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Demographic transition, education and economic growth in Tunisia

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A B S T R A C T

This paper provides empirical evidence supporting the interaction between fertility, education and economic growth through the underlying mechanism behind that correlation in accordance with Becker's theory. In consistency with the theory, the key explanatory variables in Tunisia's fertility model are real GDP per capita, infant mortality, contraceptive use ratio, and education. As opposed to most empirical works, the present study takes into consideration three educational levels, i.e., primary, secondary and higher. Also unlike most empirical research, this study attempts to analyse the impact of fertility transition on education and economic growth. To deal with too little or incomplete data, time series data for Tunisia are computed over 45 years. A multivariate cointegration analysis is carried out and shows that a long-term triangular relationship exists. A short dynamic run analysis based on the vector correction error model displays results in coherence with and close to those of the long term. Among our key results, education is found to trigger fertility transition both in the short and long run. In addition, education has relatively fostered economic growth but hardly boosted it through its dynamic interaction with fertility. Furthermore, the variance decomposition and the impulse function show that the fertility transition has produced a feedback effect on both education and economic growth.

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1. Introduction

In the literature, the link between demographic transition, human capital accumulation and macroeconomic performance has continuously been emphasized.[1] The term demographic transition describes the change that occurred from pre-industrial high fertility and mortality to post-industrial low fertility and mortality observed along economic development. Demographic transition is often believed to foster economic growth.[2]

In particular, the New Household Economics theory claims that the interaction between fertility and human capital accumulation leads to demographic transition and incites economic growth.[3] Education may participate in declining fertility rate because it vehicles values in favour of socioeconomic advances in contrast to traditional ones.[4] Human capital has also been found to affect demographic and economic growth through diverse channels. The most familiar channel, however, is related to the child quantity–quality trade-off within households (Becker, 1960) as well as gender. Accordingly, education is expected to raise wages and consequently motivates great concern with high child quality. Besides, it is assumed to boost the "price" of child quantity through increasing the opportunities cost of time devoted by women on child care (in terms of foregone labour force participation). Moreover, as the household decisions moved away from child quantity to child quality, a remarkable decline in population growth took place. An even more important channel works through the human capital return on technological progress. Indeed, the choice made by parents concerning child education affects the pace of technological progress. For example, an augmentation in human capital accelerates technological progress, which in turn raises the human capital return and thus induces the substitution of child quality for child quantity characterizing demographic transition. Another channel is through the negative education effect on mortality. Finally, human capital accumulation is one of the prime engines for economic growth as a major production factor.

In addition, human capital accumulation can indirectly spur economic growth through accelerating demographic transition. Indeed, demographic transition affects the economic performance of a country in a number of ways. During the transition, households are more willing to reduce the number of children in order to foster education and ensure better human capital for the few remaining children. Therefore, they accumulate more human capital, which accelerates economic growth. Moreover, the fertility decline lowers the dependency ratio and increases the proportion of the working age population and, consequently, the availability of economically productive time. These changes have a great impact on economic growth (Nerlove and Raut, 1993). Besides, a low population growth reduces physical capital sharing among individuals and increases income per capita.

Demographic transition in Tunisia was fast. Over the last five decades, the population rate decreased to a low and stable level of around 1.18 percent, while fertility fell down to the population replacement threshold. Meanwhile, education development and economic growth were prompt. The schooling rate of the age group 6–11 rose from 29 percent to 97.7 percent and the GNP rose from about 87 to 5048.6 dinars per capita. Tunisia presents a successful example of demographic evolution and education generalization which will provide some insights about Arabic developing countries in the MENA regions. Similarly, the case is of interest in regard to the lack of related quantitative analyses. Did education change fertility behaviour and thus contribute to the demographic transition? Does a long-run causal triangular relation exist between fertility, education and economic growth? Did Tunisia benefit from the economic opportunities of the demographic transition?

In accordance with Becker's theory, the present study empirically tests the interaction between fertility–education and economic growth through the underlying mechanism behind that link. The paper does not aim at analysing the education–fertility interaction. Rather, it seeks to investigate the link between demographic changes and macroeconomic performance through analysing the education–fertility interaction. The paper aims at providing explicit evidence justifying the dynamic

[1] E.g., Galor and Weil (2000), Tamura (2002), Kalemli-Ozcan (2002), Hansen and Prescott (2002), Doepke (2004) and Cervellati and Sunde (2005).

[2] For example, for North Africa, see Bloom and Canning (1999) and Bloom et al. (2003).

[3] Becker et al. (1990) and De la Croix and Doepke (2003).

[4] Schultz (1969, 1985), Becker (1960, 1992), and Easterlin (1996).

education–fertility relationship and its role in accelerating fertility transition, checking the impact of this dynamic relationship on economic growth. Moreover, it attempts to verify the transition feedback on education and economic growth. It is worth noting that the present empirical analysis improves upon earlier studies by enlarging the model specification by considering the three education levels.

Our methodology applies a time series modelling approach to check out the triangular relationship between demographic transition, education and economic growth. The perspective is challenged by the long- and short-run dynamic causalities. Thus, a double analysis is undertaken by using the cointegration technique to exhibit a long-run equilibrium relationship between variables and the error correction model to capture the short-run adjustment mechanism. Furthermore, to measure and trace the effect of an innovation on the present and future values of the variables, the variance decomposition and impulse response function techniques are adopted. This empirical evidence is carried out over the period 1963–2007.

This study makes three novel contributions. First, it is the first study that models the fertility rate for Tunisia within a time series framework using a cointegration and error correction modelling strategy. Second, for the first time in the literature, the three education levels are used (primary, secondary and higher). Third, this study is among the first attempts to explore the fertility transition feedback empirically. Existing studies using time series estimation methodology have concentrated on the causes and dynamics of fertility decline.[5]

The remainder of this paper is structured as follows: in Section 2, we document the Tunisian demographic and socioeconomic context. Next, in Section 3, we present the theoretical framework, while in Section 4 we discuss the data construction. In Section 5 we expose the econometric methodology and display the results. Section 6 draws major conclusions, summarizes the main findings and proposes policy implications.

2. The Tunisian demographic and economic context

Until independence in 1956, the Tunisian population used to grow at a low natural rate (less than 2 percent). The general demographic picture was bleak: the mortality rate was high (near 35 per thousand in 1950); fertility was over seven children per woman; life expectancy hardly exceeded 30 years. Besides, education remained precarious and low, with most of the population being illiterate (96 percent of women versus 74.5 percent of men). This slow demographic growth was followed by a brutal acceleration (of about 3 percent) in the demographic growth rate in 1957–1972 due to a decline in mortality associated with a high birth rate. Over time, the mortality drop was followed by a fertility decline.[6] Since 1999, the mortality rate has been at a fairly constant low rate of 5.7 per thousand and fertility has been under the population replacement threshold (2.05 children per woman). Accordingly, in 2009, life expectancy has increased to 74.5 years and the demographic growth rate has reached 1.20 percent.[7] Tunisia has thus begun its modern regime.

A huge effort was devoted on generalizing education and facilitating girls' access to school. In October 1958 the education system was unified and nationalized, and primary school was made compulsory and free of charge. Schools were created all over the country, even in its most distant corners. Consequently, woman illiteracy went down from 94 percent after independence to 22.8 percent in 2008.

In Tunisia, a major step in female emancipation took place in 1957 with the "code of Personal Status" (13 August 1956) that regulated marriage and divorce, abolished polygamy, set a minimal marriage age and replaced repudiation with divorce. The code of Personal Status also banned early marriage; since 1956 the minimal marriage age was 15 years for women and 18 years for men. The minimal marriage age was raised again in 1964 to 17 and 20 years, respectively. In 2007, women and men were getting married on average at 27.1 and 32.4 years, respectively. In 2005, the celibacy rate

[5] Cheng and Nwachukwu (1997), Masih and Masih (1999, 2000), Mc Nown (2003) and Narayan and Peng (2006, 2007).

