A Spatial Panel Analysis of Italian Regional Fertility

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ABSTRACT

Italy is a case study in lowest-low fertility. Its internal heterogeneity is substantial, and changing over time. While historically fertility was higher in the South, in recent years differentials have reversed. In this paper we adopt a macro-level perspective to investigate the convergence of regional fertility in Italy over the period 1952–2009. Then, we estimate a series of spatial panel regression models using fertility indicators as dependent variables, modelling spatial dependence in fertility among Italian provinces for the period 1999–2008. The relative effects on fertility of a selection of indicators are evaluated.

1. Introduction

Scholars have often studied fertility in Italy in cross-national comparisons with other low-fertility countries, namely Mediterranean and sometimes Central and Easter European countries. What is frequently overlooked in these studies is that Italy presents great intra-country variations (Rallu, 1983; Kertzer et al., 2009). The story of Italian regional heterogeneity dates back in history and is not just confined to a North-South divide. Regional heterogeneity embraces many aspects of the society as a whole. There are, in fact, different local economies, different labour markets and housing conditions, different levels of poverty, and different cultures. These differences in turns reflect different demographic behaviours among which, fertility behaviours. For these reasons, exploring regional differentials is likely to contribute to the study of determinants of lowest-low fertility.

Livi-Bacci (1977), Watkins (1990) and Franklin (2003) showed that regional fertility differentials existed in Italy even before the (First) Demographic Transition, which started at the end of the 19th century, and persisted after the political unification in 1861. 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, like all other industrialized countries, Italy witnessed its baby boom. In this period, fertility increased for most regions, but not for all of them. In Southern Italy, fertility was already high during the 1950s, and therefore it remained quite stable, while in most Northern and Central regions it experienced a steady increase (Terra Abrami et al., 1993). The fertility trend reversed during the mid-1960s. A fertility decline followed, ending in 1995, when a TFR of 1.19 was recorded. After 1995, fertility has been increasing at the national level, and regional differences have emerged again: during the 2000s, fertility increased for most regions, while for few others it continued its decline. In very recent years it is the North which shows the highest regional fertility, reversing what, for a long time, had been a typical characteristic of the South. Regional fertility also appears more heterogeneous than it was in the past, because we do not observe any longer a clear divide between Northern and Southern regions. For instance, fertility levels in the Southern region of Campania are more similar to those observed in North-Eastern regions than to other Southern regions.

Figure 1 maps the period total fertility rate (TFR) in the twenty Italian regions for the two years marking the beginning and the end of the period for which the national statistics institute (Istat) provides available data at the regional level. The figure shows two main features of Italian regional fertility: first, there is sub-national variation (*spatial heterogeneity*) and second, there is spatial clustering (*spatial dependence*). If in the early 1950s there was a (although not perfect) core-periphery pattern with high levels of TFR observed in Southern regions and low values observed in Northern regions, in 2009 the picture is completely different. In 2009 all Southern regions show a TFR below the national average, Campania and Sicily being the only exceptions; conversely, all Northern regions have a TFR above the national average, with the exception of Liguria. Of course regional differentials in fertility levels in 1952 were not the same as they are today. At the beginning of the period of analysis, in fact, Italian TFR was equal to 2.34 children per woman, with huge regional variations ranging from a maximum of 3.8 in Sardinia to a minimum of 1.39 in

Liguria. In 2009, when the national TFR was 1.41, variations around the mean were very moderate, ranging from 1.12 in Sardinia and Molise to 1.61 in Valle d'Aosta.

Figure 2 shows the evolution over time of the TFR for three selected Southern regions, Sardinia, Basilicata, Calabria and three selected North-Western regions, Lombardy, Liguria and Valle d'Aosta, over the period 1952–2009. Liguria held the lowest regional TFR in Italy for almost the whole period, with a value of 1.39 already in 1952. A very low fertility level was observed also for the North-Western region of Piedmont with a TFR of 1.49 children per woman in 1952. In the same year, the TFR in Sardinia (South) was 3.8 children per woman, that is almost three times the TFR of Liguria. The TFR was above 3 children per woman also in the Southern regions of Basilicata, Calabria, Apulia and Campania (3.49, 3.39, 3.38 and 3.18 respectively). 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 Friuli-Venezia-Giulia (North-East) in 1980 (1.25), and Piedmont (North-West), Tuscany (Centre) and Valle d'Aosta (North-West) in 1981 (1.27, 1.25 and 1.18). 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. Campania and Sicily instead always remained above the 1.3 threshold during the period of observation. Also the North-Eastern region of Trentino-Alto-Adige always remained above the threshold.

In the same way as in the early 1980s they were the forerunners of lowest-low fertility, in the 2000s Northern regions were also 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, the forerunner regions being Veneto (North-East), Lombardy (North-East), Valle d'Aosta (North-East), Emilia-Romagna (North-West) and Umbria (Centre) in 2004 (with TFR equal to, respectively, 1.357, 1.35, 1.33, 1.32 and 1.31). All Southern regions instead registered lowest-low fertility levels still in 2009, the only exception being Apulia, with a TFR of 1.34 children per woman. 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 1.12 children per woman in 2009.

Regional data therefore suggest that the study of fertility in Italy at an aggregate level hides great intra country variation and induces the loss of information. In this paper we study sub-regional fertility in Italy adopting a macro perspective. The aim of this paper is twofold. In a first step, using the regional economic convergence literature, we study the evolution of the Italian regional fertility differential over the period 1952–2009, i.e. the period for which there are available regional data (NUTS–2). We investigate whether Italian regional fertility has converged to a unique fertility regime, or whether, instead, different "Italies" exist for what concerns fertility measures.

Further, we are interested in understanding the causes of the very recent geographical reversal in Italian regional fertility. How did the North of Italy achieve the highest regional fertility levels, and how did the South achieve the lowest levels? In trying to answer this question we do not limit our investigation to a North-South comparison. Rather, to further explore sub-national differences we deepen the analysis to a lower level of territorial aggregation, the provincial level (NUTS–3). In this case, we limit our period of observation to the decade between 1999 and 2008, due to data restrictions. In this second step then, we study the evolution of Italian provincial fertility levels in association with a series of indicators of marital behaviours, female occupation, postponement, contribution of foreign fertility and economic development. Referring to the spatial econometric literature, we explicitly take into account spatial dependence among Italian provinces.

