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Changing determinants of low fertility and diffusion: A spatial analysis for Italy

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Improving our understanding of the key drivers and implications of population change

ABSTRACT

Italy is a case study in lowest-low fertility. Its internal heterogeneity is substantial and changes over time. Historically, the South had higher fertility, but in recent years it the North has become the area with the highest fertility. This paper adopts a diffusionist perspective to fertility to study the current temporal and spatial trends in Italian provincial fertility, considering indicators of secularization, female employment, migrant fertility and economic development. We make use of geographically weighted regressions and spatial panel regressions from spatial econometrics 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, we find that 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.

KEYWORDS

Low Fertility; Italy; Geographically Weighted Regression; Spatial Panel Models.

EDITORIAL NOTE

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CHANGING DETERMINANTS OF LOW FERTILITY AND DIFFUSION: A SPATIAL ANALYSIS FOR ITALY

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1. INTRODUCTION

The emergence of low and lowest-low fertility has triggered a vast literature that aims at assessing, in both a theoretical and empirical way, the determinants of fertility levels in contemporary advanced societies (for a recent review of the literature, see for instance Balbo et al. 2013b). Crucial research puzzles have to deal with fertility differentials across societies, i.e. variation across space, and historical trajectories, i.e. fertility variation over time. Related to these puzzles, the literature has tackled the question of which factors are associated with fertility, 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 analyse recent sub-national data from Italy, one of the countries where lowest-low fertility levels first emerged and where fertility has been below replacement for decades. We adopt a "diffusionist" perspective to fertility but enhance it with the study of factors associated with fertility dynamics over time and space. More specifically, we first discuss the potential relevance of a diffusionist perspective in the study of contemporary advanced societies characterised by low fertility by pointing to a variety of diffusion mechanisms that could come into play in these cases. Subsequently, after documenting the basic trends in the geographical heterogeneity of fertility within Italy, we add to the debate on the changing correlation between fertility and key socioeconomic factors by analysing sub-national data. We then discuss and apply 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 suggest that the diffusionist perspective might still be helpful in explaining fertility differentials and show the potential pitfalls and biases in estimating the relevance of factors associated with fertility in contexts characterized by regional heterogeneity.

2. DIFFUSION AND LOW FERTILITY

The well-known Princeton European Fertility Project (Coale and Watkins 1986; Watkins 1987; Bongaarts and 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 (Anderson 1986; Knodel and van de Walle 1979). These considerations are directly linked to the "diffusionist" perspective on fertility decline. In Bongaarts and Watkins' words (1996), "diffusion refers to the process by which innovation spreads among regions, social groups, or individuals, often apparently independently of social and economic circumstances”. In providing a review of the theoretical framework supporting the model of diffusion, Rogers (1995 p. 5) defines diffusion as “the process by which an innovation is communicated through certain channels over time among the members of a social system”. A similar definition is given in a seminal paper by Montgomery and Casterline (1993 p. 458), for whom “diffusion exists when the adoption of innovative ideas (and corresponding behaviour) by some individuals influences the likelihood of such adoption by others”. In all these definitions, diffusion is different from the other types of communication because it is driven by new ideas. 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 due to acquired knowledge and information regarding birth control techniques, spreading among people and places (Cleland and 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 dynamic in its essence and acts through social interaction, i.e. a process of social influence and/or social learning at the individual level through kinship, social and communication networks and the mass media (Retherford and Palmore 1983; Montgomery and Casterline 1996; Kohler 2000, 2001; Carter 2001). Characteristics of innovations, of innovators and of the environmental contexts, all influence the diffusion of innovations (Wejnert, 2002). Over time, this process results in a diffusion mechanism across space, leading to a general change. At the aggregate level, areas sharing a homogeneous cultural context are expected to have similar fertility trajectories.

The diffusionist perspective on fertility change has mainly been applied to historical settings (Tolnay 1995; Bocquet-Appel and Jakobi 1998; Van Bavel 2004; Murphy 2010; Goldstein and Klüsener 2014). 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. Based on the principle that the same process applies to contemporary settings where fertility is in transition, some scholars have tested the validity of this approach for contemporary fertility decline in developing regions of the world (Watkins 1987; Weeks et al. 2000; Bocquet-Appel et al. 2002; Guilmoto and Irudaya 2001). Indeed, the diffusionist perspective can be applied in general to demographic change, in particular as diffusion mechanisms can be in place whenever there is an innovation in demographic behaviours. The “Ready, Willing, and Able” (RWA) model for innovation and diffusion (Coale 1973; Lesthaeghe and Vanderhoeft 2001) offers an explanation for the successful diffusion of new demographic behaviours. According to the RWA framework, three preconditions need to be simultaneously met for new demographic behaviours to develop. One of the preconditions measures economic circumstances –the innovation's cost must be lower than its benefits ("readiness")–, whereas the other two preconditions measure norms and behaviours –the innovation must be culturally and ethically acceptable ("willingness"), and feasibly implementable ("ability"). The pace of the innovative demographic behaviour depends on the existence of barriers impeding any of the preconditions to be met. Social interaction effects play a decisive role for the success, timing and pace of diffusion of such innovative demographic behaviours (Montgomery and Casterline 1996).

For instance, the diffusion process in the Second Demographic Transition, or SDT (Van de Kaa 1987) involves ideational change and the spread of new ideas and demographic behaviours (i.e., the diffusion of non-marital cohabitation, divorce, illegitimate childbearing, and single parenthood). In accordance with the Second Demographic Transition framework, spatial patterns of family formation and their socioeconomic, cultural and political correlates are found in several European countries (Lesthaeghe and Neels 2002; Valkonen et al. 2008; Lesthaeghe and Lopez-Gay 2013), and in the United States (Lesthaeghe and Neidert 2006). Lesthaeghe and Neels (2002) find a common spatial pattern between the (First) Demographic Transition (FDT) and the SDT in Belgium, Switzerland and France, and similar results are found in a comparative study on Belgium and Spain (Lesthaeghe and Lopez-Gay 2013): in all countries, areas that were forerunners in the FDT are forerunners also in the SDT. The spatial contiguity observed for the two demographic transitions that are considered as two separate waves of demographic innovation, is interpreted as evidence of long-term regional subcultures (Lesthaeghe and Lopez-Gay 2013).

