The sample refers to 99 Italian provinces (Sardinia excluded).
***$p < 0.001$.
**$p < 0.01$.
*$p < 0.05$
GDP, gross domestic product; s.e., standard error.

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According to the total average effects, GDP is the most important predictor of fertility in Italian provinces, followed by fertility of immigrants. The total average effect of GDP is negative, suggesting a negative relationship between development and fertility, on average, across Italian provinces. The total average effect of fertility of immigrants is positive: increasing the contribution of fertility of immigrants by one standardised unit, the provincial TFR would increase by 0.71 standardised units. It should be noted that the effect of foreign fertility is probably underestimated as our data refer only to births that occurred to two foreign parents. If we had to considered births that occurred to couples with at least one foreign parent, the true contribution of fertility of immigrants on total fertility is expected to be higher. Gender gap in the labour market is not significant, suggesting that an increase in women's employment with respect to men's will not have an impact on fertility, on average. Provinces where secularisation is more widespread tend to have higher fertility than provinces where secularisation is less widespread. From GWRs, we know that the average effects mask different provincial patterns.

For each indicator considered, we are able to disentangle the average total effect into the average direct effect (i.e. the average effect of a change in each indicator in a given province on fertility in the same province) and the average indirect effect (i.e. the average effect of a change in each indicator in all neighbouring provinces on fertility in the own province). The direct average effect of GDP is negative and significant, and so is the indirect average effect, suggesting a large spillover effect on fertility from economic development in neighbouring provinces. Similarly, fertility of foreigners and secularisation show a positive impact on fertility via both a direct and indirect effect. Gender gap in labour market instead does not have any significant effect, direct or indirect. Our estimates show that fertility is influenced not only by characteristics of the area where fertility is measured but also by characteristics of neighbouring areas. Statistically significant indirect effects are to be interpreted as evidence that a change in local economies or in cultural characteristics in nearby areas is shown to have an impact on fertility.

We acknowledge that results presented in this paper refer to provincial-level data and therefore, because of the ecological fallacy problem, they need not be interpreted as proxies for individual-level behaviours. It would be ideal to study diffusion of innovations in demographic behaviours using network data, which are unfortunately rarely available.

CONCLUDING REMARKS

This paper contributes to the demographic literature on the diffusionist perspective to fertility transition by studying the temporal and spatial dimensions of Italian provincial fertility trends simultaneously. The paper also contributes to bringing space back into demographic analyses, by incorporating geographical proximity into cross-sectional regression analysis.

First, spatial heterogeneity across Italy is not just manifest in different levels in fertility at the country level, results from GWRs show that there is also substantial heterogeneity also in the association between fertility and its correlates, that is, GDP, secularisation, fertility of foreigners, and gender gap in the labour market across provinces. The strength, and in some cases, also the sign of such associations vary spatially. In other words, the association between each indicator and fertility varies locally from being statistically insignificant in some provinces to being significant in other provinces within a given country. Also, among provinces for which the association is significant, the magnitude and sign of the association varies considerably. We also showed that the associations between fertility and its correlates change over time in specific areas. For example, the negative association between fertility and women's employment with respect to men's (i.e. the negative estimate of the gender gap in the labour market coefficient) found in 1999 switches its sign in 2010 in northern areas while remains negative in the south. Second, results from SDM model show that spatial dependence in provincial fertility persists even after controlling for the usual correlates of fertility. The spatial autocorrelation coefficient always results positive and statistically significant, even after controlling for the usual correlates of fertility, which is interpreted as a confirmation of spatial diffusion in fertility. Finally, diffusion of fertility in a given area is demonstrated to

DOI: 10.1002/psp

depend not only on the economical, institutional, and cultural characteristics of the area but also on the characteristics of neighbouring areas. Hence, we conclude that the diffusionist perspective can still be helpful to explain fertility change in contemporary advanced societies. Future research will have to study diffusion on fertility change. In the study of demographic behaviours, spatial modelling is advisable when there are reasons to believe that the influence of neighbouring contexts is important. Contexts and spatial effects are embedded in individual decisions. Individuals shape and are shaped by the context in which they live. We have shown that in contexts characterised by internal heterogeneity and spatial dependence in fertility and its correlates, GWRs and spatial panel regressions are superior with respect to global models.