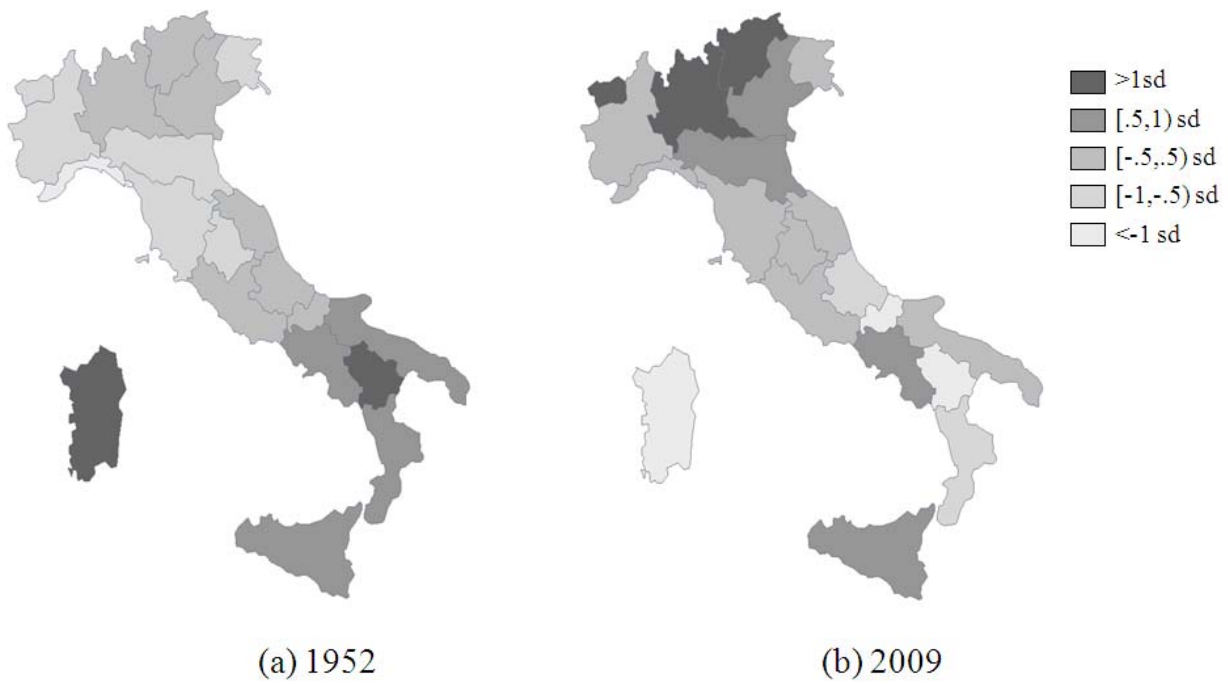

Figure 1: TFR in the 20 Italian regions; (a) year 1952 and (b) year 2009.

Note: The legend has to be read in terms of standard deviations from the mean: ">1 sd" indicates regions whose TFR is one standard deviation (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 and standard deviations were respectively equal to 2.39 and 0.74 in 1952 (a) and 1.37 and 0.13 in 2009 (b). Panel (a) considers Molise and Abruzzi as a unique region since Molise became an autonomous region only in 1964.

Source: Istat, "Tavole di Fecondità della popolazione italiana per regione di residenza" for the period 1952–2004, and Survey on Live Births after 2004.

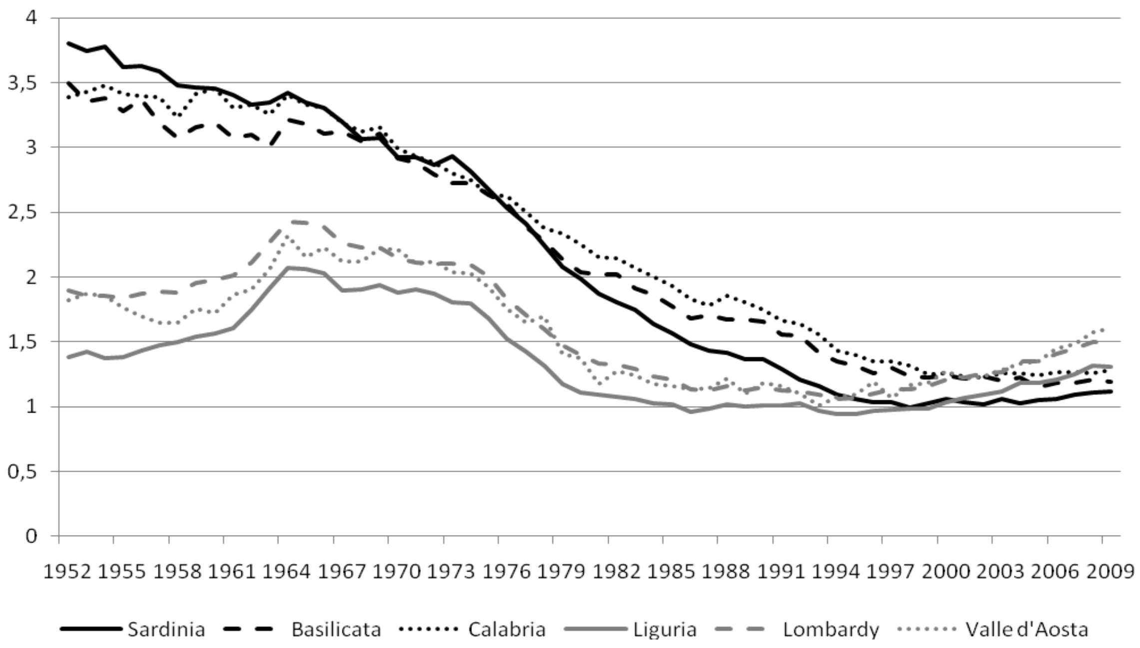

Figure 2: TFR in four selected Italian regions over the period 1952–2009: Sardinia, Basilicata, Calabria (South), Lombardy, Liguria and Valle d'Aosta (North-West).

Source: Istat, "Tavole di Fecondità della popolazione italiana per regione di residenza" for the period 1952–2004, and Survey on Live Births after 2004.

2. Fertility convergence

Lately, demographic literature has shown an increasing interest in convergence of demographic behaviours (Casterline, 2001; Wilson, 2001). Following this interest, a number of studies were published borrowing from economic growth theory, in particular to study fertility convergence (Franklin, 2003; 2009; Dorius, 2008; Lanzieri, 2010).

Sub-regional population projections have, for a long time, been based on the assumption that regional fertility would have converged to the national level, and so would have the regional age distribution, with migration seen as the only factor able to cause regional differentials in fertility levels, in the long run (O'Connell, 1981). But in many countries the expected convergence did not occur. Alonso (1980) explains the lack of within-country fertility convergence in terms of a cyclical effect, caused by short-term variations in "prosperity", and a developmental effect, due instead to changes in behaviours which permanently shift the fertility schedule.

In the case of Italy, before the baby boom a clear North-South divide in fertility levels characterized Italian regional fertility (see panel (a) in Figure 1). After the baby boom, there seems to be a diverging trend in fertility, while in the most recent years a new regional clustering is emerging (see panel (b) in Figure 1). Franklin (2009) finds evidence that a convergence in Italian regional fertility occurred in the period 1952–1995, although the speed of convergence differed across regions. The last time period considered in her study is 1995, i.e. exactly the year in which Italy experienced the lowest recorded fertility level. It is therefore not a novelty that Italian regions were converging to a common low level of fertility. It is however unclear whether, after the mid-90s, regional fertility continued the convergence or instead a new diverging pattern emerged.

Table 1 presents descriptive statistics of the Italian regional TFR and offers a first argument in favour of regional convergence since, by looking at its variance, the TFR in Italian regions was more heterogeneous in the 1952 than it was in 2009. The year 1995 is also present in the table because in that year the national TFR achieved its lowest recorded level.

Table 1: Descriptive statistics of regional period total fertility rate

Year	Min	Max	Mean	First Quartile	Second Quartile	Third Quartile	Variance	Skewness	Kurtosis
1952	1.386	3.805	2.384	1.751	2.208	3.178	0.582	0.477	1.849
1995	0.943	1.518	1.168	1.051	1.104	1.328	0.032	0.611	2.129
2009	1.120	1.610	1.367	1.295	1.380	1.445	0.017	-0.238	2.706

Note: In the year 1952 we consider Molise and Abruzzi as a unique region since Molise became an autonomous region only in 1964.

Source: Istat, "Tavole di Fecondità della popolazione italiana per regione di residenza" for the period 1952–2004, and Survey on Live Births after 2004.

Figure 3 shows the coefficient of variation of the TFR, i.e. the ratio between the standard deviation in the regional TFR and the national average for each year in the period 1952–2009. This variable measures changes in the dispersion of the TFR across Italian regions over the period we are considering. The reduction in dispersion indices over time is looked at to establish whether there is evidence of σ–convergence (Barro et al., 2004; Sala-i-Martin; 1996). The lower the value of the coefficient of variation, the stronger the argument in favor of σ–convergence. Dispersion in fertility decreased from 0.33 in 1952 to 0.17 in 1974, rose again until reaching the peak of 0.24 in 1981, declined through 2003 (0.83) and then started to increase again. A discussion on the causes of increases/reductions observed in this measure for the Italian fertility can be found in Franklin (2009), for the period until 1995. The fact that the coefficient of variation continued its decline after 1995 is probably due to the fact that most of the Southern regions were experiencing a continuing fertility decline, while most Northern and Central regions were already recording increasing fertility. If levels of fertility in the twenty Italian regions were aligned around similar values, their trends were not.