The hypothesis that social interactions are important in shaping the emergence of lowest-low fertility was put forward by Kohler, Billari and Ortega (2002), and subsequent, albeit limited, research has shown the relevance of social networks in shaping fertility choices in contemporary advanced societies (e.g. Büehler and Philipov 2005; Bernardi et al 2007; Keim et al. 2009; Balbo and Mills 2011; Balbo and Barban 2014; Balbo et al. 2013a).

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 very low and lowest-low fertility. In particular, we refer to the diffusion of institutions, institutional practices and policies, where such institutions, practices and policies can influence fertility and the compatibility between work and family in modern societies. Several theories argue that institutions matter for fertility choices, for instance McDonald's gendered fertility theory on the role of family-oriented and market-oriented institutions (McDonald 2000). Empirical results show that childcare provision matters for fertility at the subnational level (Hank and Kreyenfeld, 2003; Rindfuss et al. 2007; 2010) and therefore the diffusion of childcare provision is indeed a diffusion of fertility change. The diffusionist perspective can therefore 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. In the management literature, there is evidence for instance of diffusion in organisational practices (Guler et al. 2002). Some innovations in institutions might be directly related to fertility, for example the diffusion of family-friendly workplaces (Lee and Kim 2010). 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, fortunately, have been serving the purpose of documenting this correlation for a long time. The next step is to understand how to incorporate a diffusion process into statistical models, which might take into account covariates that may or may not necessarily be related to the diffusion. Again, a set of tools has been developed that allows dealing with this. In what follows, we analyse the case of Italy, examining provincial-level fertility dynamics through a diffusionist perspective, also taking into account the association of fertility with indicators of secularisation, women's employment, fertility of immigrants and economic development.

3. SUB-NATIONAL FERTILITY PATTERNS IN CONTEMPORARY ITALY

Italy presents great intra-country variation in fertility (e.g., Rallu 1983; Kertzer et al. 2009). The story of Italian geographical heterogeneity dates back in history and is not confined to a North-South divide. Livi-Bacci (1977) and Watkins (1990) show that regional fertility differentials existed in Italy before the FDT, which started at the end of the nineteenth century. Historically, fertility was considerably higher in the South of Italy than in the Centre and North. During the economic recovery following the Second World War fertility increased in the Centre and North (Terra Abrami and Sorvillo 1993), while in Southern Italy, where fertility was already high during the 1950s, it remained quite stable thereafter. The fertility trend reversed 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 until 2010, fertility has been slowly 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, something that used to characterize the South.

Figure 1 shows the evolution of the TFR over the period 1952-2010 for three selected Southern regions, Sardinia, Basilicata, Calabria and three selected North-Western regions, Lombardy, Liguria and Valle d'Aosta. Liguria has 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 (1.49 in 1952). In the same year, the TFR in Sardinia (one of the two main islands) was 3.8 and it was also above 3 in other Southern regions. Liguria (North-West) and Emilia Romagna (North-East) were the first two regions to cross the lowest-low fertility threshold of 1.3 in 1979 (with a TFR of 1.18 and 1.28, respectively), followed by other Northern regions. The same threshold was crossed more than 10 years later in Southern regions, starting in 1991 with Sardinia (1.29) followed in 1993 by Abruzzi (1.3), while Calabria (1.25) and Apulia (1.3) reached below replacement fertility in 1999 and 2003, respectively. 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 ceased to have lowest-low fertility. Instead, with only few exceptions, Southern regions continued to record lowest-low fertility levels in 2009. Particularly noteworthy is the case of Sardinia, which, during the 1950s was the region with the highest fertility, above 3.5 children per woman, and then, during the 1970s and 1980s experienced the fastest reduction in fertility among Italian regions until the 2000s, when it became the region with the lowest fertility with a TFR of 1.04 in 2001. 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.

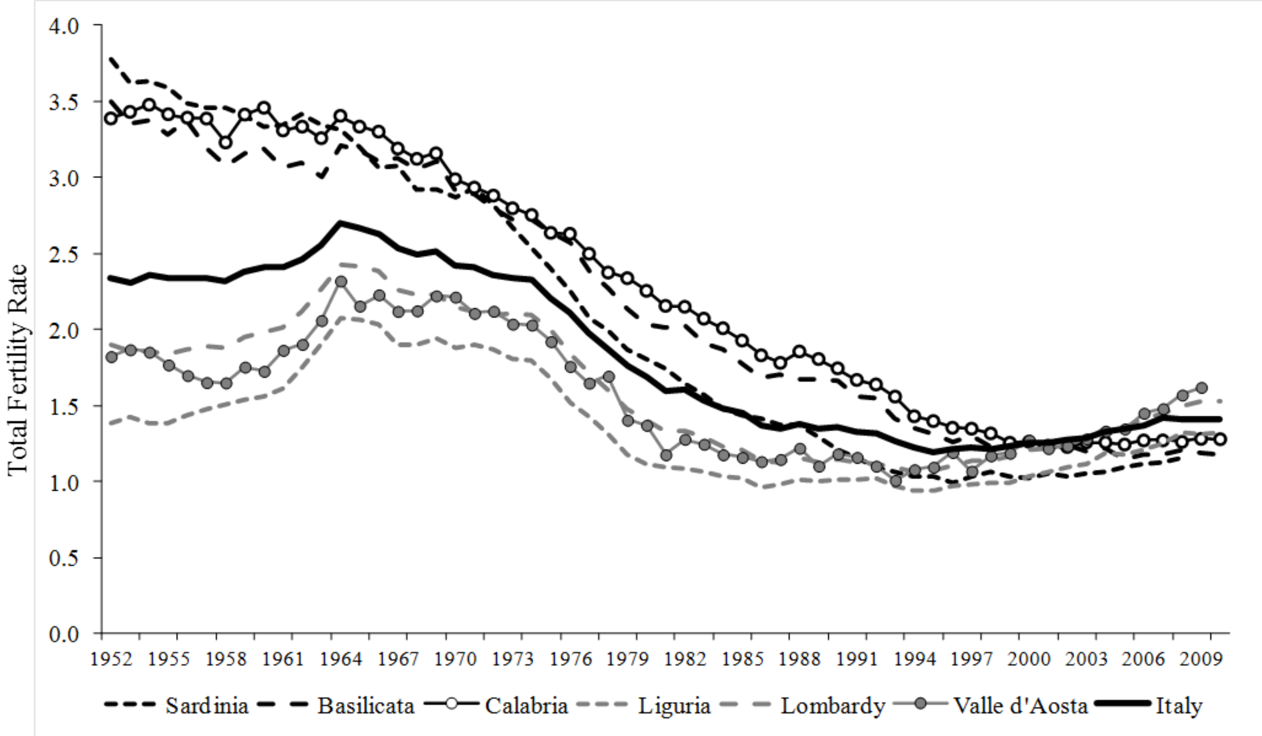

Figure 1: Total Fertility Rate in Italy and four selected Italian regions over the period 1952–2010: Sardinia, Basilicata, Calabria (South), Lombardy, Liguria and Valle d'Aosta (North-West)

Source: Istat.

