Eur J Population (2006) 22:399–421
DOI 10.1007/s10680-006-9111-5

Geographies of a silent transition: a geographically weighted regression approach to regional fertility differences in Turkey

Géographie d'une transition silencieuse: une approche des différences régionales de fécondité en Turquie par régression pondérée sur une base géographique

Oğuz Işik · M. Melih Pinarcioğlu

Received: 19 January 2006 / Accepted: 10 July 2006 /
Published online: 30 January 2007

Abstract The fertility decline that Turkey has gone through in the last few decades is characterised by sharp regional inequalities, with western regions representing patterns akin to developed countries and those in the east resembling "third-world" countries, while central regions represent an in-between case. With the help of geographically weighted regression (GWR), this article is an attempt to set up a model of causal relationships that could account for the regional fertility differentials. The results indicate that the fertility decline is not a single and all-embracing process covering all regions. On the contrary, there are regions differentiated qualitatively from each other in terms of the underlying causes of the existing fertility levels.

Keywords Turkey · Geographically weighted regression · Fertility decline · Demographic transition · Regional inequalities

Résumé La baisse de fécondité observée en Turquie au cours des dernières décennies est caractérisée par des inégalités régionales très accusées, avec les régions de l'ouest proches des pays développés, celles de l'est des pays en développement, et les régions centrales dans une situation intermédiaire. A l'aide d'une régression pondérée sur une base géographique, un modèle de causalité est élaboré en vue d'une prise en compte des différences régionales de fécondité. Les résultats montrent que la baisse de fécondité n'est pas un

O. Işik (✉) · M. M. Pinarcioğlu
Department of City and Regional Planning, Middle East Technical University,
06531 Ankara, Turkey
e-mail: ioguz@metu.edu.tr

M. M. Pinarcioğlu
e-mail: melihp@metu.edu.tr

phénomène uniforme sur tout le territoire, et qu'au contraire, certaines régions diffèrent les unes des autres de manière qualitative en termes des causes sous-jacentes aux niveaux de fécondité.

Mots-clés Turquie · régression pondérée sur base géographique · baisse de la fécondité · transition démographique · inégalités régionales

1 Introduction

Turkey has, in the last few decades, undergone a rapid and silent transition in terms of its key demographic variables. The results of the latest 2000 population census indicate that the annual rate of population growth fell below 2% for the first time since 1945. The slowdown in population growth is not on its own sufficient to reveal the scale of the transformations that Turkey has gone through. The decline in fertility is much more striking: Starting from a rate of 6.7 in the early 1950s, total fertility rate (TFR) fell down to 2.2 according to the results of the 2003 Turkey Demography and Health Survey (TDHS, 2004). Although the population continues to grow at a rate which is still high compared to many European countries thanks to the well-known population momentum impact, fertility has fallen below replacement level, except for southern and eastern parts of the country. It is estimated that the total population will reach some 98 million and stabilise around the mid-21st century (SIS, 1995). In a vast geography extending from West Asia to North Africa (excepting Israel), Turkey has thus become the first country to reach such a low level of fertility (Angın & Shorter, 1998).

The transformation that Turkey has undergone has been well documented starting from the early stages by many researchers (Düzgüneş, 1985; Farooq & Tuncer, 1974; Remez, 1998; Shorter, 1968, 1995; SIS, 1995) and with the help of quinquennial TDHS surveys (TDHS, 1999, 2004), and the problems and opportunities it brings about for the society have been widely discussed (TUSIAD, 1999; World Bank, 2006). The geography of this transformation has, however, remained largely uncharted except some references to the inequalities between broad regions (TDHS, 1999, 2004) and to the ethnic and cultural differences that overlap with regional disparities (Hancıoğlu & Koç, 1999; Sirkeci, 2000; Yavuz, 2005). As is the case in almost all economic and social variables, the demographic transition process that Turkey is obviously about to complete is characterised by wide regional inequalities and a distinct geographical pattern: western regions representing patterns of social development akin to developed countries and those in the east and southeast resembling what may be termed a "third-world" pattern, while central regions represent an in-between case.

The fertility issue we wish to deal with in this article is no exception. As we hope to make clear in what follows the final picture that emerges in the case of fertility differences is once again the well-known east-west divide, which is so deep rooted in Turkish society. However, our objective is not simply to add yet another indicator to the well-known catalogue of inequalities in Turkish society. Using the district-level results of the 2000 population census, this article is an attempt to develop a model that could explain the reasons behind the spatially uneven process of fertility decline in Turkey. It is with the help of a relatively recent technique, namely geographically weighted regression (GWR), that we wish to go beyond the mere task of documenting the existing differences and to set up a model—a set of causal relations—that would elaborate why fertility has been in decline more rapidly in some parts of the country than others.

Put in other words, our objective in this article is to make a case for geography in Turkish fertility studies. In what follows we hope to prove that "geography matters" as far as the wide fertility differences in the country are concerned. We wish to show that there exist in Turkey distinct regions differentiated from each other not only in terms of the magnitude of fertility, but also with respect to the underlying causes of the existing fertility levels. This we hope to do with the help of GWR—a *place-based* analytic technique that represents a compromise between the nomothetic and idiographic strategies that for long have haunted the students of geography (Goodchild, 2001). Allowing the parameters of a regression estimation to change locally, GWR is an effort to open up room for spatial heterogeneity in geographical research. The rationale behind the technique is simple and straightforward: the very same cause may lead to a different effect in a different setting. In contrast to the ordinary least squares (OLS) regression method, which attempts to unravel the global (*necessary*) relations between a dependent variable and a set of independent variables, GWR takes into account the spatially changing (*contingent*) impacts of independent variables on the dependent one. It is indeed the context-dependent nature of social interaction that GWR attempts to take into account, a topic that has bewildered the students of spatial analysis.

In our search for the regionally changing determinants of the fertility decline in Turkey, we start with an OLS regression model that would account for the nation-wide relations between fertility indicators and other variables that have an impact on the former. Before doing this, we present a brief background on the fertility transition and the regional inequalities that have been an integral part of this process. We then proceed to data considerations and build the OLS model, which provides us with information on the global relations between the variables. In an attempt to differentiate the necessary from the contingent, we present in following sections our GWR model and discuss its implications.

The study area (Turkey districts) is given in Fig. 1 alongside major metropolitan areas. It must be noted that almost one quarter of the total population lives in the three major metropolitan areas indicated in the map (Istanbul, Ankara and Izmir). We must also note for references in the text that the European part (the peninsula to the west of the Sea of Marmara) is known as Thrace and the Asian part as Anatolia.

Fig. 1 Study area—Turkey districts

2 Fertility decline and regional inequalities in Turkey

All through this article we use child–woman ratio (CWR) as a measure of fertility, and hence as our dependent variable in both OLS and GWR models. CWR is defined as the number of children under age 5 per 1000 women of reproductive age (ages 15–49) in a population in a given year. It may be regarded as an indicator of *recent* fertility net of child mortality. A crude and indirect measure of fertility easily obtainable from census data, CWR is frequently used in fertility studies in the absence of such specific measures as total or age-specific fertility rate. The reason why we use CWR as a measure of fertility in this article is the fact that other indicators are not available at the level of districts we wish to carry out our GWR analysis.