Relying on economic growth theory we identify absolute β–convergence in fertility if, unconditionally, the TFR in high-fertility regions decreased more than the TFR in low-fertility regions, during the period under analysis. Figure 4 gives an argument in favour of convergence. The figure displays a scatter plot between the annual TFR growth rate observed between 1952 and 2009 (y–axis) and the logarithm of TFR observed in the initial period, 1952 (x–axis). The figure shows that regions whose TFR was high in 1952 (i.e., the Southern regions), experienced larger fertility declines over the period considered, with respect to regions whose TFR was lower in 1952 (i.e., the Northern and Central regions).

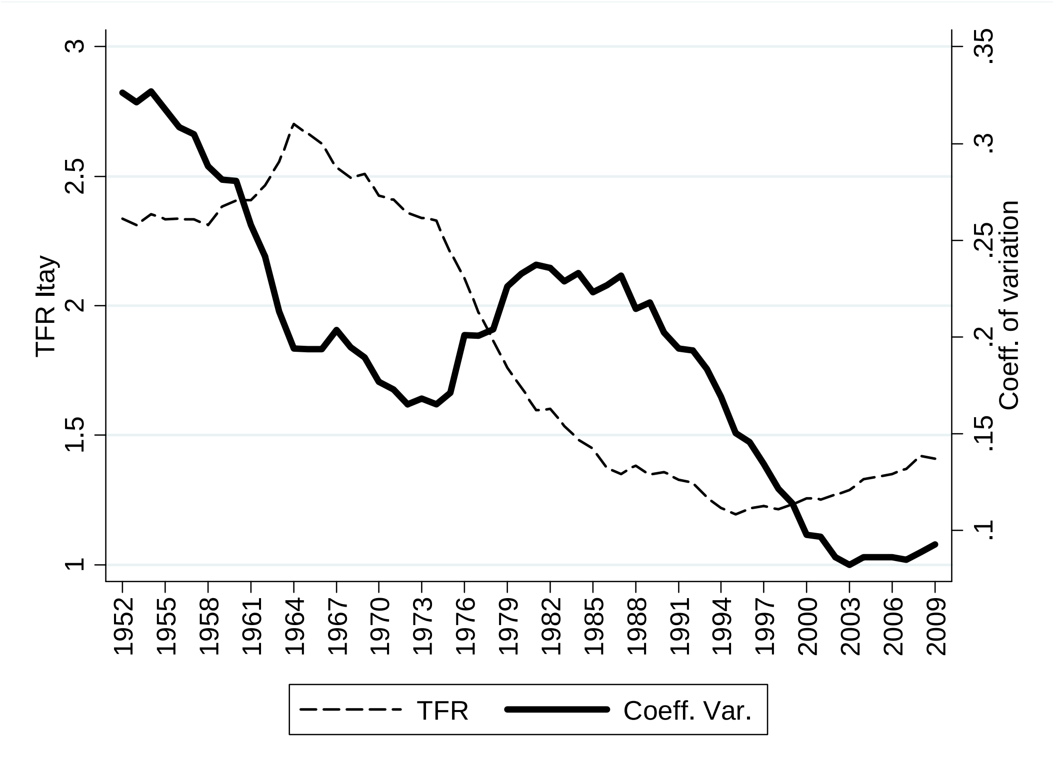

Figure 3: σ–convergence of TFR, 1952–2009 (Coefficient of variation)

Note: We only consider 19 regions: Molise is excluded for comparability over time because it became an autonomous region only after 1964.
Source: Istat, "Tavole di Fecondità della popolazione italiana per regione di residenza" for the period 1952–2004, and Survey on Live Births after 2004.

To test the significance of the absolute β–convergence hypothesis over the entire period, we run the following non-linear regression model:

$$(1/T)\ ln(TFR_{iT}/TFR_{i0}) = \alpha - [(1 - e^{-\beta T})/T]\ ln(TFFR_{i0}) + \varepsilon_{i0,T} \qquad (1)$$

where the right-hand side represents fertility growth rate of region i between year 0 and year T. From the estimated regression coefficients we then derive the speed of convergence (β). We also run the same regression including macro-area dummy variables corresponding to the five NUTS–1 subdivision into North-East, North-West, Centre –ref.–, South and Islands. The inclusion of macro-area dummy variables is meant to capture effects shared by regions belonging to the same macro-area.

Table 2 shows the results of the two non linear regression models with and without (basic Equation) macro-area dummy variables, for the whole period (1952–2009) and for six sub-periods, each covering 10 years, with the exception of the last one covering the period 2002–2009. The significantly positive estimate for β (1.25) in the whole sample has to be interpreted as evidence in favour of convergence: regions whose TFR was high in 1952, experienced a faster fertility decline over the period 1952–2009, compared to other regions whose TFR in 1952 was lower. The estimate for β in the regression with macro-region dummy variables is much lower (4% per year) with respect to the estimate obtained in the basic equation, suggesting that the speed at which *TFRs* converge across regions is higher than the speed of convergence within macro-regions. This result is obtained because regional *TFRs* are more similar within macro-regions than they are across macro-regions.

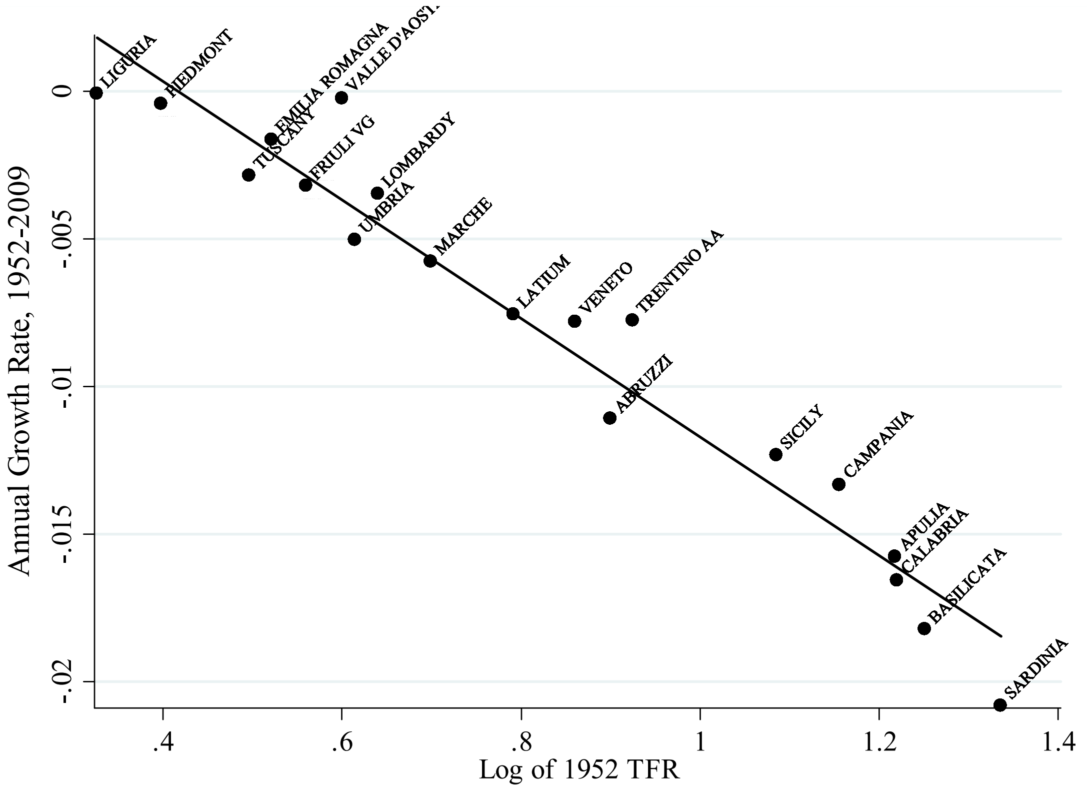

Figure 4: β–convergence of TFR. Scatter plot of the annual TFR growth rate during the period 1952–2009 versus $ln(TFR_{1952})$.