Figure 2 shows the spatial pattern of sub-national fertility in Italy in two different time periods, 1999 and 2010. 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.

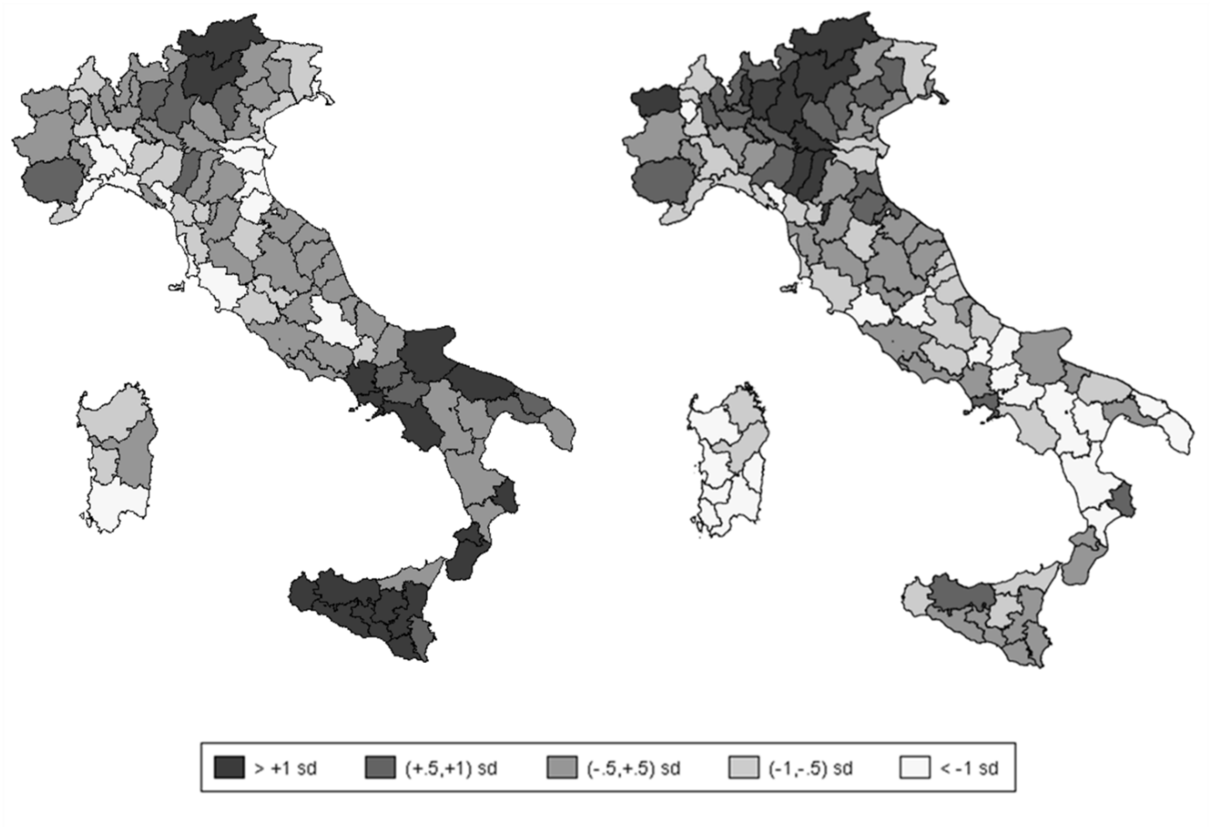

Figure 2: TFR in Italian provinces in year 1999 (left) and 2010 (right)

Note: The legend is to be read in terms of standard deviations (sd) from the mean: ">1 sd" indicates provinces whose TFR is one sd above the mean; "[.5;1)" between .5 and 1 sd above the mean; [-.5;.5) .5 sd around the mean; [-1;-.5) between .5 and 1 sb below the mean; "<-1" 1 sd below the mean. Mean, standard deviation and sample size were 1.18, 0.15, and 103 respectively in 1999 (left) and 1.37, 0.14, and 110 in 2010 (right).

Source: Istat, Survey on Live Births.

4. DATA

For subsequent analyses, we use data for 110 Italian provinces (NUTS-3) over the period 1999-2010. The number of administrative provinces increased from 103 to 110 between 1999 and 2010. In some statistical analyses we will refer to the sub-period 1999-2008 and to the subset of provinces which did not undergo administrative reconfiguration during the period under analysis. The main dependent variable is the provincial period TFR, obtained from the administrative Survey on Live Births, which Istat produces annually, since 1999. The survey covers the whole population of new-borns and collects information on births disaggregated by sex, citizenship, date and place of birth of the new-born, together with age, marital status and citizenship of both parents. As correlates of fertility, we use GDP and measures of the gender gap in the labour market, of migrant contribution to fertility, and of 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 well-known nonlinear 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, relative to the same proportion calculated for men (Source: Istat, Labour Force Quarterly Survey data for the period 1999–2003 and Labour Force Survey data after 2003). This indicator varies between zero (no gender gap in the labour market, i.e. women's employment rate equals that of men) and one (greatest gender gap, i.e. women's employment equal zero).

Fertility of foreigners is a relative measure, i.e. the proportion of births in a year to two foreign parents (Source: Istat, Migration and calculation of yearly resident population).

Secularisation. We use the proportion of all births that occur out-of-wedlock births as an indicator of secularization (Source: Istat, Survey on Live Births).