[6] The mortality decline launched after independence has accelerated thanks to the increase in industrialization, urbanization, literacy and living standards, and application of improved medical practices.

[7] Sources of all quoted statistics: Tarifa (1971), Taamallah (1987, 1995), Cochrane and Guilkey (1995), Frini (2000), Frini and El Lahga (2002), National Board for Family and Population "ONFP" (1995, 1998, 2001) and Tunisian Annual Statistics of the National Statistical Institute (from 1957 to 2009).

over the full lifecycle reached 38 percent among women (Annual Statistics of the National Institute of Statistics, 2006).

In Tunisia the fertility transition was deliberately encouraged by government policy. The Tunisian government encouraged families to limit the number of children and improve their living standard through public propaganda campaigns. Moreover, family allowances were cut for households with more than four children, then with more than three children. Advertisement and sale of contraceptive devices were legalized in 1961. The National Board for Family and Population (ONFP) was created in 1964. Its role was mainly to limit and monitor fertility. Abortion was legalized in 1973. New and modern contraceptive instruments allowing couples to better control their progeny were also provided for free. These measures contributed to the contraceptive prevalence rate rising from 31 percent in 1978 to 60.2 percent in 2006.

Over the same period, Tunisia underwent swift economic transformation, which significantly affected the labour market. Women, like men, were recognized in their right to access jobs free of wage discrimination. Nevertheless, in Tunisia the proportion of occupied active females is still low. It only rose from 18.85 percent in 1966 to 25.9 percent in 2008.[8]

Large wage hikes were accompanied by large increases in the prices of housing and education. These price movements led to child cost increases and reverse of wealth flows between parents and children. In this situation, the appeal of a large family was much reduced.

3. Theoretical framework

The present study, which focuses on the correlation between education, fertility and macroeconomic performance, has its theoretical roots in several models which have been proposed to explain the fertility transition that occurred in most countries. This framework justifies the choice of the aggregate variables included in the estimated aggregate model.

According to the "New Household Economics", based on Becker's work (1960), demographic transition is related to education and parental incentives to human capital accumulation. The theory highlights the negative relationship between quantity and quality of children in parental decisions as a major factor affecting the fertility transition (Becker, 1981). High education achievement raises time value and wages and favours a return to child quality, while it increases the "price" of child quantity by increasing the opportunities cost of time women spend in child care (in terms of foregone labour force participation). The cost of an additional child depends on its "quality" measured as incorporated human capital (e.g., health and education). Reciprocally, the full cost of higher quality children also depends on their number. Then, enhancing child quality is so expensive that there are more children. Similarly, increasing quantity is more expensive if the children are of higher quality. In these conditions each fertility decision is made by balancing the advantages and costs of an additional birth. An income increase raises the opportunity costs of child bearing and rearing. Becker argues that the substitution effect would be larger than the global income effect. The income elasticity of child quality demand would be larger than the income elasticity of child quantity demand. In such a situation, a rise in income could reduce the demand for children if a higher income leads to large increases in child education. Therefore, the household decisions move away from child quantity to child quality, which leads to a decline in population growth.

Easterlin (1969) pursues the reflexion further. He explains fertility decline by preference changes and relative income. He claims that the household preferences for a given number of children are partly shaped during the parent's childhood. Easterlin argues that the main marriage and fertility determinants are the couple's potential earnings, their material aspirations (correlated with the past income of parents by calculating the "relative income") and social background (correlated with education and environment).

According to Leibenstein (1974), social and economic changes may influence the social position of families. With socioeconomic development the corresponding utility level resulting from an additional child remains largely static while the corresponding economic benefits decrease, whereas costs increase, which favours having fewer children.

[8] Employment and unemployment indicators during 1966–2005 are taken from the publications of the National Statistical Institute and from the report of the National Employment Survey in 2008.

In contrast, Caldwell (1976, 1982, 1991) considers that traditional societies with high birth rates are characterized by "ascending transfers" (from young generations towards elder ones). Through economic and social changes, children are increasingly becoming a burden instead of a productive resource.[9] Along with development, parents are increasingly allocating resources to rearing and educating children. Thus, child cost increases and the demand for children decreases in consequence. In this setting, fertility transition is caused by the reversal of the intergenerational wealth flow between children and parents (by "descending transfers").

Education expansion not only explains demographic transition, as has been stated in previous theories, but also provides people with an extended choice of lifestyles and raises their autonomy in marital timing decisions. As education empowers women, they become able to postpone their marriage age. Hence, educated women are inclined to have fewer children compared to less educated women. Education may also reduce the perceived pool of potential partners for marriage and raise the required time to find a suitable one (Cochrane, 1979). In addition to that, education may also affect the demand for children through changing motivation, attitudes and access to fertility regulation, as described in Easterlin's theory (1975, 1978).

According to the classical demographic transition theory, infant mortality decline leads to a subsequent fertility decline; likewise, the supply of children may be altered by improved health (Handa, 2000). Indeed, high infant mortality induces parents to make the ex-ante decision to have extra children as an insurance device against child death risk or the ex-post decision to replace dead children (Ben-Porath, 1976). A decrease in mortality eliminates such motives.[10] Moreover, a reduction in death rates at all ages improves the return to parents' investment in each of their offspring relative to the returns to the number of children. If child quality and quantity are close substitutes, this shift in relative returns may incite parents to have fewer children.

Reciprocally, demographics can affect economic growth through several dimensions: age structure change, human capital enhancement, saving and financial market improvement. In Solow-type growth models, lower fertility ultimately raises the level of capital per worker which accelerates output growth. In general, lower fertility tends to be associated with an increase in the amount that parents invest in their children, which spurs economic growth through higher human capital levels.[11] Finally, the demographic transition modifies the age structure towards longer longevity and thus prompts aggregate savings.[12] These channels require a long period to bring in their full effect.

The review of the literature has allowed us to underline the major socio-economic and demographic determinants of fertility transition. Explicitly, we specify a theoretical aggregate fertility model where fertility is seen as determined by infant mortality, education, real per capita income and contraceptive use. In order to examine the dynamics of demographic transition and its determinants, we set the fertility rate as a major interest variable. The infant mortality rate is introduced as a major explanatory variable of fertility, which allows us to verify the demographic transition theory claiming that infant mortality decline is followed by a decrease in fertility. Like Masih and Masih (1999, 2000) and Narayan and Peng (2006, 2007) we introduce contraceptive use in the estimate model. As stated earlier, contraceptive use may reflect changing perceptions, ideas and attitudes towards fertility decline. Contraceptive use (the rate of women who are currently taking or have ever taken contraceptives means under the age of 49) is also taken into consideration as a demographic political control variable.

Education measured by the three levels of overall enrolment (primary, secondary and higher) is included as human capital indicators. Education can also be seen as a proxy for child-devoted time cost. In comparison with the previous works on applying times series technique such as Cheng and Nwachukwu (1997), Masih and Masih (1999, 2000), Mc Nown (2003) and Narayan and Peng (2006, 2007), we increase our model specification by the three education levels consideration. No distinction is made between male and female school attendance since we study the actual fertility, which is considered as a result of female and male fertility behaviour. Another major potential explanatory

[9] Production shifts from agriculture to industries, urbanization, financial market development, settlement of insurance system, extension of female labour force, compulsory child education and rising child opportunity cost.

[10] Kalemli-Ozcan (2003).

[11] Galor and Weil (1996, 2000) and Bloom and Canning (1999).

[12] Mohsin (2002).

variable is real per capita income. It represents the individual living standard as well as investment capacity in human capital. Following Becker's (1960) and Becker and Lewis's (1973) idea, it may also allow us to test the quantity–quality substitutions.

In this paper, we seek to explain aggregated time series in order to clarify the relations between fertility determinants and growth using cointegration analysis. However, because we can only observe a few years of data, namely from independence up to today, we only incorporate a few variables in the relationship to estimate. The perspective may certainly be challenged by data availability or inconsistency, and the long- and short-run causalities between these variables will have to be examined. In order to discuss estimate issues more precisely, we deal with data construction in the next section.