Measured through CWR, there has been a steady decline in fertility in Turkey since the early 1960s (Fig. 2). The figure reveals a pattern of fertility rising from 555 to 700 between 1945 and 1960, and falling continually thereafter and finally reaching 362 in 2000. The figure also shows that this fall in fertility has been accompanied by a secular rise in adult literacy rate (from 30.2% in 1945 to 88% in 2000) and urban population (from 25% to 68% in the same period). As Turkey has become more urbanised and better educated, the fertility indicators have registered a sharp decline.

It should be stressed, however, that this fall has been severely uneven in space. Figure 3 shows the district-wide distribution of CWR variable and independent variables used in the study. The distribution of CWR variable (top left map in Fig. 3) clearly shows the east-west divide that, as we noted above, dominates almost every aspect of social and economic life in Turkey. National average of CWR is around 362 in 2000, with a minimum of 137 and maximum of 1097. Analysing these districts is in a sense like travelling through time. About 56 out of 923 districts, almost all in the east and southeast, have CWRs higher than the national average of 40 years ago. The result is once again clear: The tendency for the fertility level to decline is surely a general

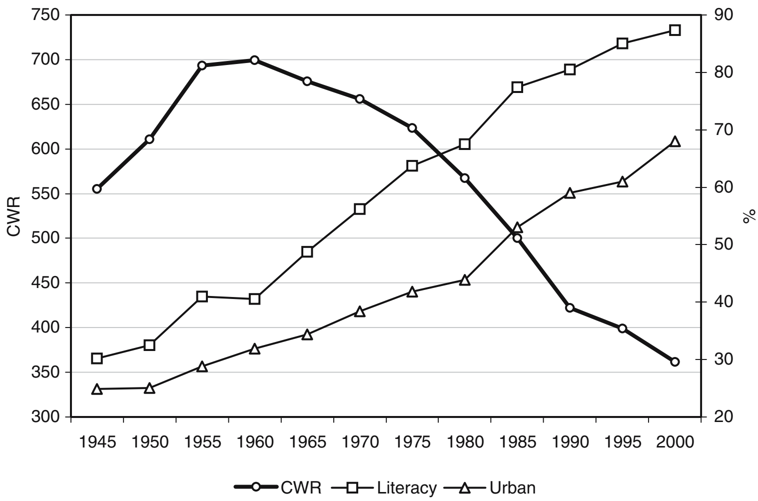

Fig. 2 Child–woman ratio (CWR), literacy and urban population by years. *Source*: State Institute of Statistics (SIS), *Statistical Yearbooks*, various years

one, but the speed at which this fall takes place is uneven in space and deserves explanation. The east-west divide seems to manifest itself especially in the case of such variables as the rate of literacy, female participation in non-agricultural labour force and GDP per capita while the variables of urban population and migration seem to have another pattern.

One very important dimension needs to be added to the question of regional inequalities in fertility and other indicators before we proceed to our model and the variables. One should be aware of the fact that all the inequalities considered herein do have a very strong ethnic dimension and that the matter can hardly be tackled without explicit reference to the part played by ethnicity. More clearly, the eastern and south-eastern provinces that represent a demographic pattern and level of social and economic development reminiscent of third-world countries are largely inhabited by Kurdish speaking groups. Based on TDHS results where ethnicity can be identified with the help of questions on mother tongue, a number of researchers have pointed out that the wide differences between the affluent west and the deprived east and southeast can indeed be attributed to different fertility patterns prevailing among Kurdish and Turkish speaking groups (Hancıoğlu & Koç, 1999; Koç & Cavlin, 2006; Sirkeci, 2000; Yavuz, 2005). Depending on 1998 TDHS results Yavuz (2005) notes that the TFR of Kurdish women is almost double that of their Turkish counterparts (4.27 and 2.29, respectively). On the basis of this evidence, he argues that the Kurds and Turks are the actors of different demographic regimes and the Kurds are the laggards in the fertility decline process in Turkey. It should also be noted that the observed fertility differences between these two ethnic groups are part of a series of wider and deeper inequalities prevailing among them. As evidenced by Içduygu, Romano, and Sirkeci (1999) and Sirkeci (2000) the Kurdish households in Turkey are

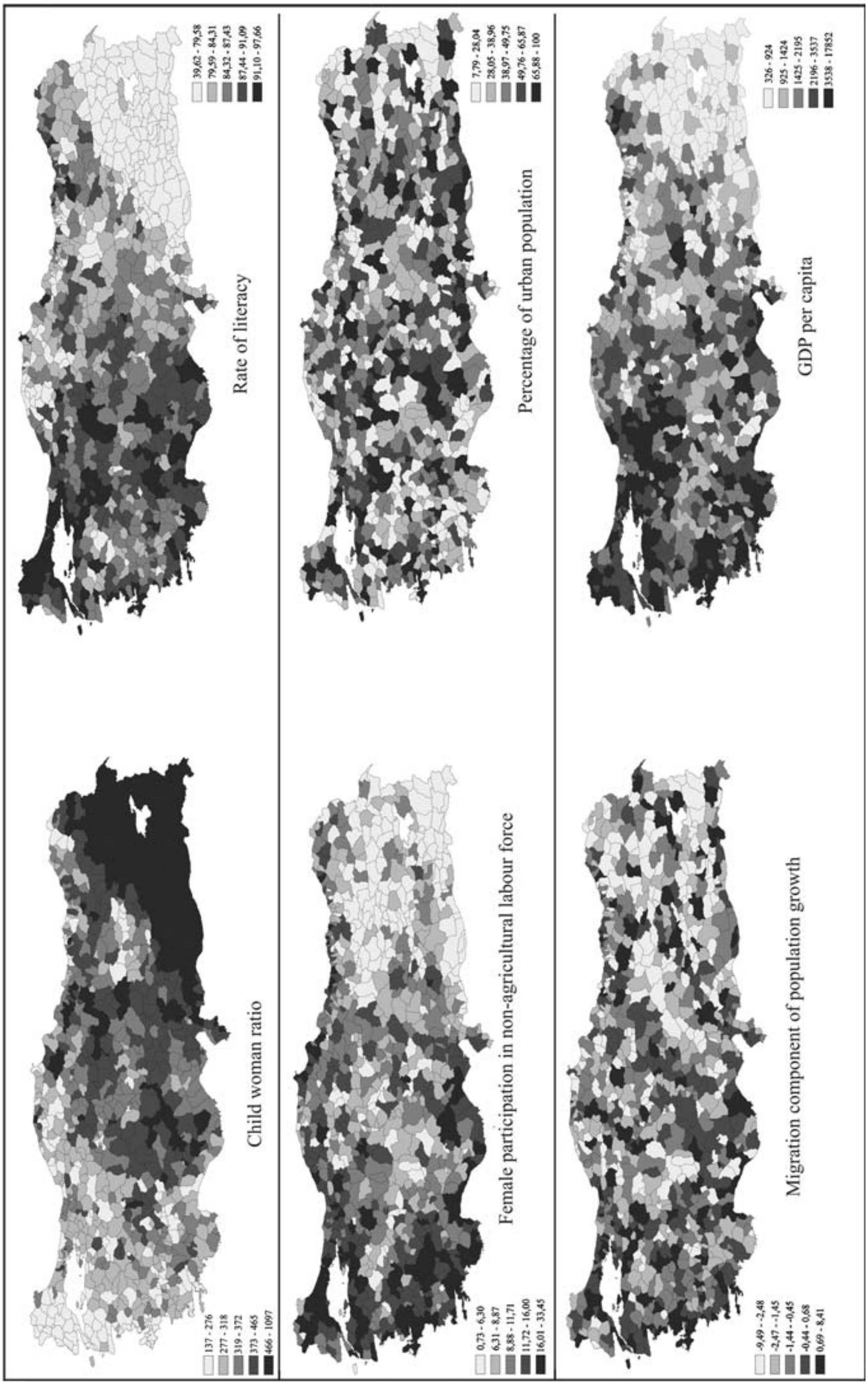

Fig. 3 Spatial distribution of variables by quintile ranges

materially worse off, live in far worse conditions and are poorly educated compared to Turkish households.