The spatial distribution of independent variables for the years 1999 and 2010 is shown in figure 3. The highest values for all indicators, except gender gap, tend to be observed in the North, with intermediate values in Central provinces 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, while 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 proportion of children with foreign parents has been rising during the period of observation. For example, the fourth quartile of the distribution of this variable went from a range of 6%-12% in 1999 to a range of 20%-32% in 2010, and the first quartile went from 0%-1% to 1%-4% in the same period. In 1999, gender gap in the labour market was 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, the labour market gender gap assumes the lowest value observed for Italy. This same indicator ranges between 50% and 70% in most Southern provinces, meaning that in these provinces the proportion of working women is less than half that of men. The figure for 2010 shows that gender gap in the labour market has been decreasing all over Italy between 1999 and 2010, i.e. the proportion of working women is growing. The proportion of out-of-wedlock births (secularisation) has increased substantially in most Italian provinces between 1999 and 2010. Marital childbearing is still dominant in Southern provinces, where the proportion 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 between those of the South and those of the North. In regression analyses all variables are standardized to ease comparisons.

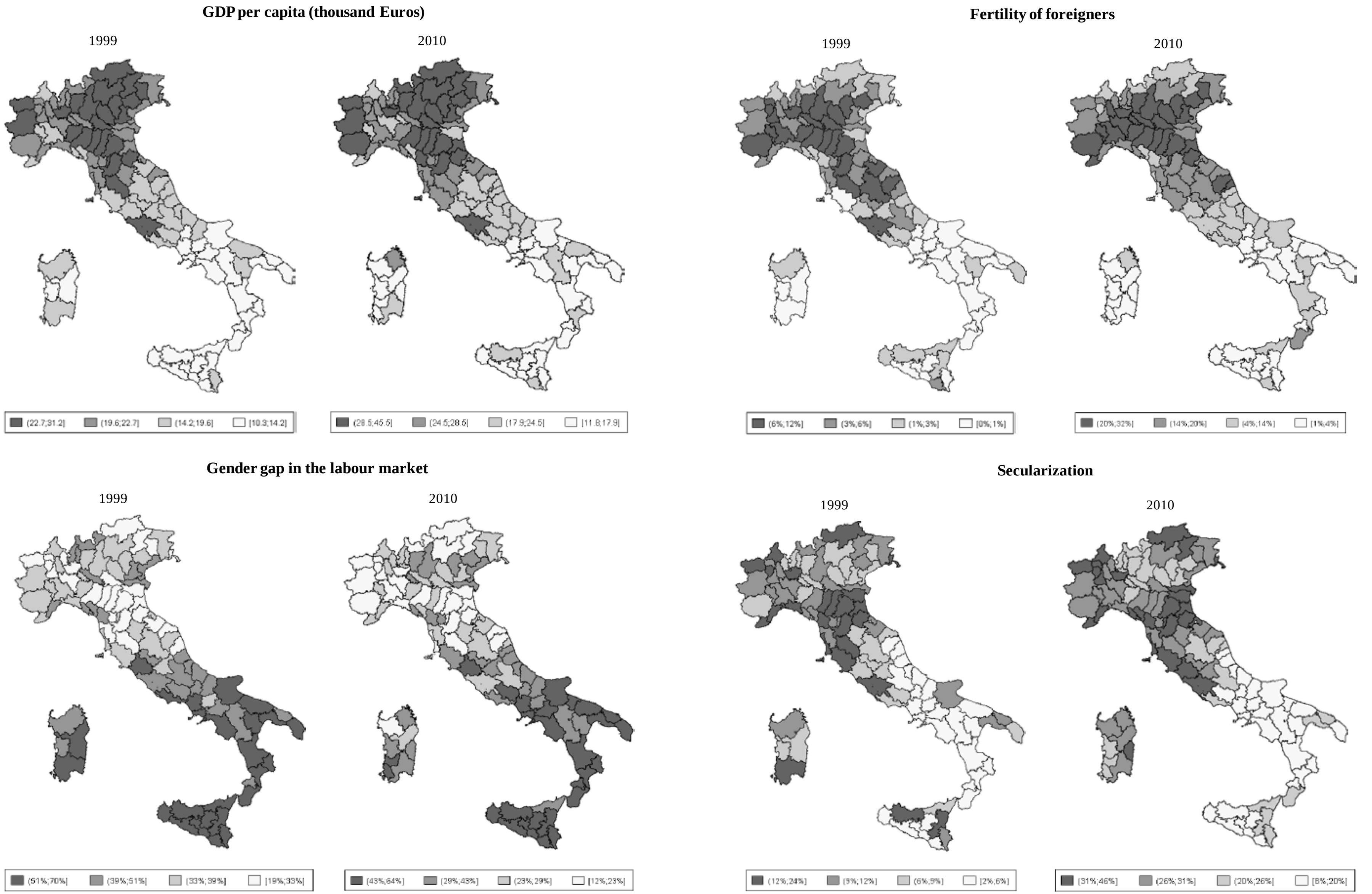

Figure 3: Observed values of indicators by quartile ranges, year 1999 and 2010

5. FERTILITY CORRELATES OVER TIME

Several scholars have studied sub-national fertility differentials and trends in Italy. Among these, Castiglioni and Dalla Zuanna (2009) find the fertility increase in Central and Northern Italian provinces in the late 1990s to be positively associated with the fertility of foreigners, the spread of new marital behaviours and income. Billari (2008) explains the recent fertility recuperation of North-Western regions in terms of earlier spread of new marital behaviours –the “new demographic spring” for Italy (Dalla Zuanna 2005) which includes non-marital cohabitation, extramarital births and marital instability. Dalla Zuanna and Righi (1999) provide an overview of sub-regional differences in fertility behaviours observed at the beginning of the 1990s, showing that Italian provinces can be grouped into six clusters using indicators that measure reproductive and marital behaviours and economic circumstances (marital and extramarital fertility, voluntary abortions, shotgun marriages, degree of industrialization, unemployment rate, and secularization). Franklin and Plane (2004) show that changes in Italian fertility in the period 1952–1991 can be explained by regional age-specific fertility differentials.