4. Data construction

The present study is based on two data sources: the National Institute of Statistics (INS) and the Quantitative Survey Institute (IEQ). Since these databases started after 1960 and are usually behind the time by at least two years, the longest possible time series are over the period 1963–2007. Moreover, these institutes could not provide us with complete series for all our variables and the methods they used to construct the series often varied over the studied period (e.g., for schooling enrolment). In addition, both institutes often report conflicting figures regarding the same series and the same year. Finally, schooling rates by education level are not available for the whole of the studied period, like the World Bank database, which also provides incomplete series.

Thus, in order to overcome this problem, we constructed our own complete series for education, fertility, infant mortality, contraceptive use, and even real GDP per capita. For computing overall enrolment by level, we considered four facts. (1) Our enrolment data is based on annual enrolment surveys, typically conducted at the beginning of the schooling year (in September) by the Ministry of Education. (2) The schooling year's number by level is modified over the studied period. For more details, schooling years were initially divided into 6 years for primary level, 7 years for secondary level and 4 years for higher level. Following the reform in the 90s, the primary level was replaced by basic schooling comprising the first cycle (of 6 years) and the second cycle (of 3 years). The secondary level accounts only for 4 years. (3) There is an accession of private schooling. (4) The precise age of the enrolled pupils is not indicated in the surveys. Accordingly, to obtain homogeneous series, we adopted the schooling year distribution by level before the reform and accounted for the pupils enrolled in both public and private school with numbers provided by the INS. After that, we first calculated the number of pupils enrolled for each schooling level. Then, using census data provided by the IEQ, we accounted for the population size corresponding to each official school age group. Lastly, we estimated the school enrolment rates by dividing the number of enrolled pupils at the considered education level, independently of their age, by the population size of the officially corresponding age group. We distinguished three levels of school enrolment: primary (TPRIM), secondary (TSEC), and higher (THE). In our econometric estimation, the illiterate population is a residue. Illiteracy tends to vanish over the studied period. In Tunisia in 1966, persons aged at least ten years old were composed of 82.5 percent illiterate, 14.6 percent primary level, 2.7 percent secondary level and 0.2 percent higher level. In 2005, these groups were respectively: 29.8 percent, 33.1 percent, 29.9 percent and 7.2 percent.

We combined two available data bases by INS and IEQ to complete series of total fertility rate (TFR), contraceptive use rate (TCN) and infant mortality rate (TMINF). Finally, GDP per capita at constant domestic prices is computed by dividing GDP per capita at current domestic prices by the consumption price index (base 1962). Constructing this indicator was necessary because there are serious doubts concerning the validity of GDP deflators used by administrations in Tunisia. We found that deflating by consumption price provides more credible estimates of real GDP per capita. As inflation indicator, the deflator was manipulated over the last decade in order to respond to government authority members. Finally, we obtain annual time series for the period 1963–2007, except for the contraceptive variable, which is available only from 1967.[13]

In the estimated model, we do not choose to transform the variables in logarithm form since it yielded better results. We checked that this specification implies neither non-normal errors nor

[13] The definitions of the variables are specified in Appendix A.

heteroskedasticity problems. The Jarque–Berra normality test on the estimated residuals does not reject the normality for linear cointegration and VEC estimate (*P*-value of 0.34). Moreover, homoskedasticity is not rejected by the results of the White test (*P*-value of 0.36).

We now turn to the estimation results. We first start by discussing the econometric model specification.

5. Econometric methodology and estimation results

Numerous empirical studies investigated the determinants of fertility, particularly with respect to the contribution of education to fertility reduction. Nevertheless, their results often seem to reveal contradictions, mainly because of the estimation method in which the dynamics education and fertility interrelationships theoretically involved are not fully captured.[14] Indeed, most studies are based on statistical correlations, which cannot always be interpreted as revealing causal links. The interaction dynamics of the diverse determinants of fertility are also neglected. When using aggregate indicators, fertility dynamics and interactions of its determinants cannot properly infer what might happen in one country over time from observations across countries at a point in time. In response to this situation, we study the dynamic relationships of fertility rate, human capital and economic growth by using time series modelling. This enables us to tackle a multivariate causal setting, which allows for the coexistence of both short- and long-term forces derived from the socio-economic interactions with fertility decisions.

The econometric cointegration techniques we use require variables integrated of the same order. Several variables are considered cointegrated if they enjoy a long-run equilibrium relationship and share common trends. In that case, as long as the two variables have a common trend, causality (in the Granger sense) in at least one direction must exist.

In our case, the N components of vector X_t, of which cointegration is investigated, are: fertility rate, education, infant mortality rate, contraceptive use, and per capita GDP. Several cointegration relationships and, as a result, several cointegration vectors may exist. If there are independent cointegration vectors, X_t is said to be cointegrated of rank *r*. In practice, a vector autoregressive model will be estimated (see Table 1 in Appendix A).

Table 1 reports results of Augmented Dickey–Fuller tests and Philips–Perron tests. For these tests, we favour specification (3), see Table 1 in Appendix A, including an intercept and a deterministic trend.[15] Indeed, there are various theoretical and empirical reasons to believe that the ΔX_t of these variables include trends.[16] For example, given technological progress, capital accumulation and other contributing factors to economic development, one expects GDP per capita to show a persistent positive growth rate over the studied period. Education variables are seen as associated to these growth dynamics, whether resulting from additional resources to fund education, motivated by increasing needs for a skilled workforce, or as deliberate persistent policies accompanying the development process. The latter motivation could also be applied to contraception policy. Finally, fertility and mortality variables are also likely to be characterized by trends, notably as consequences of persistent hikes in living standards, which produce child health improvement and induce substitution of child quality for child quantity.

The test results show that all the considered variables can reasonably be considered as being I(1), suggesting that a long-term cointegration relationship could exist between the considered variables.

5.1. Cointegration

In order to determine the cointegration ranks, we use the Johansen and Jesulius (JJ, 1990) trace test on the model with no trend in the cointegration relation and the presence of a constant in the VEC. The

[14] For example, a negative interaction is found by Rosenzweig and Wolpin (1980), Knodel and Wongsith (1991), Ahn et al. (1998), Lee (2004), Glick et al. (2005) and Conley and Glauber (2005); a positive interaction is found by Gomes (1984), Chernochovsky (1985), Hossain (1990) and Qian (2006), while no interaction is found by Mock and Leslie (1984), Kaestner (1997) and Black et al. (2005).

[15] However, results for specifications without a trend are also shown for comparison.

[16] Δ is a difference operator.

choice is justified by the fact that such a long-term equilibrium relationship between series does not have trends.

The trace test result, shown in Table 2 (in Appendix A), rejects the null hypothesis of no cointegration relationship at one percent level. It indicates the following unique cointegration equation binding variables together in a long-run equilibrium relationship characterized by a common trend.

$$\mathrm{TFR} = 3.503 + \underset{(4.56)}{0.02}\,\mathrm{TPRIM} - \underset{(-1.95)}{0.01}\,\mathrm{TSEC} - \underset{(-7.76)}{0.06}\,\mathrm{THE} + \underset{(8.11)}{0.012}\,\mathrm{TMINF} - \underset{(-20.45)}{0.06}\,\mathrm{TCN} + \underset{(11.41)}{7.337}\,\mathrm{GDP} + z_t$$

where z_t is the error term. t-Statistics are presented in parentheses.[17]

A causal triangular long-term relationship between fertility, education and GDP is consistent with the cointegration relationship. Considering the fertility rate as a dependent variable, primary schooling was found to have a significant positive effect on fertility. Primary education may enhance domestic health practices. This may have a positive impact on maternal health, which directly raises both the potential supply of children, and child health and survival. Besides, primary education of parents is associated with a low economic value of their time and lower child opportunity cost compared to more educated parents. As explained earlier, this situation is likely to stimulate higher child demand than for more educated parents.