However, despite the fact that this fertility gap between the Kurds and Turks is valid for all regions (Koç & Cavlin, 2006; Sirkeci, 2000), there is some evidence to believe that it somewhat gets narrower in areas outside the traditional Kurdish areas. For instance Yavuz (2005) mentions that the 1998 TFR for the Kurdish women living in the traditional Kurdish region is 4.84 as opposed to their national average of 4.27. Taking these figures into account and assuming that 65% (Mutlu, 1996) or 70% (Içduygu et al., 1999) of all Kurds are the inhabitants of the eastern and south-eastern regions, it could be concluded that the TFR for the Kurds living outside the traditional Kurdish region should be somewhere between 3.2 and 2.9. It therefore seems reasonable to argue that the Kurds who have migrated to other parts of the country have adopted, or are on the way of adopting, a new fertility pattern closer not to the one in their place of origin but to the one where they are settled. This refers to the necessity of making a distinction between the Kurds living in eastern and south-eastern regions and those in other parts of the country while inquiring fertility differentials between ethnic groups. On the other hand, we know, once again with reference to Yavuz (2005), that the Turkish-speaking women settled in what is referred to as the traditional Kurdish region of the country do have a TFR well above their national average (2.93 as opposed to 2.29). This means that geography plays a significant role that could explain the fertility differentials even within a particular ethnic group. With this statement we do not mean that the ethnic differences are of little importance or that they do not have an explanatory power in fertility differentials. We simply wish to make the point that an over-emphasis on ethnicity might be misleading unless a clear reference is made to geography, the context in which it exerts in influence.

In the model below designed to account for fertility differentials between regions, ethnicity is not taken into account not because it is not important or irrelevant, but because of the simple fact that the census data contains no information on ethnicity. However, by studying the very factors that differentiate one locality from others, we hope that our analysis will shed light, though in an indirect manner, onto the ways in which ethnicity works in different circumstances.

3 Determinants of fertility decline: data and OLS

The State Institute of Statistics (SIS) gathers and disseminates data essentially at two spatial levels: provinces (81 units) and districts (923 units). Province-level datasets are numerous, highly detailed and of better quality compared to district-level datasets. This means, as far as spatial analyses are concerned, that the students of geography do have to make a choice between doing their research with limited number of variables but on a large number of settlements or, carrying out their research with relatively abundant data but on a small number of settlements. Our analysis in this article is based on district-level data of the latest census in 2000. We therefore had to sacrifice some variables that would have been available had the analysis been at province level, for the sake of making our analysis for larger number of settlements, in the belief that GWR would give better and more reliable results.

As we mentioned before our dependent variable is CWR, a proxy for recent fertility. As for the independent variables that impinge upon fertility, the demography literature has a lot to offer. Few topics in demography have attracted as much attention as the study of the determinants of fertility. The wide literature on the determinants of fertility can indeed be divided into two broad groups. There are on one side studies that conceptualise fertility as a function of socio-economic, cultural and environmental factors. These factors are referred to as "indirect determinants" by Bongaarts (1978) since they exert their impact on fertility via such biological and behavioural factors as the prevalence of contraception, timing of marriage, proportion married, induced abortion, all referred to as "direct" or "proximate determinants".

The independent variables we have chosen for this study are conditioned on the one hand by data availability and, on the other, by our reading of the "indirect determinants" literature. The data used here consist of the results of the 2000 population census for 923 districts, except for the GDP variable calculated for 1996 by the SIS and regularly updated by the State Planning Organisation since then. We attempt to explain fertility differentials with the help of following variables:

(1) LITERACY—the adult literacy rate;
(2) FEMALE—female participation in non-agricultural workforce i.e. the number of women employed in non-agricultural sectors divided by the total number of non-agricultural workforce;
(3) URBAN—the percentage living in urban areas;
(4) GDP—per capita gross domestic product in US dollars;
(5) MIGRATION—the migration component of population growth, that part of population growth in each district that is attributable to migration (for calculation see below).

Of these variables the one that has attracted the utmost attention and been regarded as the main driving force behind the fertility decline is, without doubt, the level of education. Among the voluminous literature exploring the relationship between education and fertility, we may refer to Kirk (1996), Klasen and Launov (2003), Leiyu (1992), Nguyen-Dinh (1997) and Saila-Ngita (2002) who all found out a strong negative relationship between the level of education and fertility. The same relationship is verified for Turkey in various studies (Behar, 1995; Düzgüneş, 1985; Ergöçmen, 1997; Farooq & Tuncer, 1974; Remez, 1998; TDHS, 1999, 2004). TDHS 2003 results point out a striking inverse relationship between women's education and fertility. While TFR for women with no education is 3.6, it drops to 1.4 for women with at least a high school degree. Düzgüneş' (1985) and Ergöçmen's (1997) findings are worth mentioning in that they find out, depending on different data sets, that man's education level is as much effective on fertility as woman's education. The evidence for this is the fact that fertility declines even in cases when there is a considerable gap between man's and woman's educational levels, a fact which may also be regarded as an evidence of male dominance on decisions influencing fertility. With this impact on mind we chose adult literacy rate, rather than female literacy rate, as our independent variable.

Our second independent variable is a measure of women's participation in economic activity, which is also another universally accepted determinant of fertility level. Though using different measures of women's participation in economic activity, Chamratrithirong, Hirschman, and Guest (1992), Kabir, Barbhuiya, and Islam (2001), Klasen and Launov (2003), Li (1973) and Martine (1996) all find out a strong inverse relationship between fertility and women's employment. Providing direct access to non-domestic sphere and control over financial resources, employment ''transforms'' women (Kishor, 1995) and contributes to their empowerment. Just like the former one—literacy—this variable takes into account the increasing emancipation of women under the influence of modernisation and thereby their power to control their fertility. In this sense these two variables may be regarded as the expression of the modernisation assumptions that lie at the very heart of demographic transition theory. One should, however, be extremely careful while talking about Turkey, as an inconsiderate use of woman-related indicators may serve just the opposite purpose they were designed for.

In Turkey, female participation in workforce has been exceptionally low and increased very slowly. Out of a total of some 26 million working people in 2000, over one-thirds (36.3%) are women. This figure is misleading since Turkish data count unpaid family workers as employed. Three quarters of ''working'' women are in agriculture and 90% of them are unpaid family workers. Owing to the predominance of small land ownership, Turkish agriculture still depends to a large extent on family economy and unpaid women labour. Therefore, the figure of 36.3% is an indication of an economy in which work and domestic spheres are not clearly separated, and thus of the patriarchal relations women live in, not an indication of increasing emancipation or empowerment on the part of women. On the other hand, female participation in non-agricultural sectors has been extremely low. In the year 2000, out of a total of 13.4 million people working in non-agricultural sectors, only 11.7% are women; varying between a minimum of .7 and a maximum of 33.4%. With a rapid increase in working age population coinciding with a structural transformation away from labour-intensive agriculture toward industry and services, women have found it increasingly difficult to find a place for themselves in the urban labour markets essentially because of low level of educational attainment (World Bank, 2006). The growing gender gap in employment in almost all sectors does testify to the withdrawal of women from the labour force with increasing urbanisation. With these points on mind, we chose as our independent variable the percentage of female participation in non-agricultural sectors where the practice of using unpaid family labour is an exception. A similar argument with a slightly different emphasis is put forward by Ergöçmen (1997) who finds that it is the employment with social security that makes a significant negative impact on fertility, while the practice of working without social security has also a negative but smaller contribution.