We acknowledge, however, that inference based on GWRs is susceptible to some limitations. First, the estimated local coefficients can change depending on the choice of the spatial kernel and bandwidth (Farber & Paez, 2007). Also, the spatial patterns observed in the GWR can be caused by multicollinearity among explanatory variables (Wheeler & Tiefelsdorf, 2005). Finally, the inference can be biased because of spatial autocorrelation among the regression residuals (Leung *et al.*, 2000).

NOTES

(1) The TRF trend remained positive until 2010 when it reached its peak, and it started to decline from 2011, when the effects of the economic crisis started to manifest (Strozza & De Rose, 2015).

(2) The number of administrative provinces increased from 103 to 110 between 1999 and 2010. In some analyses, we will refer to the sub-period 1999–2008 and to the subset of provinces that did not undergo administrative reconfiguration during the period under study.

(3) To correct for eventual tempo distortions, we also performed the analyses using as dependent variable a simplified version of the adjusted TFR (Bongaarts & Feeney, 1998), where the period TFR in a given year is corrected by the annual rate of increase in the mean age at birth. Results (not shown) are robust.

(4) The Lagrange multiplier test was also performed, and results were in favour of the spatial lag versus spatial error model.

(5) The vector of parameter estimates for a given location i is obtained using the following weighting scheme:

$$\widehat{\boldsymbol{\beta}}(u_i,v_i) = \left(\boldsymbol{X}^{\mathrm{T}}\mathbf{W}(u_i,v_i)\boldsymbol{X}\right)^{-1}\boldsymbol{X}^{T}\mathbf{W}(u_i,v_i)\boldsymbol{y}$$

where $\mathbf{W}(u_i,v_i)$ is an $n \times n$ diagonal spatial weight matrix of the form

$$\mathbf{W}(u_i,,v_i) = \begin{pmatrix} w_{i1} & 0 & \cdots & 0 \\ 0 & w_{i2} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & w_{iN} \end{pmatrix}.$$

The generic entry w_{ij} is the weight given to location j for the estimate of the local parameters at location i. This weight follows a Gaussian distance decay and is equal to $w_{ij} = \exp[-1/2(d_{ij}/\mathrm{h})^2]$ where d_{ij} is the Euclidean distance between locations i and j. The term h is the bandwidth that determines the number of locations to be included in each local regression. As the bandwidth increases, the gradient of the kernel becomes less steep, and more locations will be included in the local calibration. The optimal bandwidth for a fixed spatial kernel with a Gaussian weighting function is around 150 km in 1999 (103 provinces) and about 200 km in 2010 (110 provinces), and it was chosen using the Akaike information criterion, which minimises the root mean square prediction error.

(6) Estimation is carried out using the 'spgwr' library (geographically weighted regression) in R.

(7) Spatial dependence operates through a spatial weight matrix (W), which is a block-diagonal matrix constant over time. It has dimension NT × NT and is a non-stochastic row-standardised matrix, which takes into account the neighbouring structure of the spatial units. Its entries, the weights, are specified as follows:

$$w_{ij} = \begin{cases} \dfrac{1}{\eta_i} \text{ if } j \in N(i) \\ 0 \quad \text{otherwise} \end{cases}$$

where $N(i)$ defines the set of all neighbours to the spatial unit i and η_i is the cardinality of $N(i)$ (i.e. the number of neighbours to spatial unit i), and it is assumed that a unit cannot be its own neighbour, that is, $w_{ii} = 0$. In this case, neighbours are defined on the basis of a contiguity criterion, such that two locations are neighbours if they share a border or an edge.

(8) The model is estimated using the 'xsmle' procedure (spatial panel data models) in Stata.

DOI: 10.1002/psp

(9) We include in the sample those provinces that did not undergo administrative changes during the period in order to have a balanced panel. Thus, the region of Sardinia is excluded from longitudinal analyses because four of its provinces came to exist in 2006. In the same way, in order to disregard the administrative changes that occurred starting from 2009, we restrict our analyses to 1999–2008.

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