The existing international literature suggests a wide range of factors which could, to some extent, help 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 1980’s. Consequently, at a cross-sectional level, two distinct equilibria can be discerned: Northern-European countries are characterized by both high female employment and high fertility while Southern-European countries are characterized by both low female employment and low fertility (Ahn and Mira 2002; Engelhardt et al. 2004; Engelhardt and Prskawetz 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 (Billari and Kohler 2004; Prskawetz et al. 2010) and GDP (Bryant 2007). The contribution of foreigners fertility on total national fertility is another crucial correlate in low-fertility contexts (Coleman 2006; Billari 2008; Billari and Dalla Zuanna 2008; Sobotka 2008).

Figure 4 shows the evolution over time of the cross-provincial correlation coefficient between the period TFR and four indicators which is used in our regression analyses: gender gap in the labour market, proportion of out-of-wedlock births (secularization), GDP and contribution of 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 secularization. One can then conclude that in those years none of the indictors is correlated with fertility. An indication of change is variation in the correlation between fertility and the four factors identified. Emerging values, norms, ideas and alteration in the socio-economic context might be driving the changing correlation. Yet, changes do not occur uniformly within the country. As it is clear from Figure 1, at the beginning of the 2000s fertility was increasing in some provinces and decreasing in others. 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 between two variables, there is a time period when the correlation is approximately equal to 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 which are randomly scattered across the country, but rather emerges in selected areas and diffuse across neighbouring provinces.

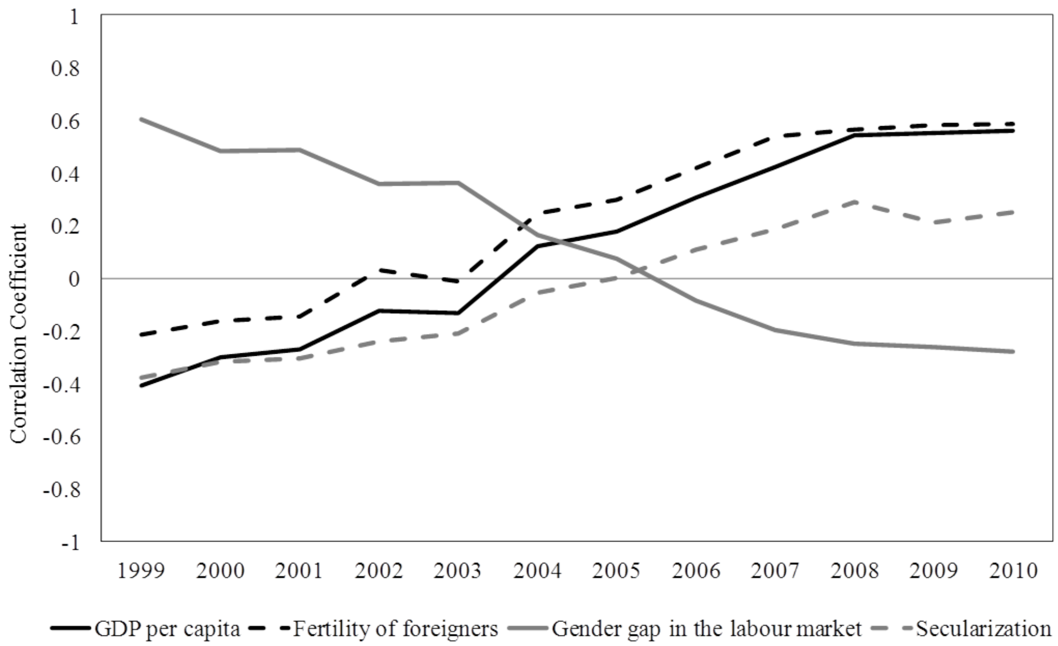

Figure 4: Correlation between TFR and four indicators, Italian provinces, 1999-2010
Note: The sample used to produce the figure refers to 110 Italian provinces (103 up to 2006).

6. METHODS: INCORPORATING SPACE INTO REGRESSION ANALYSES

The importance of spatial heterogeneity is recognized in cross-national studies on fertility in which cross-country differences are alternatively modelled through separate analyses by country (Engelhardt et al. 2004) or through dummy variables identifying groups of countries (Engelhardt and Prskawetz 2004), country fixed effects or random effects (Prskawetz et al. 2010). Spatial heterogeneity is frequently considered also in sub-national studies of fertility in Italy. For instance, Castiglioni and Dalla Zuanna (2009) focus their analyses only on Northern regions; Caltabiano (2008) and Caltabiano et al. (2009) compare cohort age-specific fertility between the North and the South (Lombardy and Campania).

The concept of spatial dependence or spatial autocorrelation, instead, is less commonly considered in fertility research, 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 and Janelle 2004; Weeks 2004; Castro 2007; Voss 2007; Chi and Zhu 2008; Lesthaeghe 2010; Vitali et al. 2013).

Although geographically referenced data have become increasing 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 and Franklin 2002; Işik and Pinarcioglu 2006; Muniz 2009; Murphy 2010; Goldstein and Klüsener 2014; Potter et al. 2010).

Figure 2 shows that Tobler's "first law of geography" (Tobler 1970) applies also for the Italian provincial TFR: provinces that are closer have more similar TFRs than provinces which are far apart, and this is true for all years in the time series. Provinces, therefore, cannot be modelled as independent units. Indeed, provinces are spatially dependent; in other words, fertility in a given province should not be assumed to be independent from fertility in a neighbouring province. Not only we can observe a spatial pattern in fertility across provinces, but we also find similar patterns for the correlates of fertility (Figure 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, for example, through the inclusion of 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 regression models. Spatial modelling 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 that generates a new variable, which is a weighted average of the neighbouring observations. Spatial dependence can then be modelled applying the spatial lag operator to the dependent variable, to independent variables or to the error term, yielding the spatial lag model, the spatial Durbin model and the spatial error model, respectively. Besides the features of cross-sectional spatial regressions, panel data with spatial interaction also allows accounting for the dynamics of the process being studied.