As for the third variable, urban population, it must be noted as stressed by Weeks, Getis, Hill, Gadalla, and Rashed (2004) that ‘‘the history of fertility transitions is almost universally a picture of fertility declining first in cities, with a later spread to rural areas’’. This, too, is a logical consequence of modernisation assumptions of demographic transition theory, since concentration of population in urban areas is regarded both as a consequence and an accelerator of modernisation process. The inverse relationship between fertility and the urban nature of a settlement is stressed by many researchers (Bollen, Glanville, & Stecklov, 2002; Brookins & Brookins, 2002; Kabeer, 2001) and, in the case of Turkey, by TDHS (2004) where the TFRs for urban and rural areas are found to be 2.06 and 2.65, respectively.

The relationship between income and fertility is also one of the most explored ones in the demography literature. There, it is argued, is an inverse relationship between the two; meaning the higher the income level, the lower the fertility. The negative impact of income on fertility decisions is explained with reference to the fact that ‘‘households prefer to provide quality services to their children rather than increasing the number of children’’ (Hondroyiannis, 2004).

The last variable we have taken into consideration is the rate of migration. As noted by Kulu (2005) the relationship between geographical mobility and fertility is a complex one. Looking at the fertility differentials of newcomers and those residing in Istanbul for some time, SIS (1995) concludes that the population of Istanbul would not grow if there were no migration, thus making it clear that migration is one of the key factors behind the rapid growth of metropolitan areas. The relationship between migration and fertility cannot, however, be reduced to a single, one-way relationship as there are various patterns of geographical mobility. As Gedik (1996) notes, urban-to-urban migration is as important as rural-to-urban migration in total migratory flows, with surely different impacts on fertility. According to Karaduman-Taş’s (no date) calculations 1993 TFRs are 2.3, 2.5 and 3.5, respectively, for non-migrant urban dwellers, urban-to-urban migrants and rural-to-urban migrants. Although the new dwellers in a particular city adapt to the urban norms of fertility in a relatively short span of time, it is expected that there would be a positive correlation between the rate of migration to a settlement and the level of fertility.

Given net migration figures solely for provinces and population growth rates and indicators of fertility for both provinces and districts, we had to make a number of assumptions in an attempt to calculate district-level migration figures. In doing this we disaggregated district-level population growth into two components—one originating from natural increase and the other from net migration. In the first place we calculated what the actual population of each *province* would have been if there had been no migration. This gave us natural population growth rate (i.e. births minus deaths) for each

Table 1 Ordinary least squares (OLS) regression results

Dependent variable	Child–woman ratio (CWR)				
Number of observations	923	Degrees of freedom	917		
R^2	.691	Adjusted R^2	.689		
F-test	409.682				
	Unstandardised coefficients	Std. error	Standardised coefficients	*T*-value	Significance
CONSTANT	1676.655	36.487		45.952	.000
LITERACY	–14.763	.462	–.783	–31.934	.000
FEMALE	–5.028	.673	–.184	–7.474	.000
MIGRATION	13.959	1.648	.183	8.468	.000
URBAN	.789	.154	.109	5.131	.000
Gross domestic product (GDP)	–.00531	.002	–.070	–2.982	.003

province between 1995 and 2000. Assuming that these differences in natural population growth rates are solely attributable to differences in fertility (thus assuming that there are no differences in mortality rates between the districts of a *given province*), we calculated a coefficient for each province. We then calculated natural growth rates for each district according to how much they differed from province-level fertility figures. Finally the difference between this growth rate and the actual growth rate gave us what we referred to as the migration component of population growth for each district.

The results of the ordinary least squares regression analysis made with the above variables are given in Table 1. The CWR variable exhibits a statistically significant negative relationship with LITERACY, FEMALE and GDP and a statistically significant positive relationship with MIGRATION and URBAN. Hence the higher the level of education, income and female participation in non-agricultural workforce in a given settlement, ceteris paribus, the lower the level of CWR variable. In a similar fashion, the higher the rate of migration to and the percentage of urban population in a given settlement, ceteris paribus, the higher the level of CWR variable. The overall regression analysis yields a significant F statistics and a reasonable global fit of .69. Of these variables the ones having the largest explanatory power are LITERACY, FEMALE and MIGRATION, which in combination explain 68% of the variations in the dependent variable. In the next section we analyse how these relations do change from one district to another and find out that there are striking differences that remain hidden in the global analysis.

4 GWR model

As a technique of spatial analysis GWR was initially formulated and developed by Fotheringham, Brunsdon and Charlton (see Brunsdon, Fotheringham, & Charlton, 1996, 1998, 1999, 2002; Fotheringham, Charlton, & Brunsdon, 1997, 1998, 2001, 2002). Since then GWR has been one of the most commonly used techniques of spatial econometrics with increasing applications in various fields including regional studies (Bivand & Brunstad, 2002), environmental studies (Osborne & Suàrez-Seoane, 2002; Platt, 2004), transportation planning (Zhao & Park, 2004), political geography (Calvo & Escolar, 2003) and real estate economics (Tu, Yu, & Sun, 2004). Indeed the GWR technique is about to become to spatial econometrics what the OLS method is to the conventional statistical analysis. However fruitful the technique may seem for the analysis of spatially changing relations, its use in demography has so far been limited with the exception of Weeks, Getis, Yang, Rashed, and Gadalla (2002a) and Weeks, Yang, Getis, Gadalla, and Hill (2002b) who studied the changing patterns of fertility in rural Egypt and Cairo.

Although the calculations required to run a GWR model may initially seem complicated and time consuming, its underlying rationale is simple and easily understandable. It depends on one of the most important premises of geography, also known as "Tobler's First Law of Geography" (Miller, 2004)—"Everything is related to everything else, but things that are closer in space are more related than distant things". One of the observations is selected as the reference point and all other observations are weighted according to a decreasing function of distance from the reference. Having calculated the parameters of estimation for the reference point, these calculations are repeated for all observations in the dataset. The result is a series of mappable coefficients showing the local relation between the dependent and independent variables.

In matrix notation the standard OLS equation is given by the following equation:

$$\beta^* = \left(X^{\mathrm{T}}X\right)^{-1}X^{\mathrm{T}}Y$$

where β^* is a vector comprising K regression parameters; Y is the dependent variable in vector form of length of N observations; and X is a matrix of independent variables consisting of N rows and $K + 1$ columns (because of 1's in the first column). In matrix notation GWR model is expressed as follows:

$$\beta_i^* = \left(X^{\mathrm{T}}W_iX\right)^{-1}X^{\mathrm{T}}W_iY$$

where W_i is the weight matrix at location i, an N by N matrix whose diagonal elements are the weights of each observation and off-diagonal elements are zero. The weights are defined as decreasing functions of distance, meaning that they are greater for points closer to the reference point.