However, both secondary and higher education have negative effects on fertility. As for secondary schooling, the interaction between education and child number has proven to be negative. Indeed, parents reaching a secondary education level have better chances to access better professional careers than those with primary schooling or no education. Access to better jobs raises the value of time and the opportunity cost of spending time on child rearing and child bearing. Besides, these households are less inclined to have many children, rather seeking to substitute an additional child for additional schooling for existing children and participate more in the labour market. On the whole, our estimation shows that in Tunisia the relationship between education and fertility has a reverse U shape in accordance with previous results in other countries.[18] A complementary interpretation of the relationship is that secondary and higher education shape the parents' preferences.

As expected, infant mortality positively affects fertility. The decline in infant mortality triggers a subsequent decline in fertility, which we interpret as related to the replacement and insurance effects of dead children. With an infant mortality decline, parents are more willing to have fewer children. Also, the increase of child survival probability negatively influences child number demand. This dynamic nexus between changes in infant mortality and fertility put on show demographic transition.

In our estimates, contraceptive use has a significant negative impact on fertility. Clearly Tunisian family planning has been successful through the widespread of contraceptive methods.

Finally, the results suggest that economic growth is positively related to fertility. In the long run, per capita income in Tunisia positively correlates with the fertility rate. This result may reflect that the income effect is explained by (1) the supply side, allowing for more children (e.g., through health improvement), and (2) the demand side if children are a normal good, which dominates the substitution effect of "quality" of a few children for many less well-endowed children in Tunisia during 1963–2007. According to Becker's theory, parents with a high income may desire a greater expenditure per child to obtain better child quality and, therefore, have fewer children. Thus, in Tunisia, where schooling costs are constant and almost free since 1958, an income increase may stimulate a corresponding increase in child demand.

Given the small proportion of the employed female workforce, at least initially, the general rise in income in Tunisia is mostly explained by a rise in male income, which positively relates to fertility.[19]

[17] An alternative approach would have been to reject the presence of any cointegration relationship at the 5 percent level. In that case, the only available route is to estimate ARMA or VAR models based on the differenced variables. However, we checked that this approach yields insignificant coefficients in almost all cases.

[18] Masih and Masih (1999, 2000), Mc Nown (2003), Diebolt and Doliger (2005), and Narayan and Peng (2007).

[19] The female unemployment rate is higher than that of males, respectively 17.3 percent and 12.8 percent in 2007. Female workers find it more difficult to penetrate the labour market; especially those with tertiary education. In 2005, 23.3 percent of female workers were unemployed versus 9 percent for male workers.

This is consistent with the economic premises according to which increases in female wages have strong negative effects on births, while male wages are positively related to fertility.[20] Moreover, rising potential wages are likely to raise the value of time of unemployed females and child cost opportunity, therefore favouring substitution of child quality for child quantity in demand. However, as male's time is not important for child services production, this substitution effect is accompanied by an income effect that stimulates the demand for an additional child. In Tunisia, unoccupied married women do not have to balance their time value cost and child opportunity cost, and are, therefore, able to achieve the husbands' desired number of children. Hence, a society characterized by a large proportion of unemployed females should present a higher fertility rate over the growth process than other typical western societies.

Similar results have been found for Greece over the period 1960–1996 (Hondroyiannis and Papapetrou, 2002), for France after the Second World War (Diebolt and Doliger, 2005) and for Japan over 1950–2000 (Narayan and Peng, 2007). However, this positive correlation may also correspond to an opposing cause and effect relationship with higher fertility stimulating economic growth. In the first stages of the development process, vigorous demographic growth necessitates heavy investment in schools, health centres and infrastructures, which stimulates economic activity. Later on, a sizeable workforce brings abundant labour inputs for growth.

Furthermore, this positive relationship between per capita income and fertility and the negative education–fertility interaction observed in Tunisia highlight the country's insufficient level of development. As demonstrated in previous empirical studies, the education–fertility relationship depends on contextual factors as well as development level.[21] Clearly, a negative relationship could only be observed at some income level. More precisely, the negative interaction is clearly observed in developing countries rather than developed ones.[22]

In this interpretation, our estimates imply that the fertility transition in Tunisia is more determined by education enhancement than by the rise in living standards. Such results support the theoretical hypothesis that negative education–fertility interaction is the most important channel accelerating transition.

5.2. *Error correction equations*

Our attention is now directed towards the adjustment mechanisms of the long-term relationship across variables. Engle and Granger (1987) showed that behind cointegration lies a corresponding vector error correction (VEC) representation. Such a representation helps us to disentangle the dynamics of fertility, education and growth in Tunisia. In this representation, the dependent variable is a function of (1) the level of disequilibrium in the cointegration relationship (captured by the error correction), and (2) changes in the other explanatory variables. It is worth mentioning that even if cointegration implies the presence of Granger causality, it does not identify the direction of causality between variables. However, Granger causality can be captured by the vector error correction model (Granger, 1986, 1988). The VEC estimates also help us to characterize the observed short-run fluctuations in a way compatible with long-term equilibrium. In particular, we seek to investigate: (1) the speed of diffusion of education in fertility behaviour, and (2) the speed of transmission of the demographic transition benefits on the economic growth process.

Results in Table 3 (in Appendix A) show that the error correction term derived from the long-term cointegration relationship is highly significant in the fertility equation described by the VEC. In these conditions, short-term fertility behaviour tends to revert to the long-term equilibrium. The adjustment towards the equilibrium is swift with a coefficient of -0.76. In the short term, fertility appears to be independent of its lagged value. However, it is negatively influenced by the lagged secondary enrolment rate and to a less significant degree by the lagged higher enrolment rate. To be

[20] Butz and Ward (1979).

[21] Buchmann and Hannum (2001) and Maralani (2007).

[22] Black et al. (2005) and Li et al. (2007) argue that developed countries, in contrast to developing ones, generally have an efficient education system and strong governmental child services which reduce the parental child burden and yield ambiguity in the child quantity–quality trade-off.

clear, education contributes to the demographic transition both in the short and in the long term. On the contrary, infant mortality and contraception practice only have long-run effects. Infant mortality change and contraceptive behaviour take time to impinge fertility towards decline. Since couples cannot immediately adjust their fertility level as soon as mortality drops or their economic ability changes a time perception is, therefore, needed.

So far, all our interpretations are based on the hypothesis that the considered equation correctly reflects the direction of dominant causality among variables, i.e. in the sense of an explanation of fertility. However, causality in the VEC models does not provide any indications regarding the dynamic properties of the system, nor does it permit to judge the relative strength of the causality chain or make quantitative measurement of the dynamic interactions between different variables. The breakdown of the variance of the forecasting error and the impulse response function will, therefore, help us deal with the previous issues. We now examine the dynamic contribution of random shocks of the determining variables on the evolution of fertility and GDP per capita.

5.3. Impulse response functions and variance decomposition

The estimated impulse response functions (IRF) show the VEC estimates in terms of the responses of a given variable to innovations in another variable. Their analysis helps to measure and trace the effect of a shock on an innovation on the present and future values of the variables. In our case, we are especially interested in the dynamic response path of fertility rate to an unanticipated shock to each of its determinants. The size of the shock corresponds to an increment of a unit standard deviation of the considered regressor.[23]

The variance decomposition analysis, however, indicates the proportion of the variable changes due to own shocks versus shocks on the other variables.[24] Namely, the variance of the forecast error of the change in fertility rate is partitioned among the contributions of the innovations in each variable of the system.

To carry out these techniques we apply the first difference on the considered variables in order to make them stationary.