Some scholars have studied the diffusion processes during fertility transition through spatial modelling. While few have modelled diffusion with an autocorrelation coefficient on the error term using a spatial error model (Loftin and Ward 1983), most agree on using an autocorrelation coefficient on fertility –the dependent variable– via the spatial lag model (Montgomery and Casterline 1993; Tolnay 1995; Palloni 2001; Muniz 2009; Murphy 2010; Goldstein and Klüsener 2014). The spatial lag model represents a diffusion process in the dependent variable, and as such it is appropriate for modelling social network as well as diffusion processes, including the diffusion of behavioural innovations and the diffusion of new ideas, as such processes spread among individuals over space. This is essentially the idea behind the diffusionist perspective on fertility transitions and in fact, the spatial lag model was proposed by Casterline (2001) for modelling the dynamics of innovative fertility behaviours.

6.1. A SPATIAL CROSS-SECTIONAL PERSPECTIVE

Geographically Weighted Regression (GWR) techniques are local regressions which allow the estimation of heterogeneous relationships between the dependent and independent variables when the observations are measured at different locations (Brunsdon et al. 1998; 1999; Fotheringham et al. 2002). This technique is particularly useful when the relationship among variables differs from location to location (non-stationarity).

For a given cross-section and for each location, GWR fits a single linear regression equation of the form:

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

where y_i denotes the response variable in the province $i=1,...,N$, 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. The vector of parameter estimates for a given location $_i$ is obtained using the following weighting scheme:

$$\hat{\boldsymbol{\beta}}(u_i,v_i) = (\boldsymbol{X}^T \mathbf{W}(u_i,v_i)\, \boldsymbol{X})^{-1} \boldsymbol{X}^T \mathbf{W}(u_i,v_i)$$

$$\boldsymbol{y} \qquad (2)$$

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

$$\mathbf{W}(u_i,v_i) = \begin{pmatrix} w_{i1} & 0 & \cdots & 0 \\ 0 & w_{i2} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & w_{iN} \end{pmatrix} \qquad (3).$$

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 which 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. In order to choose the optimal value for the bandwidth, we use the Akaike Information Criterion (AIC), which minimizes the root mean square prediction error. Estimation is carried out using the "spgwr" library (Geographically Weighted Regression) in R.

GWRs 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. GWR methodologies are only available for the study of cross-sectional data and therefore we limit our analysis to the years 1999 and 2010.

Işik and Pinarcioglu (2006) and Muniz (2009) have used GWRs to explain fertility differentials in Turkey and Brazil, respectively. Here we study110 Italian provinces (103 in 1999), and use GWRs to estimate a regression equation for each province while taking into account spatial dependence in the model. In order to compare the marginal effect of the different indicators on fertility, i.e., in order to assess which indicator has more explanatory power on fertility, we run a regression model which simultaneously includes GDP and its square, fertility of foreigners, gender gap in the labour market and secularization. All variables are standardized according to their mean and standard deviation.

6.2. A SPATIAL PANEL PERSPECTIVE

The next step in the analysis is the inclusion of the time dimension in the study of diffusion of fertility. The interaction between locations is modelled through a spatially lagged dependent variable allowing the TFR in a given location to depend on the TFR observed in neighbouring locations.

Spatial panel methodologies are one of the most promising tools to simultaneously analyse the spatial and the temporal dimensions (Anselin 1988; Elhorst 2003, 2010; Baltagi et al. 2007; Anselin et al. 2008). In what follows, we employ a fixed effects spatial panel data regression model and compare coefficient estimates with those obtained through a traditional panel model with fixed effects.

The first model is the traditional panel model with spatial, i.e. provincial fixed effects which can be expressed as follows:

$$y_{it} = \boldsymbol{x}_{it}\,\boldsymbol{\beta} + \mu_i + \varepsilon_{it}, \qquad (4)$$

where i indexes the provinces ($i = 1,\ldots,N$) and t the time periods ($t = 1,\ldots,T$). The dependent variable y_{it} is the TFR observed in province i in year t, $\boldsymbol{x}_{it}$ is the vector of independent variables of dimension *1*x*k*, $\boldsymbol{\beta}$ a matching vector of fixed unknown parameters, while μ_i denotes province-specific fixed effects, assumed to be constant over time and independent of the error term ε_{it}. The error term ε_{it} is independently and identically normally distributed with mean 0 and variance to be estimated. Province-specific fixed effects control for all fixed (i.e. time invariant) provincial-specific characteristics.

The fixed effects panel model described in (4) can be extended to account for spatial patterns in both the dependent and independent variables. We estimate the spatial panel Durbin (SDM) model with spatial fixed effects (Anselin 1988) which, using the notation in Elhorst (2010), takes the form:

$$y_{it} = \delta \sum_{j=1}^{N} w_{ij}\, y_{jt} + \boldsymbol{x}_{it}\, \boldsymbol{\beta} + \sum_{j=1}^{N} w_{ij}\, \boldsymbol{x}_{ijt}\, \boldsymbol{\gamma} + \mu_i + \varepsilon_{it} \qquad (5)$$

where y_{it} is the TFR observed in location i at time 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 of dimension measured in province j, both of dimension *1*x*k*, while $\boldsymbol{\beta}$ and $\boldsymbol{\gamma}$ a 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 of 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 the 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 values of the 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 independent 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 ($\Sigma_{j=1}^{N} w_{ij}\ \boldsymbol{x}_{ijt}\ \boldsymbol{\gamma}$). The vector parameter $\boldsymbol{\gamma}$ allows testing of the assumption that fertility in each province i is affected by characteristics averaged over its neighbouring provinces. Spatial dependence operates through a pre-defined, user-specified spatial weight matrix (**W**). The spatial weight matrix is a block-diagonal matrix constant over time. It has dimension *NT*x*NT* and is a non-stochastic row-standardized matrix which takes into account the neighbouring structure of the spatial units. Its entries, the weights, are specified as follows:

$$w_{ij} = \begin{cases} 1/\eta_i & \text{if } j \in N(i) \\ 0 & \text{otherwise} \end{cases} \quad (6)$$

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 a location i) and it is assumed that a unit cannot be its own neighbour i.e. $w_{ii} = 0$. In this case neighbours are defined on the basis of a contiguity criterion, according to which two locations are neighbours if they share a border or an edge (queen criterion). The model is estimated using the “xsmle” procedure (Spatial Panel Data Models) in Stata.

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 province is considered its neighbours’ neighbour, a change in a given independent variable in province i affects fertility in province i also through an effect going from province i to the neighbouring province 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. The average total effect is the sum of the direct and indirect effect. It measures the impact of a change in a given independent variable on fertility taking into account both own-province and spatial spillover effects. For a detailed explanation of the computation and interpretation of direct, indirect and total effect, see Vitali et al. (2013).