One of the most crucial problems in the design of a GWR model is the use of distance between spatial units as a weighting factor. The weights are defined as a continuous decreasing function of distance, whereby the points closer to the reference point exert larger influence compared to more distant ones. The point here is the selection of bandwidth that controls the rate at which this decay in weighting occurs (Brunsdon et al., 2002). If the bandwidth is too large the GWR results tend to be too coarse to be meaningful, closing to the OLS results as the bandwidth gets closer to infinity. On the contrary, if the bandwidth is too small, GWR parameters would be too localised reflecting only the conditions in the immediate vicinity of each reference point (Fotheringham et al., 2001). In this study we used a fixed kernel bandwidth selection procedure with the help of the following formula:

$$W_i = \exp\left[-1/2\left(d_{ij}/h\right)^2\right]$$

where d_{ij} is the distance between locations i and j; and h is the bandwidth. In this formula the weights are non-zero no matter how far they are from the point i. We also used a cross validation method for the selection of optimum bandwidth (See Fotheringham et al., 1997, 1998, 2002 for further details). A bandwidth of 57 km gave in our case the optimum results.

The results obtained indicate that GWR significantly improved the OLS results with the Akaike Information Criterion (AIC) value dropping from 10,870 to 10,130 and R^2 rising from .69 to .90. That the GWR model is a significant improvement on the global model can also be seen in Table 2, where ANOVA comparison of models is given.

The spatial distribution of GWR parameters, including the intercept term, is given in maps in Fig. 4. When evaluated together with Table 3 showing the average values of GWR parameters and variables arranged in quintile ranges for GWR results, these maps give a fairly complete account of the local determinants of fertility in Turkey. The top left map in the figure shows the spatial distribution of the intercept terms in Turkey. Following Huang and Leung (2002), the intercept term or constant parameter measures the fundamental level of CWR excluding the impacts of all factors on fertility across Turkey. It may therefore be referred to as the ‘‘basic level of fertility’’. There seems to be a clear spatial variation in the distribution of constant parameters with the eastern and south-eastern regions and the southern parts of central Anatolia having the highest values, and western and central-northern regions having the lowest values. This map should be regarded as the ‘‘corrected’’ version of the top left map in Fig. 3 showing the country-wide distribution of CWR.

As to the changing aspects of local relationship between fertility and individual independent variables, following comments can be made:

Table 2 ANOVA comparison of the ordinary least squares (OLS) and geographically weighted regression (GWR) models

Source	Sum of squares	Degrees of freedom	MS	F	Adjusted R^2
OLS	6,932,831	6			.688674
GWR improvement	5,269,331	216.62	24,324.81		
GWR	1,663,500	700.38	2,375.15	10.2414	.902161

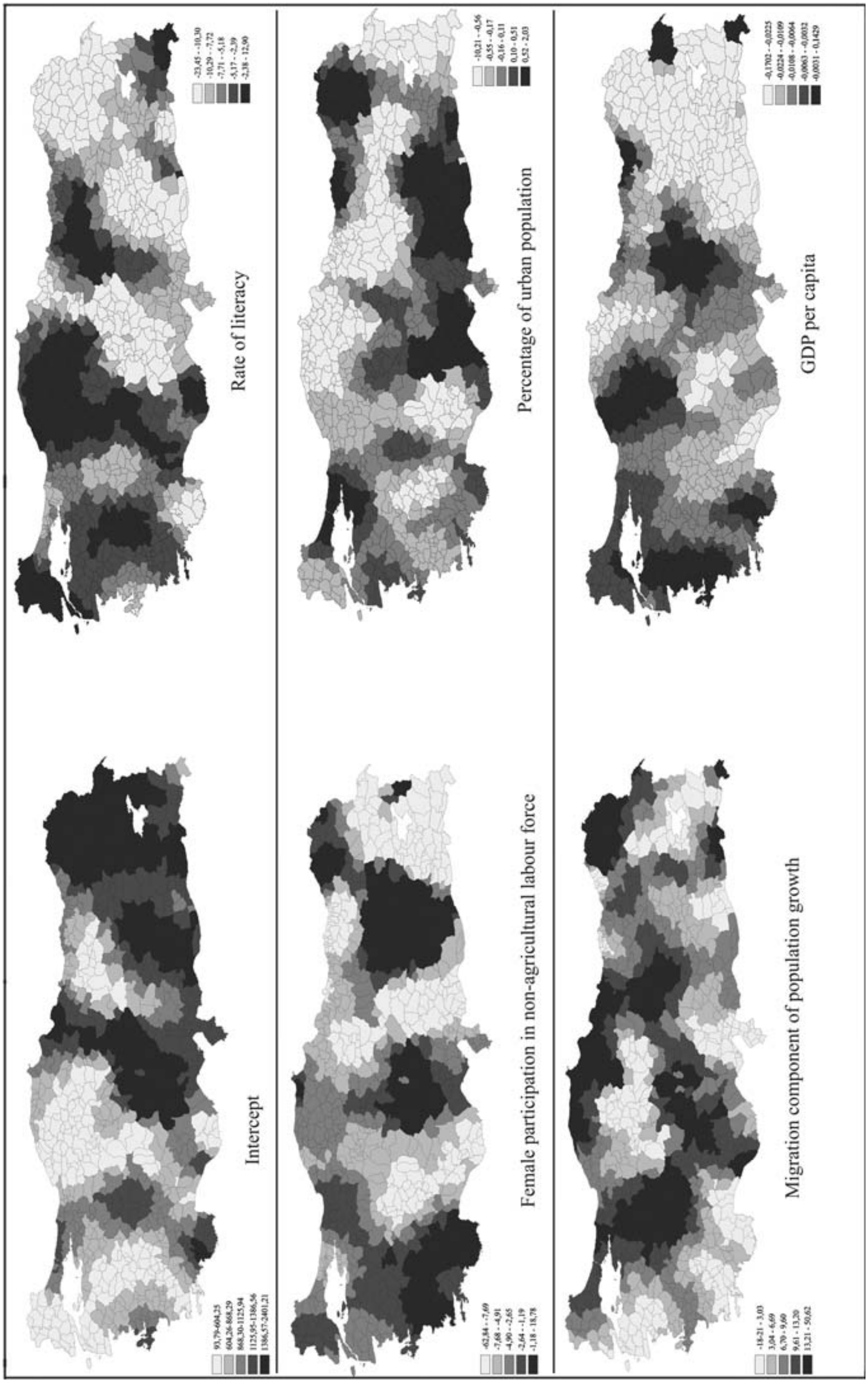

Fig. 4 Spatial distribution of geographically weighted regression (GWR) parameters by quintile ranges

Table 3 Mean values of GWR parameters and variables in quintile ranges

	GWR parameters for						Observed values of					
	INTERCEPT	LITERACY	FEMALE	URBAN	MIGRAT.	GDP	CWR	LITERACY	FEMALE	URBAN	MIGRAT.	GDP
INTERCEPT												
Lower quintile	424.48	–0.30	–3.81	–0.39	5.65	–0.00652	313	86.4	12.3	45.4	–0.9	2832
Upper quintile	1691.66	–13.89	–4.15	0.16	11.51	–0.03041	519	78.2	7.5	41.3	–1.5	1338
LITERACY												
Lower quintile	1673.56	–14.32	–1.68	0.29	11.53	–0.02447	468	78.3	8.0	41.1	–1.5	1518
Upper quintile	446.66	–0.06	–5.25	–0.62	6.83	–0.00793	339	89.7	11.2	46.2	–1.0	2531
FEMALE												
Lower quintile	1184.82	–7.02	–12.50	–0.11	8.65	–0.01984	517	79.6	7.9	43.4	–1.3	1285
Upper quintile	1249.95	–10.08	2.57	0.03	7.68	–0.02628	392	82.2	16.8	43.7	–1.3	2125
URBAN												
Lower quintile	957.26	–4.85	–5.34	–1.24	12.95	–0.02079	433	80.4	9.0	41.8	–1.6	1484
Upper quintile	1310.05	–10.43	–3.70	0.97	9.56	–0.02044	410	83.7	12.1	67.1	–0.8	2741
MIGRATION												
Lower quintile	882.12	–5.11	–4.67	0.07	–0.42	–0.01763	398	84.5	11.6	47.2	–0.7	2349
Upper quintile	1209.38	–8.27	–5.35	–0.55	19.78	–0.01644	384	83.9	9.9	42.5	–1.3	2005
GDP												
Lower quintile	1398.12	–9.84	–3.68	–0.05	11.05	–0.05246	563	75.3	7.1	42.2	–1.8	1104
Upper quintile	801.32	–4.56	–5.41	–0.33	6.26	0.00279	341	86.6	12.5	51.0	–0.4	3514