Note: We only consider 19 regions: Molise is excluded for comparability over time because it became an autonomous region only after 1964.

Source: Istat, "Tavole di Fecondità della popolazione italiana per regione di residenza" for the period 1952–2004, and "Rilevazione degli iscritti in anagrafe per nascita" after 2004.

The estimated β coefficient is positive in all sub-periods, with macro-regional dummy variables included and not included, in both cases with the exception of the period 1972–1982, the same decade for which we also found evidence of lack of σ–convergence. The speed of convergence is higher across regions than within macro-regions in all sub-periods, except for 1962–1972. For the ten-year period 1992-2002 we find an increase in the speed of convergence with respect to previous periods, confirming that around 1995 there was in fact convergence. In the following period, the speed of convergence decreases.

We know that there is convergence in Italian regional fertility until 1995. But what happens after 1995 is not entirely clear. Apparently, there is convergence (in 2009 maximum deviations from the mean equals to +.20 and -.29). But is it true convergence? Starting from mid-1990, most regions located in the North and Centre of Italy showed an increasing trend in fertility levels, while most regions in the South experienced a continued fertility decline. The coexistence of the two trends implied a progressive convergence of regional fertility levels. Of course, if the dual dynamics had to remain, convergence would be a transitory phenomenon. There are, however, reasons to believe that the South will adjust to the national trend in the future. For instance, Lesthaeghe et al., 2002 have shown that behavioral innovations in the context of the First and Second Demographic Transitions spread following a spatial pattern. According to this literature on spatial diffusion theories, we could expect that as Southern regions acted as followers in the fertility decline of Northern regions, they will also follow in the fertility recuperation, leading to another period of fertility convergence towards higher levels. Nonetheless, the year 2003 marked the beginning of a period of increasing variability in Italian regional fertility. The increase in the coefficient of variation justifies the hypothesis that regional variability in fertility started to increase again in the first decade of the 2000s.

Table 2: β–convergence of TFR

	Basic Equation				Macro-area Dummy Variables included			
	(β)		(s.e.)	Adj. R2	(β)		(s.e.)	Adj. R2
Period: 1952–2009	1.252	***	(0.001)	0.94	0.041		(0.023)	0.95
Period: 1952–1962	0.031	***	(0.006)	0.71	0.027	.	(0.013)	0.73
Period: 1962–1972	0.027	***	(0.005)	0.66	0.039	**	(0.011)	0.78
Period: 1972–1982	-0.030	**	(0.008)	0.35	-0.010		(0.017)	0.65
Period: 1982–1992	0.023	**	(0.007)	0.42	0.005		(0.014)	0.52
Period: 1992–2002	0.129	**	(0.034)	0.77	0.032	*	(0.013)	0.94
Period: 2002–2009	0.034		(0.037)	0.05	0.027		(0.017)	0.83

p-value: ‘***’<0.001; ‘**’<0.01; ‘*’<0.05; ‘.’<0.1.

Note: The samples referring to periods 1952–2009, 1952–1962, 1962–1972 have 19 observations since Molise became an autonomous region only in 1964, the other samples have 20 observations.

Source: Istat, “Tavole di Fecondità della popolazione italiana per regione di residenza” for the period 1952–2004, and Survey on Live Births after 2004.

Due to its historical dualism in fertility trends, though, absolute convergence is probably not appropriate in the Italian case, as it only assumes the existence of a unique equilibrium, towards which regional fertility is assumed to converge. In future work we thus should rely on the study of club convergence, which instead assumes the existence of multiple equilibria. According to this framework, 'clubs' of regions may convergence to different equilibrium levels. Still, it would not be easy to distinguish club convergence from conditional convergence, i.e., the idea that different regions may converge to different equilibrium due to differences in other peculiar characteristics like, for instance, circumstances in the labour market, or preferences for different family models. It is therefore necessary to inspect more in detail the association between fertility levels and a set of other indicators.

3. Provincial fertility differentials

In the remainder of the paper we adopt a deeper geographical perspective, focusing on a lower level of territorial aggregation: the provincial level. Istat started to collect statistical data disaggregated at the provincial level starting from 1999, and this is the reason why in the previous section, in order to study a longer time period, we relied on regions, for which the time series available dates back to 1952. The provincial perspective allows studying spatial heterogeneity and dependence in Italian fertility more in detail. The comparison between regional and provincial fertility (Figures 5) shows that, in some cases, regional fertility mirrors provincial fertility. This is the case of Marche, Abruzzi, Latium, Sicily, Campania and Trentino-Alto-Adige in 1999. Other regions, instead, are characterized by between-province variability. The case of Emilia Romagna in 1999 serves as an example: the province of Ferrara registered one of the lowest TFR in 1999, equal to 0.85 children per woman, while for the province of Reggio Emilia it was 1.128. Thus the correlation between fertility and other indicators measured at a broad geographical level (country, macro-regions or regions) might differ when the same indicators are measured at lower geographical levels –what is referred to as the *modifiable areal unit problem* (Openshaw, 1984; Arbia, 2006).

We now consider provinces as the unit of analysis and seek to explain cross-provincial differences in fertility levels over the period 1999–2008. We are interested in testing the relative importance of selected indicators on the evolution over time and space of the period TFR in Italy. Existing literature suggests a wide range of indicators which are, to some extent, able to explain cross-country fertility differentials.

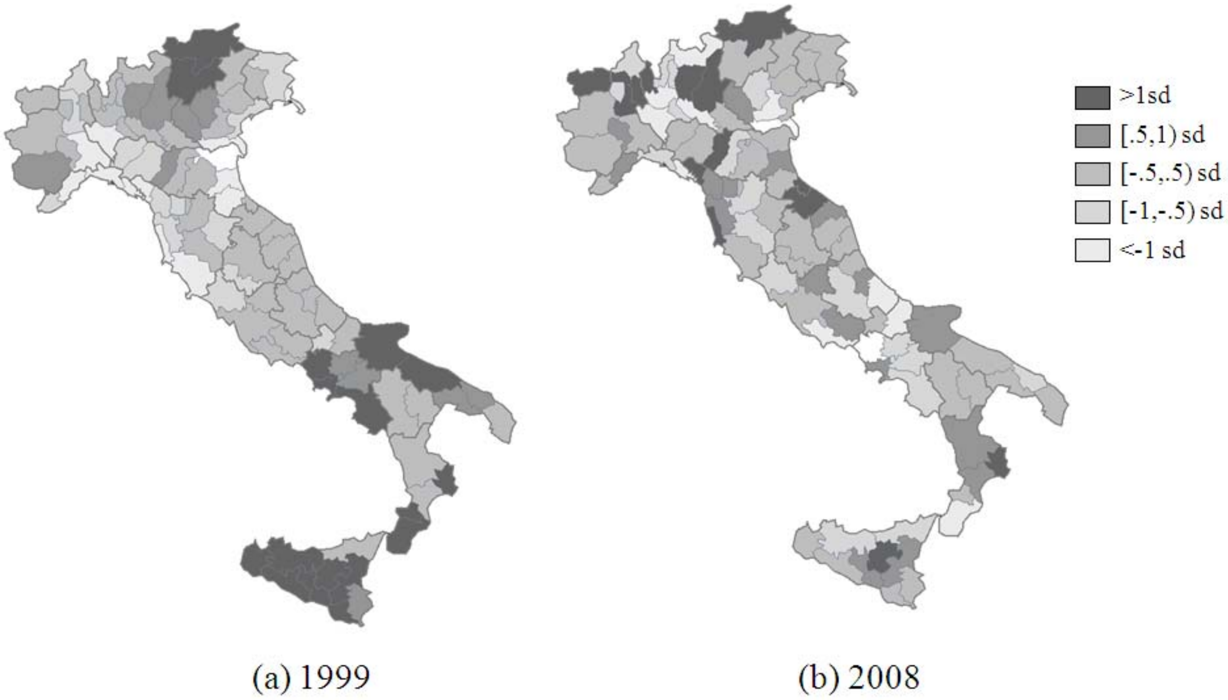

Figure 5: TFR in 99 Italian provinces; (a) year 1999 and (b) year 2008.