The sample used for longitudinal analyses refers to the period 1999-2008 and to 99 provinces. We include in the sample those provinces which 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.

7. RESULTS

7.1. RESULTS FROM GEOGRAPHICALLY WEIGHTED REGRESSIONS

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

Figure 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 association 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 the map of Italian provinces. 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, i.e. closer to zero, and then turns positive. Conversely, Southern provinces, the association between fertility and GDP is not statistically different from zero. Compared to 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 statistically not significant in most Central 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 the recent finding that advances in development can reverse fertility declines (Myrskylä et al. 2009).

The 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 very 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 is a temporary place of residence before heading off for their final destination in Northern Italy or continental Europe (Venditto and Caruso 2012). Therefore, foreign couples 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 to men's would have led to a further fertility decline in Southern provinces. In 1999, the strength of the association between fertility and gender gap in labour market ranges from 0.11 in the Centre-North to 0.90 in two distinct areas: the island of Sicily and three regions in the North-East (the so-called "Triveneto", with Veneto, Trentino-Alto Adige, 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 is 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 (Brewster and Rindfuss 2000; Ahn and 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 pattern between fertility and female employment that was universal until the late 80s in all advanced countries. 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 secularization is the proportion of out-of-wedlock births, therefore provinces where such indicator assumes high values are provinces with low religiosity as well as higher diffusion of new family models. It is expected that these provinces will also show high rates of divorces and legal separations, non-marital cohabitation, and civil marriages. In 1999, the association between secularization 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 characterized by a positive association between fertility and secularization has broadened to include, in addition to Sicily, most of the other Southern provinces, whereas all other Italian provinces are characterized by a negative association between fertility and secularization. The highest values of secularization are found in the North of Italy, while Southern provinces are more traditional in this respect. Our results indicate that an increase in secularization would increase fertility in Southern provinces.

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 across provinces. 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. Also, among provinces for which the association is significant, the magnitude and sign of the association varies considerably.

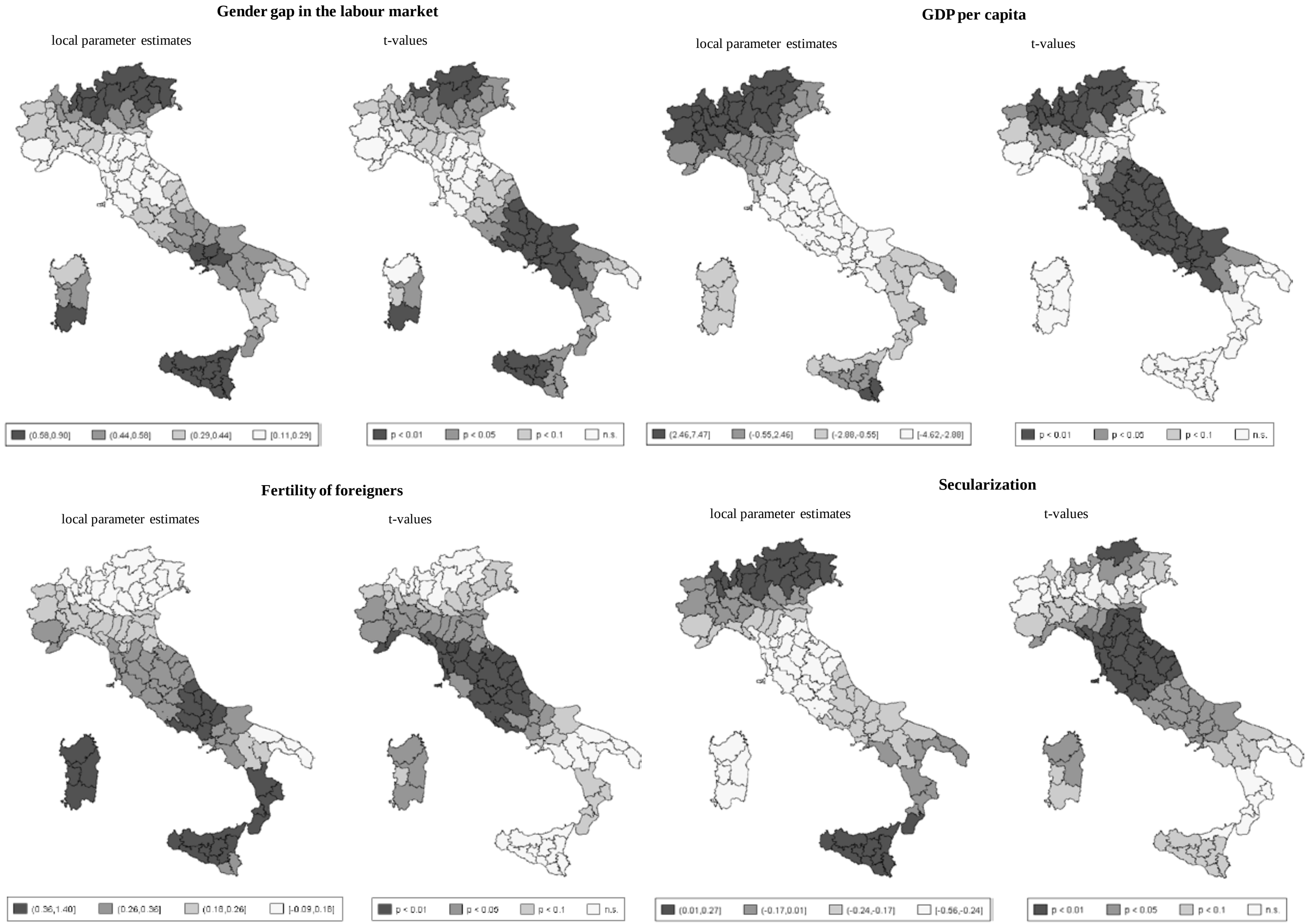

Figure 5: Results from GWRs on TFR: local parameter estimates by quartile ranges and t-values, year 1999