4.1 LITERACY (top right map in Fig. 4)

Although there exists at the national level negative highly significant relationship between the level of education and fertility, the GWR results make it clear that this relationship is highly variable in space. Not only does the magnitude of interaction between fertility and education change considerably from one district to another, but also the direction of this relationship is reversed in some cases. It may be observed from the map that the inverse relationship between literacy and fertility is stronger in eastern and south-eastern parts of Turkey, where the intercept term is also the highest and the level of education is lower. This means that in this region, the low level of education does have a pronounced negative impact on fertility. Table 3 makes it clear that in districts where the negative impact of education is strongest, fertility is high and the level of education is low. This indicates that, ceteris paribus, the lower the level of education, the stronger and more significant its negative impact on fertility. This finding has a crucially important policy dimension as to the regions where the level of education is low: In such regions, even a small increase in the level of education could lead to a multiplied decline in fertility, much higher than it could in other regions.

As one goes from east to west, this negative relationship between education and fertility starts to weaken and even turns to positive in regions where the level of education is higher. The settlements in Thrace can be cited an examples of such areas. In such areas, it is highly likely that an increase in the level of education would not bring with itself a further decline in fertility. A saturation point may thus be claimed to have been reached in these districts in terms of the relationship between fertility and education. There are, however, three major exceptions in the western region i.e. enclaves where there is a negative highly significant relationship between education and fertility: Istanbul, Izmir and the south-west corner. In these areas, the level of education exerts its impact on fertility in a fashion similar to eastern districts. All these three areas have attracted significant migration in the decade preceding 2000 (see bottom left map in Fig. 3). This could be the reason why in these areas the relationship between education and fertility is akin to that in eastern and south-eastern districts.

4.2 Female participation in labour force (middle left map in Fig. 4)

Those said above in connection with the relationship between education and fertility are also valid, to a large extent, for the local interaction between fertility and female participation in non-agricultural labour force. This relationship is too highly variable in space, exhibiting striking variations in terms not only of magnitude, but also of the direction of the relationship. The negative relationship between fertility and female participation is stronger in eastern and south-eastern Turkey, and in settlements along the Mediterranean and Black Sea coast. Table 3 indicates that where the inverse relationship between the two variables is stronger, the level of female participation is already low and fertility is high. This is a conclusion akin to the one discussed above in connection with education: In areas where the female participation in non-agricultural labour force is already low, its negative impact on fertility is stronger, implying that a possible rise in women's participation in the non-agricultural economy could lead to a marked decline in fertility. In those parts of the country where women more actively take part in non-agricultural sectors, its impact on fertility somewhat weakens and is even reversed in some parts.

4.3 Urban population (middle right map in Fig. 4)

The OLS results revealed the existence of a positive significant relationship between the percentage of urban population and fertility. There are, however, settlements where the two variables are correlated in both directions. On one end of the spectrum, there are settlements in eastern regions and along the Black Sea coast where the level of urbanisation and fertility are inversely related. Note from Table 3 that these are areas where the percentage of urban population is already low. On the other end of the spectrum, there are settlements where the percentage of urban population is higher than the national average. Especially in Istanbul and surrounding settlements where a considerable portion of the urban population lives, the magnitude of the positive relationship between the percentage of urban population and fertility is the highest. It is thus possible to conclude that where the percentage of the urban population is above the national average, its impact on fertility is positive and strong. Conversely, the percentage urban population seems to have a strong negative impact where the percentage of urban population is low.

4.4 MIGRATION (bottom left map in Fig. 4)

Despite the fact that the OLS results implied a positive relationship between fertility and migration, the exact relationship between the two is extremely contingent in space and more complex than a cursory examination might reveal. The map shows that in eastern regions and settlements along the central Black Sea, and in an area to the east and west of Central Anatolia, there is a strong positive relationship between fertility and migration. We already know (see bottom left map in Fig. 3) that these are areas where there is a considerable out-migration. It seems that the rapid out-migration in these areas explains, in part, the higher-than-expected fall in TFR from 1998 to 2003 observed in the Central and Northern Anatolia (TDHS, 2004). On the other hand, the Istanbul metropolitan area, to which we know there is a rapid migration, is also included in this group. This has a very clear explanation: Fertility and migration is strongly positively correlated in areas where there is rapid in—and out-migration. In settlements where the migration variable is negative (i.e. settlements with a high level of out-migration), the level of fertility tends to be lower, since it is in most cases the younger generations that migrate to cities. In such areas, the lower the migration variable, the lower the level of fertility (positive correlation). On the contrary, in areas where there is a rapid in-migration the level of fertility tends to increase because of the fact that it takes some time for the newcomers to adapt to the urban norms of fertility. In such areas, therefore, the higher the migration variable, the higher the level of fertility (positive correlation).

4.5 Gross domestic product (bottom right map in Fig. 4)

The final picture that arises in connection with the local relationship between GDP and fertility is very clear and be expressed in a few words. In areas where per capita income is low (eastern and south-eastern areas), its impact on fertility is negative. In relatively more well-off parts of the country, the correlation between the two somewhat weakens and is neutral in most cases.

5 Conclusions

Turkey is surely about to complete its demographic transition process. This is a general and irreversible process that affects, though in varying degrees, all localities and social groups. It is obvious that the fertility decline is not a linear and all-embracing process that automatically leads to homogenised demographic behaviours, since the pace with which and the ways in which a particular locality or social/cultural group is affected from the dynamics of social change do vary considerably from one locality or group to another. The most important conclusion to be drawn from the analysis we have carried out is the fact that the regional differences in Turkey cannot simply be reduced to the differences of quantity, but there are regions and settlements that are qualitatively different from each other. It is not merely the magnitudes that differ from one region to another but also the very reasons that lead to the levels of fertility. The differences between localities are too diverse and complex to be fully grasped by the analyses such as OLS that assume single and one-way relationship between the variables. Even in settlements with the same or similar fertility levels, entirely different dynamics are at play. The very same cause may lead, in a different local setting, to entirely different results. It is not simply the case that one and a single process of transition has been experienced at different paces in different localities. On the contrary, we argue that there does not exist a single, ubiquitous process of fertility decline, but that different localities have been undergoing qualitatively different transitions within the overall transition process.