The results as displayed in Table 4 (in Appendix A) underline the role of education in the Tunisian demographic transition. Education variables interact with fertility much more in the long than in the short term. A relatively constant proportion of the change in fertility variance is accounted from the third year respectively by primary and secondary schooling shocks (about 4.25 percent and 9.34 percent of the fertility change variance). The higher education shocks account for 5.86 percent of the fertility change variance in the short run (over two years), while they account for distinctly more in the long run (over ten years) with 9.09 percent. The estimated impulse response functions, shown in Fig. 1 in Appendix A, map out the dynamic response path of the fertility rate owing to a unit standard deviation shock for each education level. A shock on primary enrolment increases fertility mostly in the first year, while secondary schooling reduces it significantly in the first year. By contrast, a positive short-term effect of higher education can be observed but disappears after a few years.

Per capita income shocks explain the variance of fertility innovations by about 5.94 percent in the variance decomposition after the fourth year, but with a relatively more significant proportion in the first year. In the impulse function graph, a GDP shock instantaneously affects fertility in the first year, while its short-term influence vanishes rapidly and almost disappears after five years. Thus, empirical evidence highlights both the long- and short-term roles played by secondary and higher schooling and the economic growth process in explaining fertility transition.

A shock on contraceptive use contributes to explaining the fertility variance by 2.35 percent in the short term (over two years) and 3.05 percent after six years. In addition, an important share of the variance of the contraceptive use innovations (about two fifth) is explained by a higher education shock after three years.

Concerning infant mortality rate innovation on fertility, an almost negligible impact is found. The variance of infant mortality is, however, influenced by short-term education evolution. Education (all

[23] In Fig. 1 in Appendix A we report only the requisite impulse response functions of the interest variables in order to enrich our discussion.

[24] The Cholesky decomposition method is used in orthogonalizing the innovations across equations.

three levels together) contributes to infant mortality change variance by 7.77 percent after three years and by a relatively constant proportion of about 10.73 percent after six years. The generalization of education on the one hand and fertility control on the other have improved health and fostered the demographic transition both in the long and short term.

To conclude, we can say that the demographic transition in Tunisia is determined by a mix of influences combining economic changes, education development and family planning policies.

Unexpectedly, it is found that education seems to have little contribution in stimulating economic growth in Tunisia. As little as 8.19 percent of per capita income, error variance is explained by education (all three levels together) over three years and 9.25 percent after six years. Primary and higher education shocks produce most economic consequences with relatively similar importance. On the contrary, secondary education shocks have a reduced short-term impact on economic performance. This is confirmed by the corresponding impulse function, which does not reveal any impact of secondary education shocks starting from the third year. In impulse functions, a primary schooling shock corresponds to a small instantaneous negative effect, which disappears after six years. This negative contribution of primary education to growth may be related to the increasing needs for a skilful workforce in the Tunisian labour market. Primary education is no longer sufficient to find well-paid jobs in Tunisia and is, therefore, considered as being costly to society if not followed by secondary education which is likely to produce skills. On the contrary, a higher education shock produces a slight instantaneous positive impact, which vanishes after eight years. Education development did not efficiently contribute to the economic growth process mainly because of three major raisons: (1) a labour force endowed with few education years; (2) bad labour market flexibility; and (3) an inconsistent education system with labour market requirements.[25] Similar results were found in Pritchett (2001) and Teuling and Van Rens's (2003) works.

In the long term, fertility shocks seem to produce a 'feed-back' effect on education, particularly on the secondary level. They generate little influence on secondary education by about 4.19 percent after two years and twice as much after the first year. Also, the dynamic response path of secondary schooling to fertility shocks displays an instantaneous negative effect, which disappears after five years. This confirms the negative interaction between education and fertility (especially the secondary schooling) both in the short and the long term.

Likewise, actual feedback effects on economic growth can be observed. Fertility changes contribute to a variance of changes in real per capita GDP by 20 percent, essentially due to immediate impact. Indeed, the impulse response function mapping out the dynamic response path of real GDP per capita owing to a unit standard deviation shock to fertility confirms an immediate effect of a fertility shock on GDP, which quickly disappears after two years.

To sum up, an economic shock affects fertility slightly in the short term. On the contrary, a demographic shock has a more pronounced short-term impact on GDP. A dynamic interaction is also detected between education and fertility, mostly for education affecting fertility. These results reveal the existence of a complex interaction between fertility and education on the one hand and economic growth on the other. This possibility has already been discussed in the literature.[26] However, we provide precise aggregate statistical criteria which highlight the dynamic structure of these interactions.

6. Conclusion and policy implications

This paper aims at highlighting the link between demographic changes and macroeconomic performances via the education–fertility interaction (using Tunisian time series data). In the Tunisian context, a dynamic triangular relationship between fertility, education and economic growth is confirmed. Besides, fertility and education enjoy a long-term dynamic interaction towards long-term equilibrium. The adjustment process towards equilibrium occurred progressively, referring to the VEC estimation. In accordance with previous results, education–fertility has a long-term reversed U relationship. Education triggers fertility transition both in the long and short term. Moreover, the generalization of education and family planning services has improved health and fostered the demographic transition. Results also reveal

[25] In 2005 about half (51.2 percent) of the occupied active population had no education or education at the primary level, 35.7 percent had the secondary level and only 13.1 percent the higher level.

[26] Bloom and Williamson (1997), Bloom et al. (2003), and Doepke (2004).

a dominant and direct positive effect of income on fertility and show that infant mortality decline and contraceptive use take time to impinge fertility towards decline. This suggests that fertility transition is more determined by education enhancement than by the rise in living standards.

Accordingly, the VDC and IRF techniques demonstrated that fertility transition in Tunisia is determined by a mixed influence of economic changes, education development and family planning policies. In particular, the education–fertility dynamic interaction is more intense in the long than in the short term and is, in fact, more pronounced as the education level rises and the income impact becomes more intense. Moreover, the analysis proved that education has a more significant impact on fertility than fertility has on education and that fertility has a more pronounced impact on economic growth than growth has on fertility.

This empirical work proves that the education–fertility interaction explains demographic transition and economic growth and that fertility behaviour is directed by the negative interaction between quantity–quality of children. Unfortunately, however, the Tunisian education system has relatively impinged the long-term economic growth process as it has indirectly reinforced it through its interaction with fertility. Education improvement has been slightly translated into the human capital formation required to increase productivity. This fertility decline, driven and amplified by education development, has in turn fostered economic growth. Interestingly, the statistical finding is in favour of the critical importance of the combined role of education and fertility in spurring economic growth. Fertility transition has produced positive feedback effects on human capital and economic growth by changing the age structure in favour of education development, high productivity and capital efficiency. This may allow the Tunisian economy to benefit from the demographic transition dividends. Population dynamics are a key factor in determining economic growth.

These major findings imply strong policy implications in order to better capitalize economic demographic transition opportunities. Government should develop the requirement synergy between labour market, education system and professional formation. This will enhance labour force productivity and contribute to the economic growth process. Also, to sustain the economic growth process, it is necessary to improve the quality of the reduced quantity of children. For this purpose, the adopted policy of mass education must be replaced by a policy in favour of education quality. As for women's position in the labour market, it should be reinforced by reconsidering their insertion.

This study provides basic information regarding the Tunisian prospects of demographic evolution and macroeconomic performance. In particular, Tunisia is beginning her modern regime experience, which is considered as a sign of development but also of hard economic pressures due to the rapid increase of the dependent elderly ratio. To overcome these expected economic pressures, the Tunisian government should be aware of the impact of the ageing population on the labour market, the security system and the financial market. It is recommended to focus on adopting consistent social and economic accompaniment policies rather than trying to alter demographic evolution.

Appendix A

Definition of the variables

The total fertility rate (TFR) is the average number of children that would be born to a woman over her reproductive lifetime if she were to experience the exact current age-specific fertility rates (in the year).

The infant mortality rate (TMINF) is calculated as a ratio of the number of deaths of children under 1 year occurring in any year to the total number of births in the same year (for 1000 live births).

The contraceptive prevalence rate (TCN) represents the proportion of women of 15–49 years of age practicing, or whose husbands are practicing, any form of contraception.