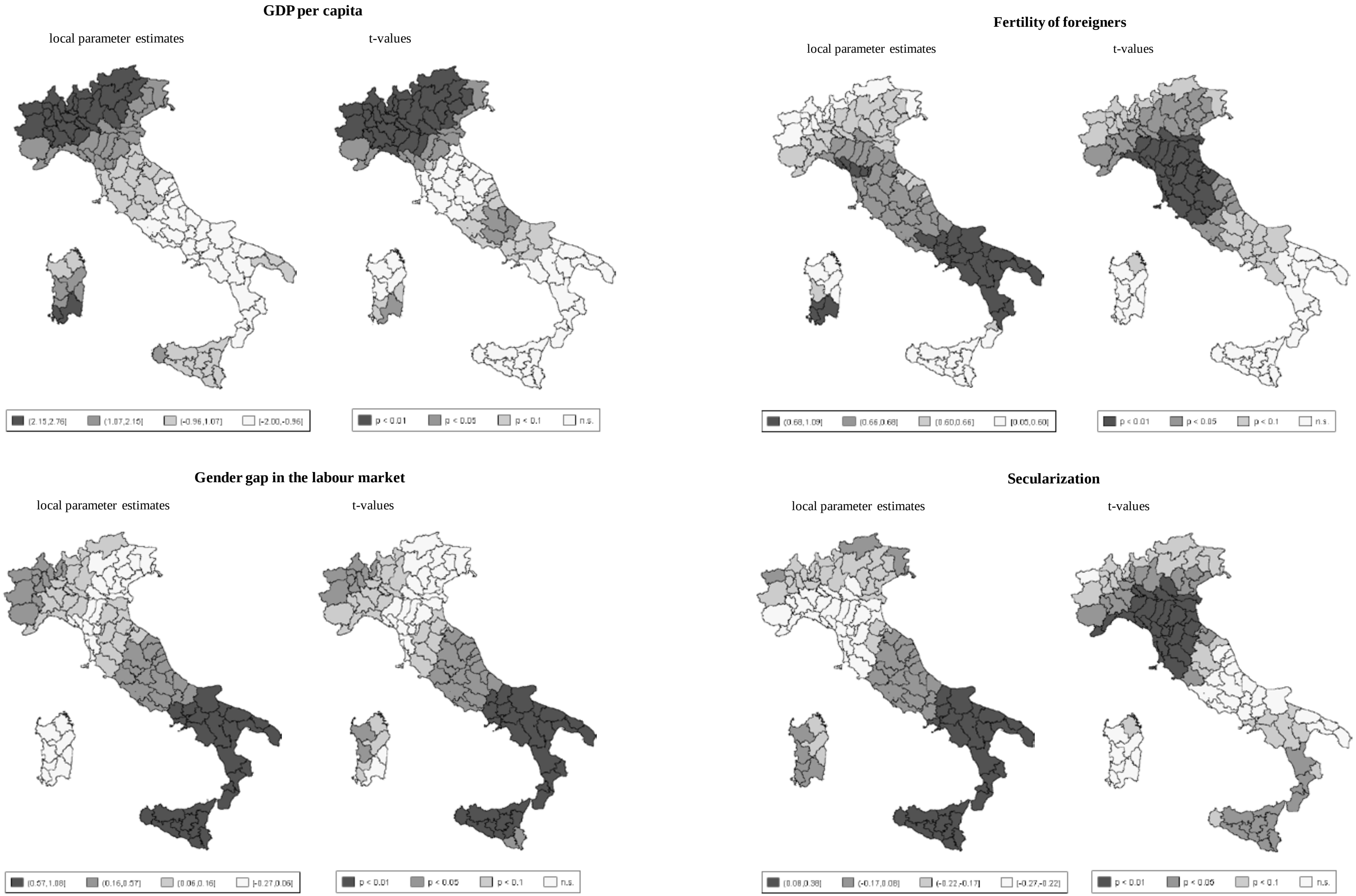

Figure 6: Results from GWRs on TFR: local parameter estimates by quartile ranges and t-values, year 2010

7.2. RESULTS FROM SPATIAL PANEL MODELS

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

	Fixed-Effects Panel Model				**Fixed-Effects Spatial Panel (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
Secularization	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 * Secularization					0.158	**	0.053
ρ					0.302	***	0.038

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

Note: All variables are standardized. The sample used to produce the figure refers to 99 Italian provinces (Sardinia excluded). p-value: *** < 0.001; ** < 0.01; * < 0.05.

Following LeSage (2008), in order to correctly measure the sign and magnitude of the impacts of a change in a given independent variable in the SDM, we compute the average direct, indirect and total effects (Table 2). If we look at the total average effects, based on the selection of indicators chosen, 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 standardized unit, the provincial TFR would increase by 0.71 standardized units. It should be noted that the effect of foreign fertility is probably underestimated as our data refer only to births which occurred to two foreign parents. If we had also considered births which occurred to couples with at least one foreign parent, the true contribution of fertility of immigrants on total fertility is expected to behigher than our estimate. 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 secularization is more widespread tend to have higher fertility than provinces where it is less widespread. From Geographically Weighted Regressions we know that the average effects mask different provincial patterns.

	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
Secularization	0.346	***	0.069	0.105	**	0.029	0.241	***	0.067

Table 2: Effects of changes in selected indicators on fertility from spatial panel Durbin (SDM) models with provincial fixed effects, 1999-2008

For each indicators 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 secularization 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 characteristics of other neighbouring areas.

8. 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. Results from Geographically Weighted Regressions show that the associations between fertility and GDP, secularization, fertility of foreigners and gender gap in the labour market are not homogeneous across provinces. The strength, and in some cases, also the sign of such associations vary spatially. Our results document that the associations between fertility and its correlates can be heterogeneous across areas within a given country.

By incorporating geographical proximity into longitudinal regression analysis, results from the spatial Durbin model show that spatial dependence in provincial fertility persists even after controlling for the usual correlates of fertility. The spatial lag coefficient always results positive and statistically significant, which is interpreted as a confirmation of spatial diffusion in fertility. Finally, diffusion of fertility in a given area is demonstrated to depend not only on the economical, institutional and cultural characteristics of the area, but also on the characteristics of neighbouring areas.

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. This paper focuses on Italian provinces, but the same considerations on the appropriateness of a spatial approach to model fertility are applicable to other national contexts characterized by internal heterogeneity and spatial dependence in both fertility and its correlates.

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