Note: The legend has to be read in terms of standard deviations from the mean: ">1 sd" indicates provinces whose TFR is one standard deviation (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 and standard deviations were respectively equal to 1.18 and 0.15 in 1999 (a) and 1.37 and 0.14 in 2008 (b). In 2006 four provinces came to exist in Sardinia. In lack of population data for all municipalities, we cannot reconstruct backward the TFR of all provinces in Sardinia. Thus, for comparability over time we excluded Sardinia and refer to the remaining 99 Italian provinces.
Source: Istat, Survey on Live Births.

One of the most cited of such indicators is female employment. At the country level it has been shown that female participation in the labour market negatively correlates with fertility in a variety of European countries (see, e.g., Brewster et al., 2000). In some countries, the negative correlation between female employment and fertility has reversed its sign by the late 1980's, while in some others it still persists, so that at a cross-sectional level, two distinct equilibrium can be discerned: Southern-European countries exert both a low employment rate and a low fertility rate, while Northern-European countries exert both a high employment rate and a high fertility rate (Ahn et al., 2002; Engelhardt et al., 2004; Engelhardt and Prskawetz, 2004; Boeri et al., 2005).

A sign reversal in the cross-country correlation with fertility has been observed also for other indicators as marriage propensity, cohabitation, divorce and extramarital births, mean age at first birth, mean age at first marriage (Billari et al., 2004; Prskawetz et al., 2010) and GDP (Bryant, 2007; Myrskylä et al., 2009). Beside such widely used indicators, we also consider fertility of foreigners (Coleman, 2006; Billari, 2008; Billari et al.; 2008; Sobotka, 2008) and fertility postponement (Kohler et al., 2002; Sobotka, 2004) because their contribution to the evolution of total national fertility is crucial in a low-fertility context.

For what concerns sub-regional fertility differentials in Italy, Castiglioni et al. (2009) find that the fertility increase in Central and Northern Italian provinces in the late 1990s is positively associated with fertility of foreigners, spread of new marital behaviours and income. Also 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 include non-marital cohabitation, extramarital births and marital instability. Dalla Zuanna et al. (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 on the basis of a selection of indicators measuring reproductive and marital behaviours and economic circumstances (marital and extramarital fertility, voluntary abortions, shotgun marriages, degree of industrialization, unemployment rate, and secularization). Franklin et al. (2004) show that changes in Italian fertility for the period 1952–1991 can mainly be explained by regional age-specific fertility differentials, while Waldorf et al. (2002) find that the Easterlin hypothesis is confirmed in most Italian regions over the period 1952–1995.

Figure 6 shows the evolution over time of the cross-province correlation coefficients between fertility (TFR) and seven indicators among the most widely discussed in fertility literature: female employment rate, nuptiality rate, extramarital fertility, mean age at first marriage, fertility of immigrants, late fertility, GDP.

Besides studying the effect of postponement on the TFR, it is also interesting to look at the effects of a selection of indicators on postponement itself. In Italy late fertility is the result of a combination of late home leaving, late age at first marriage, high marriage propensity and low prevalence of cohabitation and extramarital births (Billari et al., 2004). Giorgi et al. (2007) have shown that late fertility follows different patterns in different regions of Italy. A visual representation of the evolution over time of the cross-province correlation between late fertility and our selection of indicators can be found in Figure 7.

We argue that the relationship between the TFR and the commonly used indicators is overestimated in regression models where spatial dependence is not taken into account. We will show that the relationship between TFR and each indicator might mask a spatial relationship.

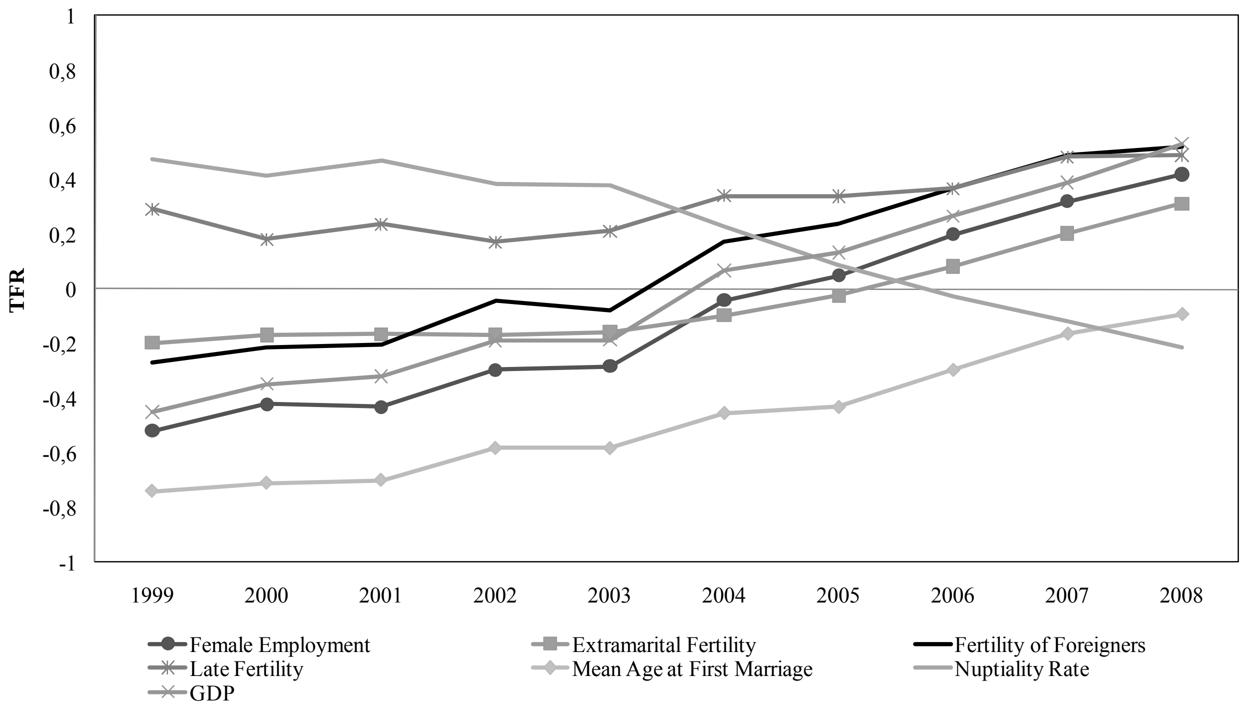

Figure 6: Correlation between TFR and seven indicators, Italian provinces, 1999-2008.

Note: In 2006 four provinces came to exist in Sardinia. In lack of population data for all municipalities, we cannot reconstruct backward the TFR of all provinces in Sardinia. Thus, for comparability over time we excluded Sardinia and refer to the remaining 99 Italian provinces.
Source: Istat, "Tavole di Fecondità della popolazione italiana per regione di residenza" for the period 1952–2004, and "Rilevazione degli iscritti in anagrafe per nascita" after 2004.