Gross enrolment rate primary schooling (TPRIM) is the estimate of the proportion of pupils of all ages enrolled in primary school per total number of children corresponding to the primary age group (6–12 years old).

$$\text{TPRIM} = \frac{\text{number of pupils enrolled in primary}}{\text{total number of children corresponding to primary age group}\,(6-12\,\text{years old})} \times 100$$

Gross enrolment rate of secondary schooling (TSEC) is calculated in the same way as that of the primary. The secondary schooling age is defined as 13–20 years old.

Gross enrolment rate of higher education (THE) is calculated by dividing the number of students enrolled in universities by the population aged 21–25 years old.

The GDP per capita at constant domestic prices (GDP p.c.) is a measure of the total output, taking the gross domestic product (GDP) at current local domestic prices by the consumption price index (base 1962) per capita.

Table 1
Unit root tests.

The probability value of the unit roots tests (*P*-value)						
	Augmented Dickey–Fuller (ADF)			Phillips–Perron (PP)		
Model	Model (1)	Model (2)	Model (3)	Model (1)	Model (2)	Model (3)
Level						
Demographic variables						
TFR	0.000	0.996	0.322	0.000	0.965	0.285
TMINF	0.001	0.954	0.323	0.000	0. 985	0.258
Demographic policy variable						
TCN	0.966	0.996	0.011	0.968	0.993	0.044
Education variables						
TPRIM	0.705	0.140	0.024	0.843	0.087	0.002
TSEC	0.997	0.732	0.982	1.000	0.823	0.992
THE	0.993	0.969	0.998	1.000	0.992	1.000
Economic variable						
GDP p.c.	1.000	0.967	0.999	1.000	0.919	0.999
First difference (Δ)						
Demographic variables						
TFR	0.064	0.000	0.000	0.000	0.000	0.000
TMINF	0.016	0.010	0.001	0.003	0.002	0.001
Demographic policy variable						
TCN	0.026	0.000	0.000	0.000	0.000	0.000
Education variables						
TPRIM	0.000	0.018	0.004	0.000	0.024	0.006
TSEC	0.045	0.012	0.003	0.013	0.012	0.002
THE	0.136	0.022	0.043	0.045	0.025	0.054
Economic variable						
GDP p.c.	0.063	0.000	0.000	0.000	0.000	0.000

Notes: Model (1) with no intercept and no deterministic trend: $\Delta X_t = (\rho - 1)X_{t-1} + \sum_j^k \theta_j \Delta X_{t-j} + \varepsilon_t$.

Model (2) with intercept and no deterministic trend: $\Delta X_t = (\rho - 1)X_{t-1} + \upsilon + \sum_j^k \theta_j \Delta X_{t-j} + \varepsilon_t$.

Model (3) with intercept and deterministic trend: $\Delta X_t = (\rho - 1)X_{t-1} + \lambda + \delta t + \sum_j^k \theta_j \Delta X_{t-j} + \varepsilon_t$.

Both the ADF and the PP tests take the unit root as the null hypothesis H_0: $\rho = 1$. This null hypothesis is tested against the one side alternative H_1: $\rho < 0$.

Table 2
Trace test.

H_0: *r* or fewer cointegration vectors	Eigen value	*P*-Value
None	0.698	0.005
At most 1	0.575	0.092
At most 2	0.426	0.323
At most 3	0.307	0.439
At most 4	0.250	0.390
At most 5	0.184	0.371
At most 6	0.019	0.378

Notes: The trace test indicates 1 cointegrating equation(s) at the 10 percent level.

Table 3
Vector error correction model.

	Dependant variables						
	D(TFR)	D(TPRIM)	D(TSEC)	D(THE)	D(TMINF)	D(TCN)	D(GDP p.c.)
Error correction term ECT1	−0.769 (−3.034)	9.686 (2.484)	3.187 (1.123)	−1.939 (−1.084)	7.662 (0.870)	−3.933 (−1.270)	−0.004 (−0.224)
Explanatory variables							
D(TFR(−1))	−0.064 (−0.355)	−4.495 (−1.620)	−2.185 (−1.082)	0.796 (0.625)	−4.929 (−0.787)	−0.551 (−0.250)	0.011 (0.819)
D(TPRIM(−1))	0.014 (1.578)	0.269 (1.884)	0.099 (0.960)	−0.041 (−0.628)	−0.156 (−0.485)	0.079 (0.699)	−0.000 (−0.984)
D(TSEC(−1))	−0.041 (−2.879)	0.411 (1.869)	0.336 (2.101)	0.153 (1.517)	−0.440 (0.886)	0.030 (0.175)	−1.63E−05 (−0.014)
D(THE(−1))	0.038 (1.743)	−0.141 (−0.420)	0.186 (0.765)	0.570 (3.708)	0.914 (1.207)	−1.291 (−4.851)	0.000 (0.416)
D(TMINF(−1))	−0.007 (−1.288)	0.035 (0.411)	0.011 (0.182)	0.010 (0.253)	0.353 (1.801)	−0.007 (−0.112)	−0.000 (−0.612)
D(GDP p.c.(−1))	1.933 (0.776)	95.97 (2.508)	−6.810 (−0.244)	2.274 (0.129)	0.870 (0.010)	5.170 (0.170)	0.051 (0.257)
D(TCN(−1))	−0.002 (−0.187)	−0.217 (−1.023)	−0.193 (−1.251)	0.085 (0.880)	−0.538 (−1.121)	0.080 (0.477)	−0.000 (−0.271)
C	−0.145 (−3.134)	−1.379 (−1.937)	0.762 (1.471)	0.117 (0.359)	−1.853 (−1.152)	1.948 (3.443)	0.007 (2.015)
R^2	0.555	0.425	0.298	0.503	0.250	0.537	0.123

Note: Student's *t* is in parentheses.

Table 4
Variance decomposition (Cholesky ordering).