Turkey is a country of wide regional inequalities not only in terms of fertility-related variables, but also in almost every aspect of social and economic life. These regional inequalities are, however, too complex to be grasped by a simple east-west divide. There are, between these two extremes, different shades of grey, in-between cases that defy classification. An analysis departing from national averages cannot fully comprehend these intermediary forms and, thus, cannot lead to different modalities of action. In this sense, the GWR results are potentially useful in targeting priority areas for further action. Furthermore, in a country like Turkey characterised by an extremely high level of social and geographical mobility, perspectives like modernisation theory having fixed points of reference are destined to fail even at the outset (Işık and Pınarcıoğlu, 2001). In an attempt to go beyond the "black and white" approaches of demographic transition perspective and to fully grasp the different shades of grey that lie in between, different methods that would emphasise contingency and local dynamics are needed.

As far as demographic variables are considered, our analysis revealed the existence of, and added some new dimensions to, the well-known problem of regional disparities in Turkey. The eastern and south-eastern regions of the country are characterised by high rates of fertility and a different demographic pattern, close to the national average of three decades ago, while other regions have already reached below-replacement levels of fertility. The GWR results showed that the basic determinants of demographic transition—such as education, female participation in labour force, migration and income—do have a pronounced impact on the level of fertility in the eastern and south-eastern regions of the country. This is an optimistic picture as it indicates that even a minor change in these variables could pave the way for a marked decline in fertility, at a rate much higher than they could in other regions.

This optimistic picture as to demographic change in the east and southeast turns into a grimy one as one considers wider variables and the complex matrix of power relations in the region. The pace of not only demographic transition but also the wider social and economic transformation of the region is inevitably linked to the pace at which modernisation dynamics can penetrate into the region. It is clear that modernising dynamics have been extremely slow in dissolving the existing social and economic relations in the region. One of the major reasons for such a slow change should be sought in the problems originating from the overlap between the regional economic disparity and a particular ethnic (Kurdish) identity, which in the last three decades has been translated into growing Kurdish nationalism (Yavuz, 2001). The existence of an armed conflict in the region has further complicated the problems. Despite some significant investments in the region especially in power plants and irrigation, the main agent that could trigger a wider social and economic change in the region—the state—has been extremely slow and passive as far as the dissolution of "tribal" relations is concerned (Mutlu, 2001). The maintenance of traditional relations in the region has been to the benefit of the state that feels under increasing threat due to growing Kurdish nationalism in the region. The east and the southeast is, therefore, in a stalemate out of which there does not seem to be an exit in the short run. The pace of demographic transition in the region will surely depend on how this dilemma is solved.

In addition to the east and southeast, there are also other regions that deserve particular attention. The districts along the Black Sea coast and in central Anatolia seem to have undergone a fertility decline at a pace much higher than the rest of the country. The GWR results pointed out that the large-scale out-migration that these regions have experienced is the main reason behind this rapid decline in fertility. On the other hand, the growing tendency for the population to concentrate in the metropolitan areas and in areas along the west and south-west coast is one of the most important reasons for the observed fertility differentials among the regions. The 2003 TDHS results point out that the rate of fertility has already fallen below replacement level, to 1.8 in Istanbul. This is a striking figure especially when one considers that Istanbul is still a major attraction point for the migrants who contribute positively to fertility in the short run. Given the fact that the rate of migration to Istanbul has slowed down and will continue to do so in the near future, it would not be wrong to expect further decline in fertility in the years to come. Furthermore, there are also reasons to assume that the influx of population to Istanbul would not cause a rise in fertility to the degree as it did in the past, because of the growing share of urban-to-urban migration in total migratory flows. The GWR results indicated in the case of Istanbul a strong correlation between almost all independent variables and the level of fertility, which means that the fertility is likely to continue to fall.

We should also draw attention to women's status in Turkish society in connection with not only the demographic transition but also the wider societal changes in the medium to long run. In contrast to the assumptions of modernisation theories, Turkey achieved its demographic transition without a significant change in women's status in the society. Women who used to work in family farms cannot find a place for themselves in the urban labour market essentially because of their low level of educational attainment. The issue of education is likely to appear as a major problem in dealing with the problems associated with making use of an increasing labour supply.

Finally the results indicate that education, women's empowerment and geographical mobility are the elements with crucial impact on demographic variables. Our analysis revealed that these three major variables, all having strong dissolving impacts on traditional relations and structures, do exhibit striking regional variations and that they could lead to different outcomes in different settings. What Turkey is likely to experience in the short to medium run not only in the sphere of demographic change but also in terms of wider societal changes will be determined to some extent by how these there variables will articulate with the political discourse.

References

Angın, Z., & Shorter, F. C. (1998). Negotiating reproduction, gender and love during the fertility decline in Turkey. *Social Science and Medicine, 47*(5), 555–564.

Bollen, K. A., Glanville, J. L., & Stecklov, G. (2002). Economic status proxies in studies of fertility in developing countries: Does the measure matter? *Population Studies, 56*(2), 81–96.

Behar, C. (1995). The fertility transition in Turkey: Reforms, policies, and family structure. In C. M. Obermeyer (Ed.), *Family, gender and population in the Middle East* (pp. 36–57). Cairo: The American University of Cairo Press.

Bivand, R. S., & Brunstad, R. J. (2002). Regional growth in Western Europe: An empirical exploration of interactions with agriculture and agricultural policy. Norwegian School of Economics and Business Administration, Discussion Paper.

Bongaarts, J. (1978). A framework for analyzing the proximate determinants of fertility. *Population and Development Review, 4*(1), 105–132.

Brookins, M. L., & Brookins, O. T. (2002). An exploratory analysis of fertility differentials in India. *The Journal of Development Studies, 39*(2), 54–72.

Brunsdon, C., Fotheringham, A. S., & Charlton, M. (1996). Geographically weighted regression: A method for exploring spatial nonstationarity. *Geographical Analysis, 28*(4), 281–289.

Brunsdon, C., Fotheringham, A. S., & Charlton, M. (1998). Geographically weighted regression—Modelling spatial non-stationarity. *The Statistician, 47*(3), 431–443.

Brunsdon, C., Fotheringham, A. S., & Charlton, M. (1999). Some notes on parametric significance tests for geographically weighted regression. *Journal of Regional Science, 39*(3), 497–524.

Brunsdon, C., Fotheringham, A. S., & Charlton, M. (2002). Geographically weighted summary statistics—A framework for localised exploratory data analysis. *Computers, Environment and Urban Systems, 26*, 501–524.

Calvo, E., & Escolar, M. (2003). The local voter: A geographically weighted approach to ecological inference. *American Journal of Political Science, 47*(1), 189–204.

Chamratrithirong, A., Hirschman, C., & Guest, P. (1992). A multi-level analysis of the determinants of fertility in the four regions of Thailand. *Asia-Pacific Population Journal, 7*(1), 51–64.

Düzgüneş, M. (1985). *Socio-economic development and fertility decline in Turkey*. New York: United Nations.

Ergöçmen, B. A. (1997). An overview of women's status and fertility in Turkey. In M. E. Cosio-Zavalla (Ed.), *Women and families: Evolution of the status as factor and consequences of changes in family dynamics* (pp. 79–105). Paris: CICRED.

Farooq, G. M, & Tuncer, B. (1974). Fertility and economic and social development in Turkey: A cross-sectional and time series study. *Population Studies, 28*(2), 263–276.

Fotheringham, S., Charlton, M., & Brunsdon, C. (1997). Measuring spatial variations in relationships with geographically weighted regression. In M. M. Fischer, & A. Getis (Eds.), *Recent developments in spatial analysis* (pp. 60–82). London: Springer-Verlag.