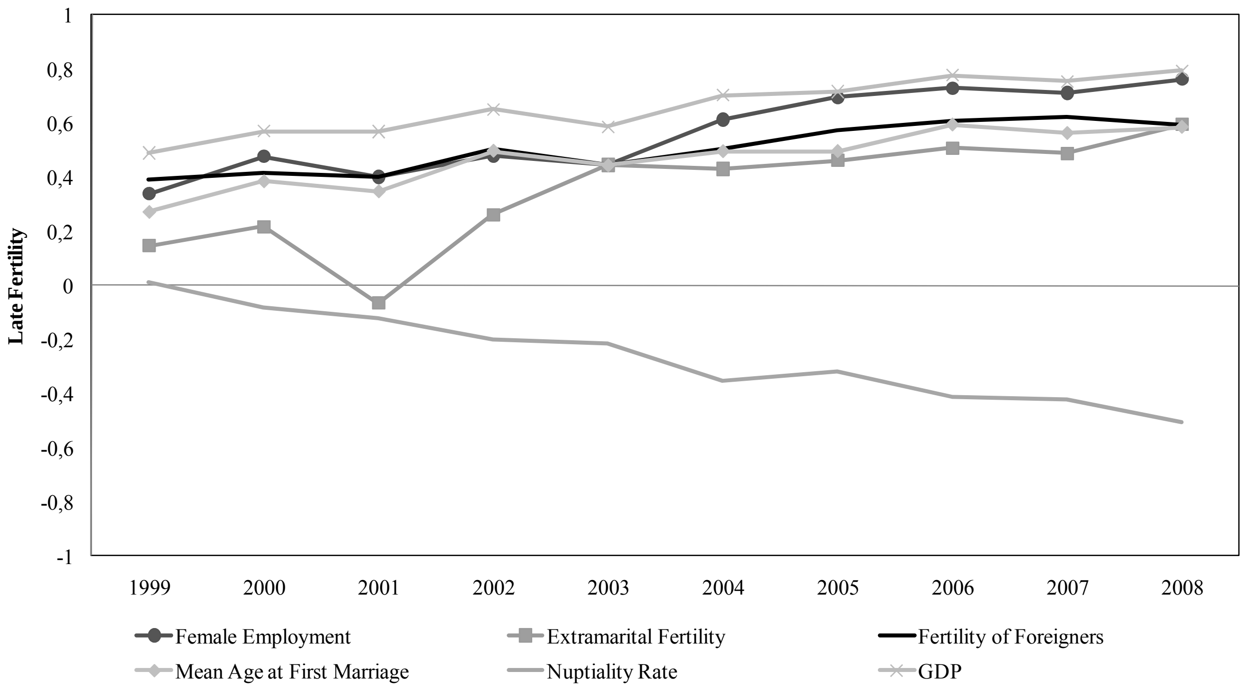

Figure 7: Correlation between late fertility (TFR at age 35 and later) and six indicators, Italian provinces, 1999-2008.

Note: In 2006 four provinces came to exist in Sardinia. In lack of population data for all municipalities, we cannot reconstruct backward the TFR of all provinces in Sardinia. Thus, for comparability over time we excluded Sardinia and refer to the remaining 99 Italian provinces.
Source: Istat, "Tavole di Fecondità della popolazione italiana per regione di residenza" for the period 1952–2004, and "Rilevazione degli iscritti in anagrafe per nascita" after 2004.

4. Spatial panel models

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 et al. (2009) concentrate their analyses only on Northern regions; Caltabiano (2008) compares cohort age-specific fertility between one Northern (Lombardy) and one Southern region (Campania), while Caltabiano et al. (2009) does the same comparison between the North and the South.

The concept of *spatial dependence*, instead, is less commonly considered, although spatial contiguity generally induces dependence in demographic behaviours. A number of studies called the attention on the existence of spatial patterns and the need to take these into account (Boyle, 2003; Goodchild et al., 2004; Weeks, 2004; Voss, 2007; Chi et al., 2008; Lesthaeghe, 2010). Although geographically referenced data have become increasing available, it is still uncommon for demographers to explicitly account for spatial dependence[1] in the study of demographic behaviours. In particular, very few studies model spatial dependence in fertility (Weeks et al., 2000; Waldorf et al., 2002; Işik et al., 2006; Muniz, 2009; Potter et al., 2010; Murphy, 2010; Goldstein et al., 2010).

Figure 1 shows that Tobler's "first law of geography" (Tobler, 1970) applies also for the Italian regional TFR: closer regions have more similar TFRs than regions which are far apart, and this is true for all years in our time series. Figure 5 shows that also at the provincial level spatial contiguity implies a dependence in fertility measures. Provinces, therefore, cannot be modelled as independent units. Indeed, provinces are spatially dependent; in other words, it cannot be assumed that fertility observed in a given province is independent from fertility observed in a neighbouring province. However, independence among observations is the main assumption of traditional regression models. In this paper we do not want to superimpose a geographical structure which would a priori generate clusters of regions. Therefore we explicitly account for spatial dependence among provinces, by the means of spatial regression models. Our spatial units are 99 Italian provinces.[2] We define two provinces as neighbours if they share a border or an edge (queen criterion).

The interaction between provinces is modelled including a spatially lagged dependent variable (a spatial lag) as well as a spatially autoregressive error term (a spatial error). The spatial lag allows the TFR to depend on the TFR observed in neighbouring provinces, while the spatial error allows the provincial error term to be correlated across space so that unobserved factors, while affecting the province itself, are also assumed to affect all other neighbouring provinces.

We are also interested in the time dimension, and for this purpose, we rely on a panel dataset, constituted of repeated observations for provinces over a ten-year period. Spatial panel data are one of the most promising tool to analyze the spatial and the temporal dimension simultaneously. We employ a spatial panel data regression model developed by Baltagi et al. (2007), which accounts for spatial dependence between provinces at each time period, for serial correlation on each province over time,[3] and allows for heterogeneity across provinces using a random effect. Spatial dependence is taken into account through two different effects: a spatial lag on the dependent variable and a spatially autoregressive error term.

Let N denote the number of spatial units (i.e. 99) and T the number of time periods (i.e. 10, from 1999 to 2008). The dependent variable y and the error term u are vectors of dimension NTx1 and the matrix of dependent variables X has dimension NTxk. Then, the model we employ is described as follows:

$$y=\rho Wy+X'\beta+ u \qquad (1.1)$$

[1] In this paper, we use the term spatial dependence and spatial autocorrelation interchangeably.

[2] We exclude the 8 provinces of Sardinia because 4 of them came to exist in 2006, making it impossible, in lack of municipal data, to reconstruct backward all the variables we are using in our analyses.

[3] If serial correlation in the error term is not taken into account, it is implicitly assumed that the only existing correlation over time is due to the presence of the same provincial effect across the panel. This may be a restrictive assumption since an unobserved shock in a given period does affect the TFR in the next periods. Also, ignoring serial correlation leads to inefficient estimates of the regression coefficients and to biased standard errors.

The coefficient ρ measures the spatial autocorrelation in the dependent variable i.e. a spatial lag (Cliff et al., 1973). If this coefficient is positive, there is evidence of spatial autocorrelation in the TFR or, in other words, that provinces with similar values of the TFR tend to cluster together in space; while a negative ρ would imply that high-fertility provinces tend to be surrounded by low-fertility provinces and vice versa. Spatial dependence operates through a pre-defined, user-specified weight matrix (W). The weight matrix $W=(I_T \otimes W_N)$ has dimension NTxNT. W_N is a non-stochastic row-standardized spatial weight matrix which takes into account the neighbouring structure of the spatial units such that its entries satisfy the following:

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

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 of spatial unit i) and it is assumed that a unit cannot be its own neighbour i.e., w_{ii}=0.[4] In our case neighbours are defined on the basis of a contiguity criterion, according to which two locations are neighbours if they share a border. It is assumed that the W_N weight matrix does not change over time.