Year	S.E.	DTFR	DTPRIM	DTSEC	DTHE	DTMINF	DTCN	DGDP.p.c
Relative variance of total fertility rate (TFR)								
1	0.117	99.997	0.000	0.000	0.000	0.002	0.000	0.000
2	0.138	74.600	1.855	8.626	5.863	0.091	2.357	6.605
3	0.148	70.381	4.064	9.177	7.976	0.111	2.453	5.834
4	0.150	69.118	3.948	9.191	8.422	0.378	2.990	5.949
5	0.152	68.277	4.239	9.336	8.795	0.441	2.947	5.962
6	0.152	68.039	4.217	9.301	8.927	0.524	3.041	5.947
7	0.153	67.849	4.258	9.346	9.020	0.545	3.031	5.947
8	0.153	67.796	4.254	9.334	9.056	0.564	3.051	5.942
9	0.153	67.753	4.260	9.345	9.080	0.569	3.049	5.941
10	0.153	67.740	4.259	9.342	9.090	0.573	3.053	5.940
Relative variance of primary schooling (TPRIM)								
1	1.736	0.243	96.478	0.000	0.000	1.675	1.602	0.000
2	1.953	0.565	81.558	8.440	0.178	3.052	1.645	4.560
3	2.009	0.545	77.900	10.534	0.604	4.195	1.630	4.588
4	2.026	0.537	76.972	10.947	0.682	4.723	1.616	4.519
5	2.031	0.537	76.683	11.082	0.716	4.871	1.608	4.500
6	2.033	0.536	76.572	11.131	0.741	4.920	1.604	4.493
7	2.034	0.536	76.531	11.142	0.755	4.939	1.603	4.490
8	2.034	0.536	76.515	11.145	0.762	4.947	1.603	4.488
9	2.034	0.536	76.509	11.145	0.766	4.950	1.603	4.488
10	2.034	0.536	76.506	11.145	0.768	4.951	1.603	4.488
Relative variance of secondary schooling (TSEC)								
1	1.176	2.170	0.062	91.349	0.000	1.429	4.988	0.000
2	1.306	4.264	2.558	82.758	0.722	1.479	7.081	1.135
3	1.350	4.159	3.160	81.490	1.769	1.499	6.795	1.125
4	1.367	4.220	3.392	80.968	2.070	1.472	6.765	1.110
5	1.374	4.187	3.416	80.883	2.200	1.465	6.745	1.099
6	1.376	4.197	3.441	80.783	2.267	1.462	6.752	1.096
7	1.378	4.192	3.442	80.759	2.302	1.460	6.749	1.094
8	1.378	4.193	3.444	80.739	2.318	1.459	6.750	1.093
9	1.378	4.192	3.444	80.734	2.326	1.458	6.750	1.093
10	1.378	4.192	3.444	80.729	2.330	1.458	6.750	1.093
Relative variance of higher education (THE)								
1	0.741	0.105	0.074	1.047	95.488	0.000	3.283	0.000
2	0.904	0.116	0.593	6.562	86.264	2.747	3.097	0.619
3	0.968	0.252	0.772	8.073	82.736	3.786	3.838	0.540
4	0.999	0.336	0.799	8.516	81.543	4.166	4.105	0.531
5	1.014	0.387	0.800	8.729	80.987	4.369	4.202	0.521
6	1.022	0.407	0.802	8.856	80.697	4.470	4.247	0.516
7	1.026	0.420	0.802	8.9171	80.553	4.518	4.273	0.514
8	1.027	0.425	0.802	8.949	80.482	4.541	4.285	0.513
9	1.028	0.428	0.802	8.965	80.446	4.552	4.291	0.512
10	1.029	0.429	0.801	8.974	80.428	4.558	4.294	0.512
Relative variance of infantile mortality (TMINF)								
1	3.622	0.000	0.000	0.000	0.000	100.000	0.000	0.000
2	3.853	0.144	0.326	1.230	2.570	94.072	1.356	0.298
3	3.957	0.154	0.802	1.222	5.751	90.353	1.369	0.346
4	4.007	0.184	0.954	1.194	7.125	88.761	1.440	0.339
5	4.031	0.181	1.069	1.204	7.766	87.968	1.466	0.342
6	4.043	0.195	1.091	1.202	8.085	87.584	1.499	0.341
7	4.049	0.194	1.106	1.214	8.251	87.382	1.508	0.342
8	4.052	0.198	1.109	1.218	8.331	87.282	1.516	0.341
9	4.053	0.198	1.111	1.224	8.373	87.230	1.519	0.342
10	4.054	0.199	1.111	1.227	8.393	87.204	1.521	0.342
Relative variance of contraceptive use (TCN)								
1	1.291	1.222	0.000	0.000	0.000	0.116	98.661	0.000
2	1.611	2.103	0.276	0.119	31.774	0.659	64.218	0.848

Table 4 (*Continued*)

Year	S.E.	DTFR	DTPRIM	DTSEC	DTHE	DTMINF	DTCN	DGDP.p.c
3	1.737	2.304	0.281	0.792	37.621	1.709	55.781	1.509
4	1.794	2.200	0.684	2.193	38.730	2.269	52.496	1.425
5	1.820	2.344	0.676	2.313	39.342	2.550	51.386	1.385
6	1.834	2.310	0.714	2.555	39.682	2.669	50.686	1.381
7	1.840	2.338	0.711	2.603	39.830	2.743	50.400	1.372
8	1.843	2.330	0.718	2.667	39.905	2.773	50.234	1.370
9	1.845	2.335	0.717	2.682	39.942	2.789	50.164	1.367
10	1.846	2.333	0.718	2.699	39.960	2.796	50.123	1.367
Relative variance of real GDP per capita								
1	0.008	19.164	0.826	2.266	0.932	0.065	0.825	75.919
2	0.008	20.760	3.050	2.109	1.341	0.640	1.566	70.530
3	0.008	20.353	3.096	2.447	2.650	0.629	1.713	69.109
4	0.008	20.210	3.250	2.434	3.240	0.715	1.697	68.450
5	0.008	20.157	3.259	2.426	3.433	0.802	1.723	68.197
6	0.008	20.121	3.279	2.430	3.538	0.835	1.724	68.070
7	0.008	20.109	3.278	2.428	3.590	0.854	1.731	68.007
8	0.008	20.099	3.280	2.431	3.617	0.862	1.731	67.976
9	0.008	20.096	3.280	2.431	3.630	0.866	1.733	67.961
10	0.008	20.094	3.280	2.432	3.637	0.867	1.733	67.953

Notes: Cholesky ordering: DTMINF, DTFR, DTCN, DTPRIM, DTSEC, DTHE, DGDP p.c.

The Cholesky decomposition method is used in orthogonalizing the innovations across equations. Percentage of forecast variances is explained by innovations.

The second column, labelled "S.E.", contains the forecast error of the variable at the given forecast horizon. The source of this forecast error is the variation in the current and future values of the innovations to each endogenous variable in the VAR. The other columns give the percentage of the forecast variance due to each innovation. In general, to deal with the ordering issue of variables in the variance decomposition technique, it is assumed to rank variables from the most exogenous to the most endogenous one. As we are interested in measuring the demographic transition feedback on education and economic growth, we suppose demographic variables to be the less endogenous ones. So, among several alternatives of variable order, we choose to include demographic variables such as infant mortality, fertility and contraceptive use, followed by the socio and economic variables. According to the theory stated earlier, mortality change is followed by fertility change; therefore, we consider infant mortality to be the most exogenous variable and it is ranked first, followed by total fertility rate, contraceptive use, education, and GDP per capita.