Fotheringham, S., Charlton, M., & Brunsdon, C. (1998). Geographically weighted regression: A natural evolution of the expansion method for spatial data analysis. *Environment and Planning A, 30*(11), 1905–1927.

Fotheringham, S., Charlton, M., & Brunsdon, C. (2001). Spatial variations in school performance: A local analysis using geographically weighted regression. *Geographical & Environmental Modelling, 5*(1), 43–66.

Fotheringham, S., Charlton, M., & Brunsdon, C. (2002). *Geographically weighted regression*. Chichester: John Wiley.

Gedik, A. (1996). Internal migration in Turkey, 1965–1985: Test of some conflicting findings in the literature. *Working Papers in Demography* No: 66, The Australian National University.

Goodchild, M. F. (2001). A geographer looks at spatial information theory. In D. R. Montello (Ed.), *Spatial information theory: Foundations for geographic information science. Proceedings of COSIT 2001* (pp. 1–13). Berlin: Springer.

Hancıoğlu, A., & Koç, I. (1999). Demographic differentials and demographic integration of Turkish and Kurdish populations in Turkey. Paper for the European Population Conference 1999, 30 August–3 September 1999, The Hague, The Netherlands.

Hondroyiannis, G. (2004). Modeling household fertility decisions in Greece. *The Social Science Journal, 41*, 477–483.

Huang, Y., & Leung, Y. (2002). Analysing regional industrialisation in Jiangsu province using geographically weighted regression. *Journal of Geographical Systems, 4*, 233–249.

Içduygu, A., Romano, D., & Sirkeci, I. (1999) The ethnic question in an environment of insecurity: The Kurds in Turkey. *Ethnic and Racial Studies, 22*(6), 991–1010.

Işık, O., & Pınarcıoğlu, M. M. (2001). *Nöbetleş e Yoksulluk—Sultanbeyli Örneği (Rotating Poverty—Case of Sultanbeyli). Istanbul: İletiş im Publications.*

Kabeer, N. (2001). Ideas, economics and "the sociology of supply": Explanations for fertility decline in Bangladesh. *The Journal of Development Studies, 38*(1), 29–70.

Kabir, A., Barbhuiya, M. A., & Islam, M. S. (2001). Determinants of fertility in Bangladesh: Evidence from the three national surveys. *The Sciences, 1*(5), 302–307.

Karaduman-Taş, A. (no date). Internal migration and fertility: An application of the Bongaart's Model. State Institute of Statistics, working paper; available at www.die.gov.tr/tkba/paper1_3.pdf.

Kirk, R. (1996). Determinants of fertility: Implications for the ''new'' federalism. *Review of Black Political Economy, 25*(2), 89–101.

Kishor, S. (1995). *Women's status module for use with DHS model questionnaires*. Calverto, Maryland: Macro International Inc.

Klasen, S., & Launov, A. (2003). Analysis of the determinants of fertility decline in the Czech Republic. Institute for the Study of Labor, Discussion Paper No. 870, www.iza.org.

Koç, I., & Cavlin, A. (2006). Demographic differentials and demographic integration of Turkish and Kurdish populations in Turkey. paper presented at European Population Conference 2006, Liverpool UK, 21–24 June 2006.

Kulu, H. (2005). Migration and fertility: Competing hypotheses. *European Journal of Population, 21*, 51–87.

Leiyu, S. (1992). Determinants of fertility: Results from a 1989 rural household survey in China. *Science Journal, 29*(4), 457–477.

Li, W. L. (1973). Temporal and spatial analysis of fertility decline in Taiwan. *Population Studies, 27*(1), 97–104.

Martine, G. (1996). Brazil's fertility decline, 1965–95: A fresh look at key factors. *Population and Development Review, 22*(1), 47–75.

Miller, H. J. (2004). Tobler's first law and spatial analysis. *Annals of the Association of American Geographers, 94*(2), 284–289.

Mutlu, S. (1996). Ethnic Kurds in Turkey: A demographic study. *International Journal of Middle East Studies, 28*(4), 517–541.

Mutlu, S. (2001). Economic bases of ethnic separatism in Turkey: An evaluation of claims and counterclaims. *Middle Eastern Studies, 37*(4), 101–135.

Nguyen-Dinh, H. (1997). A socioeconomic analysis of the determinants of fertility: The case of Vietnam. *Journal of Population Economics, 10*, 251–271.

Osborne, P. E., & Suàrez-Seoane, S. (2002). Should data be partitioned spatially before building large-scale distribution models? *Ecological Modelling, 157*, 249–259.

Platt, R. V. (2004). Global and local analysis of fragmentation in a mountain region of Colorado. *Agriculture, Ecosystems and Environment, 101*, 207–218.

Remez, L. (1998). In Turkey, women's fertility is linked to education, employment and freedom to choose a husband. *International Family Planning Perspectives, 24*(2), 97–98.

Saila-Ngita, D. (2002). An econometric analysis of the determinants of fertility and the demand for prenatal care services in Guatemala. PhD Thesis at the University of Connecticut.

Shorter, F. C. (1968). Information on fertility, mortality and population growth in Turkey. *Population Index, 34*(1), 3–21.

Shorter, F. C. (1995). The crisis of population knowledge in Turkey. *New Perspectives on Turkey, 12*, 1–31.

Sirkeci, I. (2000). Exploring the Kurdish population in the Turkish context. *GENUS, An International Journal of Demography, 56*(1–2), 149–175.

SIS. (1995). *The population of Turkey, 1923–1994: Demographic structure and development*. State Institute of Statistics, Publication No, 1839, Ankara.

TDHS. (2004). *Turkey demography and health survey, 2003*. Ankara: Hacettepe University, Institute of Population Studies.

TDHS. (1999). *Turkey Demography and Health Survey, 1998*. Ankara: Hacettepe University, Institute of Population Studies.

Tu, Y., Yu, S., & Sun, H. (2004). Transaction-based office price indexes: A spatiotemporal modelling approach. *Real Estate Economics, 32*(2), 297–328.

TUSIAD. (1999). *Turkey's window of opportunity—Demographic transition and its consequences*. Istanbul: Turkish Industrialists' and Businessmen's Association, Publication no: 99-3-254.

Weeks, J. R., Getis, A., Yang, X., Rashed, T., & Gadalla, S. M. (2002a). Spatial patterns as predictors of fertility in Cairo, Egypt. Paper presented at the Annual Meeting of the Population Association of America, Atlanta, GA.

Weeks, J. R., Yang, X., Getis, A., Gadalla, S. M., & Hill, A. G. (2002b). Spatial patterns as predictors of fertility change in rural Egypt. Paper presented at the Annual Meeting of the Population Association of America, Atlanta, GA.

Weeks, J. R., Getis, A., Hill, A. G., Gadalla, M. S., & Rashed, T. (2004). The fertility transition in Egypt: Intraurban patterns in Cairo. *Annals of the Association of American Geographers, 94*(1), 74–93.
World Bank. (2006). *Turkey: Labor market study*. World Bank, Poverty Reduction and Economic Management Unit, Report no: 33254-TR.
Yavuz, H. M. (2001). Five stages in the construction of Kurdish nationalism. *Nationalism & Ethnic Politics, 7*(3), 1–24.
Yavuz, S. (2005). Fertility transition and the progression to third birth in Turkey. Max Planck Institute for Demographic Research, Working Paper WP 2005-028.
Zhao, F., & Park, N. (2004). Using geographically weighted regression models to estimate annual average daily traffic. *Information Systems and Technology Transportation Research Record, 1879*, 99–107.