For each cross-section of the panel ($t=1999,...,2008$), the following three assumptions hold:

$$u_t = \mu + \varepsilon_t \text{, with } u'_t = (u_{t1},...,u_{t99}) \quad (1.2)$$

$$\varepsilon_t = \lambda W \varepsilon_t + v_t \text{, with } \varepsilon'_t = (\varepsilon_{t1},...,\varepsilon_{t99}) \quad (1.3)$$

$$v_t = \psi v_{t-1} + e_t \text{, with } v'_t = (v_{t1},...,v_{t99}) \quad (1.4)$$

The error term u_t in (1.2) is expressed as the sum of a provincial random effect (μ) and a remaining error component (ε_t). The vector $\mu'=(\mu_1,..., \mu_{99})$ denotes the province-specific random effects, assumed to be constant over time and independent of the error term $\varepsilon'=(\varepsilon_{t1},...,\varepsilon_{t99})$. Both μ and ε are independently and identically normally distributed with mean 0 and variance to be estimated. The ratio between their variances, defined as $\varphi = \sigma_\mu/\sigma_\varepsilon$, gives the contribution of provincial-specific variation in the TFR relative to the variation due to unobserved factors. For each cross-section in (1.3) the error component ε_t is further decomposed to isolate a spatial dependence in the error term, measured by the coefficient λ and operating through the weight matrix W. Finally, in (1.4) it is assumed that the error component (v_t) has a first-order autoregressive component and the coefficient ψ measures its serial correlation.

The novelty of this model is that the error term u_{ti} is able to catch four different effects simultaneously: a province-specific random effect (μ_i) constant over time, a spatial autocorrelation

[4] A spatial weight matrix is a matrix that selects neighbors. Suppose that the spatial unit i has two neighbors, say the spatial units j and k; then, the i^{th} row of the W matrix will have two non-zero elements i.e., the entries w_{ij} and w_{ik} will be different from zero. The matrix W_N is row standardized because $\sum_{j=1}^{\eta_i} w_{ij} = 1$.

coefficient in the dependent variable (ρ), a spatial autocorrelation coefficient in the error term (λ), and a serial correlation coefficient (ψ).

Other model assumptions require that the spatial autoregressive λ and ρ coefficients are bounded in absolute value (i.e. $|\lambda|<1$ and $|\rho|<1$), e_{it} is independently and identically normally distributed with zero mean and variance to be estimates, and v_{i0} is normally distributed with zero mean and variance equal to $\sigma_e^2/(1-\rho^2)$. The model is estimated by two-step Maximum Likelihood.

5. Data

We develop several regression models on two distinct dependent variables: the provincial TFR and the provincial TFR for women above age 35, to which we refer as late fertility. Both variables are measured in a panel of 99 Italian provinces (Sardinia is excluded from our analyses) and 10 years (1999–2008). The two dependent variables are obtained from the Survey on Live Births, which Istat produces annually, starting from 1999, and which provides territorial data referring to geographical macro-areas, regions, provinces and regional and provincial capitals. The survey covers the whole population of newborns[5] and collects information on births disaggregated by sex, citizenship, date and place of birth of the newborn, together with age, marital status and citizenship of both parents.

As independent variables we use each of the seven indicators we introduced in section 4 (female employment rate, nuptiality rate, extramarital fertility, mean age at first marriage, fertility of immigrants, late fertility, GDP). We measure fertility of immigrants through the proportion of children with at least one foreign parent on the total number of children born in a given year (Source: Istat, Migration and calculation of yearly resident population). Female employment refers to the proportion of working women on the total female population aged 15 and over (Source: Labour Force Quarterly Survey data for the period 1999–2003 and Labour Force Survey data after 2003).[6] Following Castiglioni et al. (2009), we measure new marital behaviours by the proportion of children born out of wedlock on the total number of children born in a given year and province (Source: Istat, Survey on Live Births), to which we refer as extramarital fertility. To account for fertility recuperation at later ages, we use the TFR for women above age 35 (Source: Istat, Survey on Live Births). Nuptiality rate is calculated as the number of marriages on the average yearly resident unmarried population, while female mean age at first marriage is weighted by age specific nuptiality rate. GDP is expressed in Euros per inhabitants and calculated at current market prices (Source: Eurostat, Regional Statistics).

For both fertility and postponement, we run the general spatial panel model described in (1.1)–(1.4) in section 4 as well as the traditional fixed-effects panel model.

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[5] Coverage passed from 95,8% of total babies born in 1999 to 98,9% in 2008.

[6] Labour Force Quarterly Survey data should not be compared with Labour Force Survey data, due to the reorganization carried out to meet European harmonization criteria. However, in lack of other comparable data at provincial level for the whole time series, this indicator was the best we could find.

We use three regression models: a traditional fixed-effects panel model (Model 1), a spatial fixed-effects model (Model 2), and the general spatial panel model described in (1.1)–(1.4) in section 4 (Model 3). The traditional fixed effects panel model can be extended to include a spatially lagged dependent variable (Anselin, 1988). The spatial panel model that we fit (Model 2) can be written in stacked form as:

$$y=\rho Wy+(\iota_T\otimes \alpha)+X'\beta+\varepsilon \tag{2}$$

where ρ is the spatial autoregressive coefficients, α is the vector of provincial fixed effects, $\varepsilon_i \sim N(0,\sigma^2)$ and W is defined as above.

In the regression in which the independent variable is GDP, we include also its squared in order to capture the cross-sectional nonlinear relationship between TFR and GDP, which is shown in Figure 8 for the starting (1999) and ending year (2008) of our time series for Italian provinces. All variables in our models are standardized.

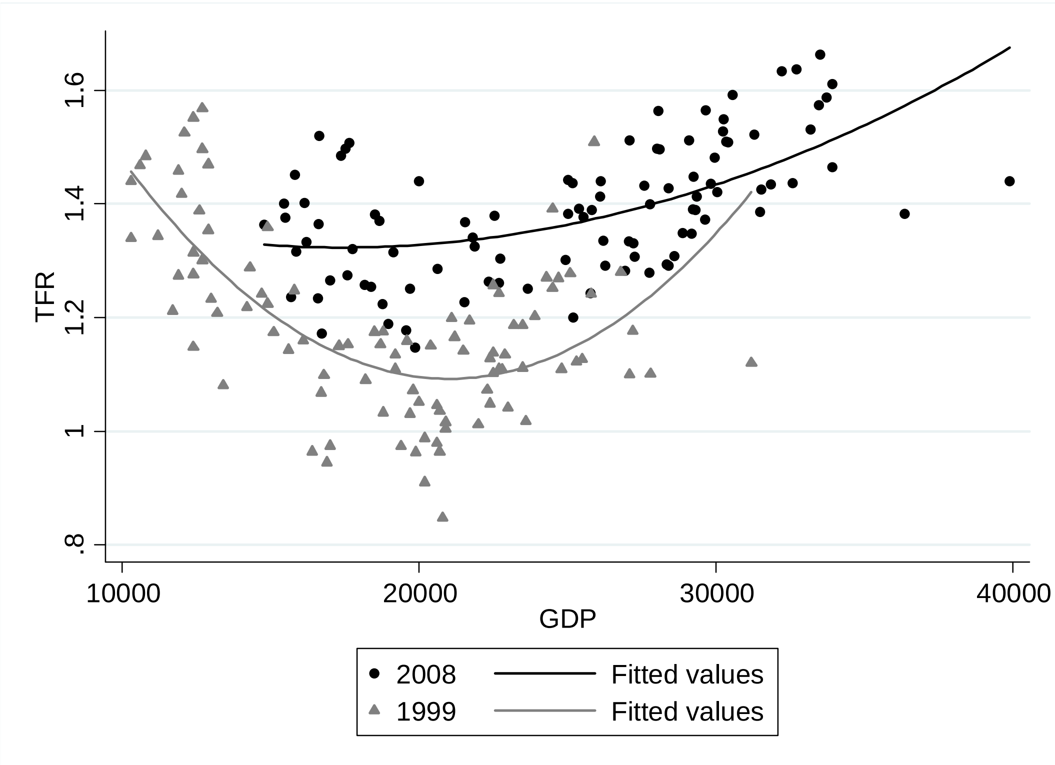

Figure 8: Cross-sectional relationship between TFR and GDP per capita in 99 Italian provinces, 1999 and 2008.

Note: GDP is expressed in Euros per inhabitants and calculated at current market prices.
Source: Istat, Survey on Live Births and Eurostat, Regional Statistics.