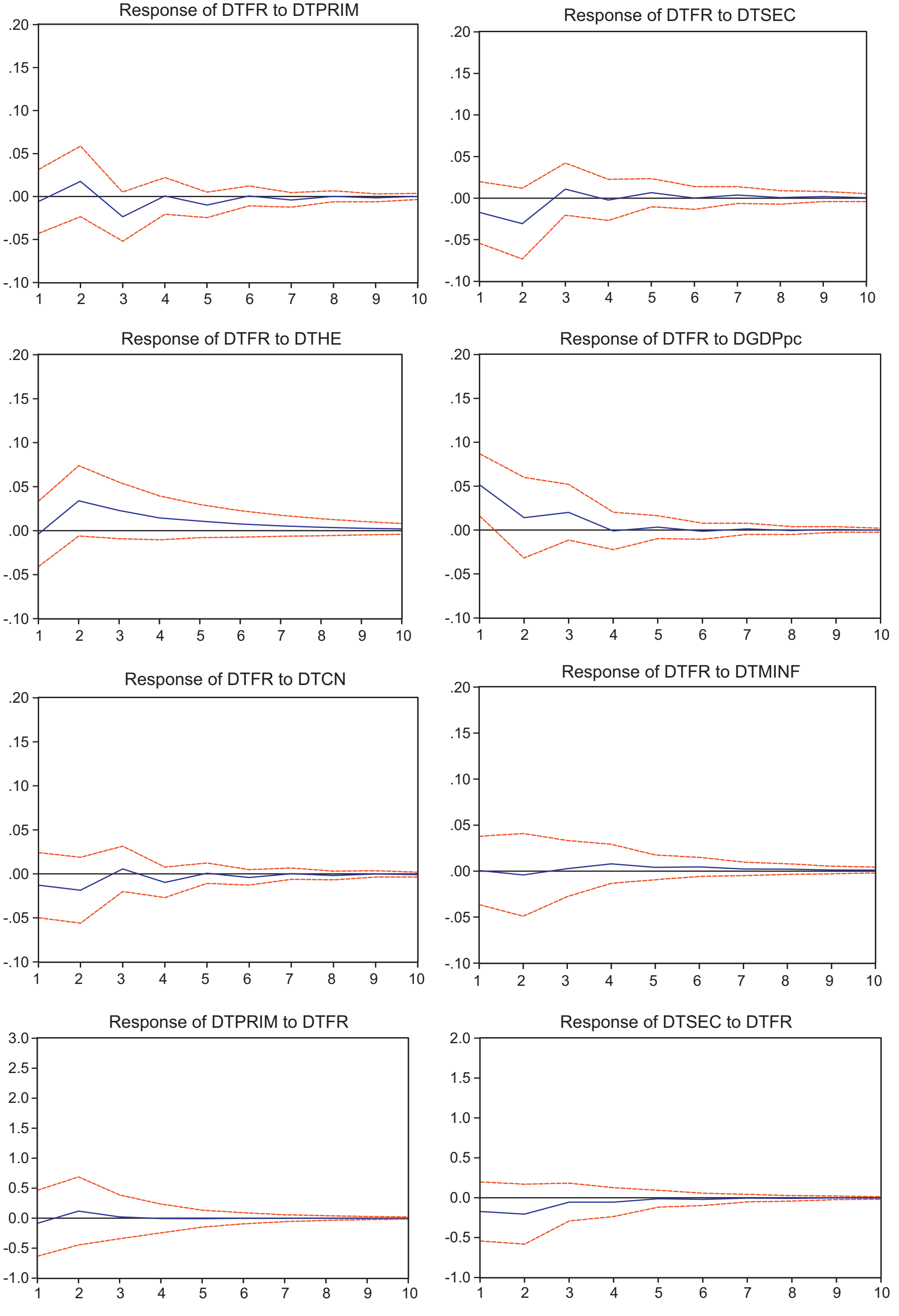

Fig. 1. Response to generalized one S.D. Innovation ±2S.E.

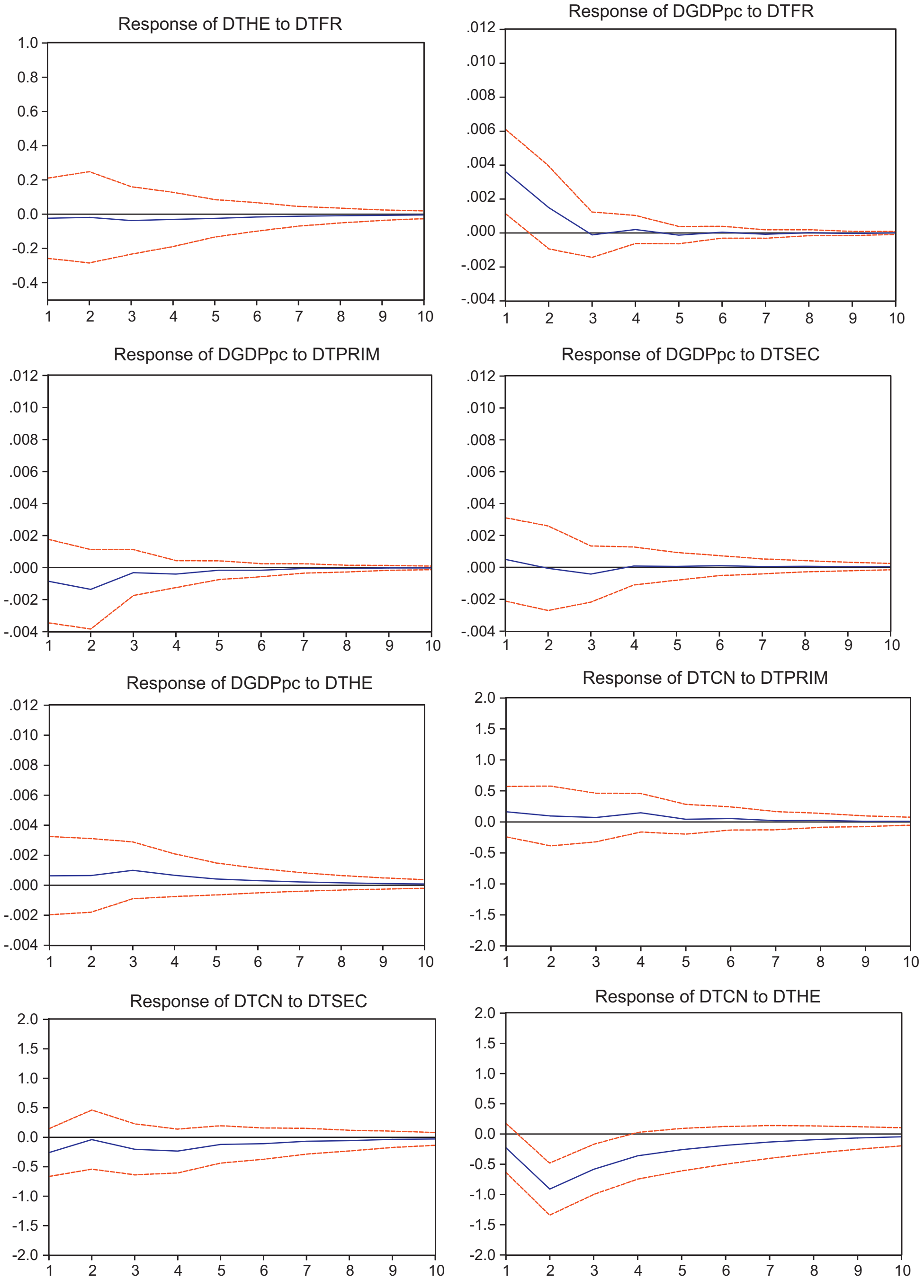

Fig. 1. (*Continued*).

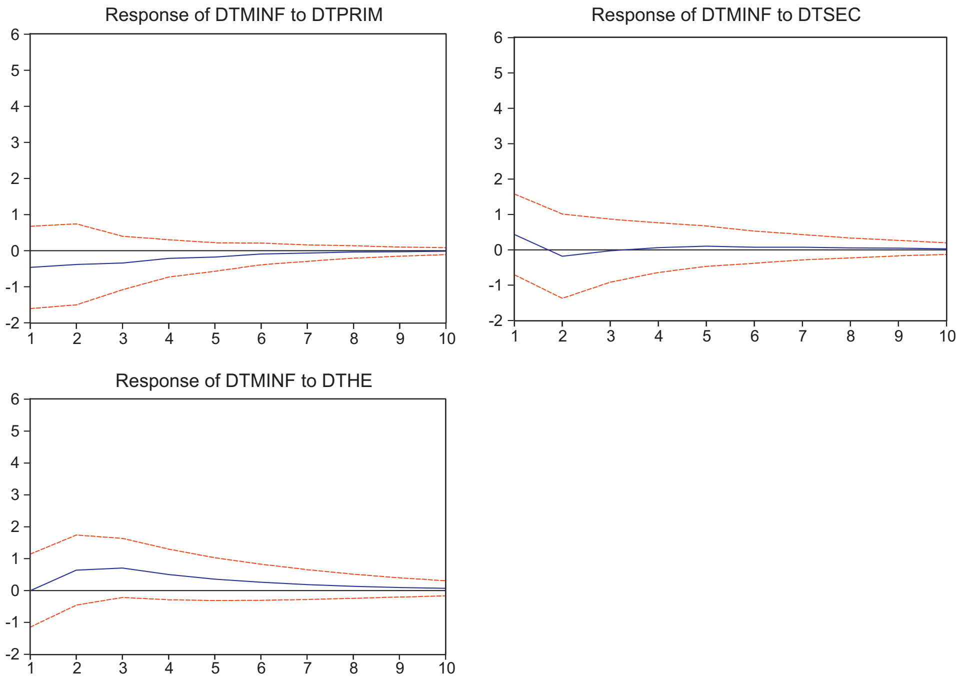

Fig. 1. (*Continued*).

Notes: To determine the lag of our VAR model we refer to Akaike (AIC) and Schwarz (SC) criteria. For the two information criteria, the smaller value is preferred. Because of the restricted number of observations we check criteria to three lags. According to the table, we choose lag one.

lag	Akaike (AIC)	Schwarz (SC)
$P=1$	10,684	13,048
$P=2$	11,451	15,929
$P=3$	10,101	16,737

To deal with the ordering issue of variables, the generalized impulses responses is used with the option analytic asymptotic response standard errors. Generalized impulses constructs an orthogonal set of innovations that does not depend on the VAR ordering.

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