6. Results

Table 3 reports coefficient estimates for the traditional panel model with provincial fixed effects (Model 1), the spatial panel model with provincial fixed effects (Model 2) and the general spatial panel model (Model 3).

Our investigation shows that disregarding spatial dependence leads to overestimating the effect of all the seven indicators we chose to explain fertility. For instance, if we estimate the effect of provincial extramarital fertility on the provincial TFR using the traditional fixed effects panel model (Model 1), we find that a one standard deviation increase in the indicator leads to a 0.68 standard deviation increase in the TFR. This effect reduces to 0.02 when we account for spatial dependence across neighbouring provinces, using the spatial panel fixed effects model (Model 2). If we then take into account serial autocorrelation and model the provincial-specific effect by the means of random rather than fixed effects (Model 3), the estimated coefficient of extramarital fertility is further reduced to 0.11. A similar reduction in the estimated coefficient exists for mean age at first marriage (MAFM), female employment, nuptiality rate, fertility of foreigners and GDP.

In all models the spatial autocorrelation coefficient of the TFR (ρ) is positive and statistically significant, indicating a positive spatial dependence of fertility across provinces. As expected, the coefficient measuring serial correlation (ψ) is positive and significant (TFR is a given year is obviously correlated with TFR in the previous year). The contribution of provincial-specific variation in the TFR is significantly higher than the contribution of the variation due to unobserved factors (φ), while spatial dependence in the error term (λ) is negative in all models we estimated. If in some cases this coefficient does not result significantly different from zero, in most cases it does. Its negative sign can be interpreted as negative spatial dependence between provincial TFR and unobserved factors measured in neighbouring provinces. We can explain the negative spatial dependence with residential mobility of parents-to-be. If, for instance, quality of life in a given province is high, but this is not the case in neighbouring provinces, intra-provincial migration is expected to take place and this results in a negative effect on the province's TFR (Michielin et al., 2008; Kulu et al., 2009). Had we not included in our model the spatial lag coefficient accounting for spatial dependence in the dependent variable (ρ), the estimated coefficient of spatial dependence in the error term λ would have been significantly positive (results not shown).

In order to compare the marginal effect of different indicators on fertility and late fertility, i.e., in order to assess which indicator has more explanatory power on fertility and on late fertility, we also run the same regression model simultaneously including three indicators, namely fertility of foreigners, female employment and extramarital fertility. The selection of these indicators follows Castiglioni et al. (2009) and is also based on the evaluation of the correlation among independent variables. Results of these models are reported in Table 4. According to our results, fertility of immigrants is the most important predictor of fertility in Italian provinces. If fertility of immigrants is increased by one standardized unit, the provincial TFR would increase by 0.27 standardized units. It should be noted that the effect of foreign fertility is probably underestimated as our data refer to births with at least one foreign parent legally resident in one of the Italian provinces. As a result, we should expect the true contribution of fertility of foreigners on total fertility to be more important than what we are actually estimating. Provinces where extramarital fertility is more widespread tend to have significantly higher fertility with respect to provinces where new family models are less widespread; however, the intensity of such association is very small (standardized coefficient equal to 0.03) if compared to the other effects we consider. Finally, when we control for these two indicators, the association between female employment and fertility turns negative in such a way that if female employment is increased by one standardized unit, the TFR would decrease by 0.05 standard units. Thus fertility is higher in provinces where the contribution of fertility of foreigners is high, new family models are more widespread and female employment rate is low. Table 4 also reports coefficient estimates for the general spatial panel regression model of postponement (i.e. TFR for women aged 35 and above) on the same three indicators. Fertility of foreigners and extramarital fertility maintain a positive effect on provincial TFR (standardized coefficients equals to 0.09 and 0.05), while the coefficient of female employment is significantly positive (standardized coefficients equals to 0.12). Thus provinces where female employment rate and the contribution of fertility of foreigners are high and new family models are more widespread are also the provinces with higher total fertility rates for women above age 35. The comparison of the two models suggests that spatial dependence of fertility across provinces (ρ) is higher for late fertility than for fertility, while the opposite is true for temporal autocorrelation (ψ).

Table 3: Estimates of the regression of fertility on selected indicators

	Model 1			Model 2			Model 3		
	β		s.e.	β		s.e.	β		s.e.
MAFM	0.651	***	0.023	0.135	***	0.016	0.078	***	0.010
ρ				0.799	***	0.017	0.885	***	0.015
φ							9.786	***	1.623
ψ							0.560	***	0.047
λ							-0.751	.	0.060
Extramarital Fertility	0.678	***	0.024	0.164	***	0.014	0.113	***	0.011
ρ				0.787	***	0.016	0.875	***	0.014
φ							9.858	***	1.597
ψ							0.495	***	0.043
λ							-0.751	*	0.058
Female Employment	1.133	***	0.069	0.142	***	0.031	0.102	***	0.022
ρ				0.852	***	0.013	0.913	***	0.011
φ							9.653	***	1.614
ψ							0.543	***	0.048
λ							-0.801	**	0.056
Nuptiality Rate	-0.661	***	0.027	-0.128	***	0.015	-0.052	***	0.009
ρ				0.816	***	0.015	0.910	***	0.011
φ							10.045	***	1.657
ψ							0.517	***	0.047
λ							-0.785	**	0.057
Fertility of Foreigners	0.974	***	0.017	0.473	***	0.027	0.266	***	0.010
ρ				0.536	***	0.025	0.746	***	0.024
φ							9.832	***	1.539
ψ							0.417	***	0.041
λ							-0.636	***	0.065
Late Fertility	0.620	***	0.014	0.231	***	0.017	0.331	***	0.014
ρ				0.673	***	0.022	0.557	***	0.062
φ							6.255		1.193
ψ							0.764	***	0.052
λ							-0.164	***	0.137
GDP	-0.038	***	0.004	-0.016	***	0.002	-0.011	***	0.002
GDP^2	0.002	***	0.000	0.001	***	0.000	0.000	***	0.000
ρ			0.665	0.665	***	0.021	0.827	***	0.018
φ							9.002	***	1.449
ψ							0.440	***	0.042
λ							-0.702	***	0.061

p-value: ‘***’<0.001; ‘**’<0.01; ‘*’<0.05; ‘.’<0.1.

Note: Model 1 refer to the traditional panel model with provincial fixed effects, Model 2 to the spatial panel model with provincial fixed effects and Model 3 to the general spatial panel model. All coefficients are standardized. Significance of spatial and temporal parameters (φ,ψ,λ) is tested by the means of one-dimensional conditional tests developed in Baltagi et al. (2007). ρ: TFR in neighboring provinces; φ: ($\sigma_\mu/\sigma_\varepsilon$), contribution of provincial-specific variation in the TFR relative to the variation due to unobserved factors; ψ: serial correlation; λ:spatial dependence in the error term.

Table 4: Estimates of the regression of fertility and late fertility on selected indicators

	Fertility			Late Fertility		
	β		s.e.	β		s.e.
Fertility of Foreigners	0.270	***	0.017	0.086	***	0.013
Female Employment	-0.054	.	0.027	0.121	***	0.022
Extramarital Fertility	0.031	.	0.017	0.052	***	0.014
ρ	0.733	***	0.026	0.877	***	0.013
φ	9.540	***	1.503	5.701	**	0.916
ψ	0.403	***	0.041	0.171	***	0.043
λ	-0.606	***	0.068	-0.877	***	0.051

p-value: '***'<0.001; '**'<0.01; '*'<0.05; '.'<0.1.

Note: All coefficients are standardized. Significance of spatial and temporal parameters (φ,ψ,λ) is tested by the means of one-dimensional conditional tests developed in Baltagi et al. (2007). ρ: TFR in neighboring provinces; φ: ($\sigma_\mu/\sigma_\varepsilon$), contribution of provincial-specific variation in the TFR relative to the variation due to unobserved factors; ψ: serial correlation; λ:spatial dependence in the error term.

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