E C O N O M I C S   B U L L E T I N

DEMOGRAPHIC TRANSITION IN EUROPE

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Abstract

Using panel cointegration analysis, we show that a cointegration relationship exists among fertility choice, infant mortality, real wages and real per capita output. The results suggest that in low mortality economies reductions in infant mortality will decrease fertility.

The views expressed in this paper are those of the authors and not those of the Bank of Greece. The authors wish to thank Chiang and Kao who offer the NPT 1.2 as public program and Peter Pedroni for providing his program for the estimation of FMOLS. All errors and deficiencies are the responsibility of the authors.
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1. Introduction

Most countries, industrialized or not, experience important demographic changes, one of the most important of which is the transition from a phase of rapid population growth to one in which population growth is low. Initially, a country experiences a mortality decline and fertility rises, both contributing to a rise in population growth. With some time lag, the reduction in mortality triggers a steady and continuous decline in fertility. This pattern is called the “demographic transition”.

The debate between followers of the Malthusian theory and neoclassical economists shows the crucial link between fertility, mortality and economic growth. However, the modern economic theory of population emphasizes the interdependence between infant mortality and fertility in the context of economic theories of behavior (Sah 1991; Cigno 1998; Becker *et al.* 1999). In Cingo’s model an exogenous reduction in child mortality may either raise or lower fertility. When the level of child mortality is high, reductions in it are likely to raise both fertility and survival-enhancing expenditures on children, because it lowers the price of a surviving child. When fertility is low, further reductions in it are likely to reduce fertility and survival-enhancing expenditures on children. Sah (1991) finds that when parents have a target fertility level and are sufficiently risk averse, then better survival opportunities for their children tend to reduce fertility. In the analysis by Becker *et al.* (1999) parents choose their number of children and investments in the human capital of each child to maximize their dynastic utility. In their model birth rates are lower in the modern world with growing human capital than in the agricultural economies partly because adult and child mortality is much lower.

However, limited empirical research addressed the issue of fertility, infant mortality and economic growth with rather inconclusive evidence on the relationship among the variables. Schultz (1985), using Swedish data from 1860 to 1910, has shown that a quarter of the decline in fertility over this period was due to a 50 percent reduction in child mortality. Yamada (1985) using a sample of developed and less developed countries showed that infant mortality and fertility are jointly determined. He found that a decline in infant mortality that is due to an increase in per capita real income causes a subsequent decline in fertility. Rostow

(1990) uses cross- section data from seventy-six countries and finds that birth and death rates are negatively correlated with per capita GNP.

This paper's contribution to the existing literature is as follows. First, using country by country and panel cointegration modeling for nine European countries for the period 1960-1998, we show that a long-run cointegration relationship exists between demographic variables, such as fertility and mortality, real wages and real per capita output. Second, consistent with the theoretical findings of Cigno (1998), Sah (1991) and Becker *et al.* (1999) we demonstrate that in modern economies, where the level of infant mortality is already low, further reductions in it are likely to reduce fertility.

For this purpose the Pedroni technique (1997, 2000) for heterogeneous panel data is applied to search for the existence of cointegration in the panel setting to explicitly accommodate and estimate the dynamic long-run interrelations in levels. Finally, the fully modified OLS for heterogeneous panel (FMOLS) technique is applied to estimate the long-run estimates in country -by -country basis and in panel modeling.

The remainder of the paper is organized as follows. Section 2 presents the data and describes briefly the panel cointegration methodology. Section 3 presents the empirical results. Section 3 concludes.

2. Empirical Analysis

2.1 *Data description*

The empirical analysis has been carried out using annual data for the period 1960 to 1998 for nine European countries. The nine European countries are: Germany, France, Italy, United Kingdom, Spain, Ireland, Netherlands, Finland and Sweden. The wage variable (RWAGE) is the real wage; the fertility choice variable (FERT) is the total fertility rate (i.e. the number of children which a woman would bear if she followed throughout her life the current age specific birthrates); the infant mortality rate (MORT) is defined as the number of children aged under one year old who die per 1000; the output variable (RCGDP) is the real per capita GDP at market prices. The data on real wage and real per capita output are obtained from the *International Financial Statistics* data set. The data of fertility and infant mortality are obtained from the *Eurostat Demographic Statistics* published by the Eurostat. All variables are expressed in logarithmic form (LFERT, LMORT, LRWAGE, LRCGDP).

2.2 *Panel Cointegration*

Following Sah (1991) and Cigno (1998), it is possible to derive an equation for fertility

$$LFERT = f(LMORT, LRWAGE, LRCGDP) \qquad (1)$$

In the empirical analysis we estimate equation (1) to test for the validity of “demographic transition” theory and for the contribution of economic forces to the demographic transition process. In particular, we employ the panel cointegration approach and the fully modified OLS estimation technique to test whether a cointegration relationship exists among fertility mortality, real wages and real per capita output.

Table 1 summarizes the results of cointegration analysis among the four variables using the Johansen maximum likelihood approach employing the trace statistic[1,2]. The tests provide evidence to reject the null of zero cointegrating vectors in favor of one cointegrating vector at 5% level for all the countries. On the basis of the results, the long-run relationship between demographic variables, real wages and real per capita output finds statistical support in each individual country.

Next, panel unit roots are used to examine if the panel data series are I (1). The Hadri (2000) unit root tests for each variable for the panel data are estimated. Table 2 presents the results. The null hypothesis of stationarity is rejected at 1% level of significance in both cases (constant, constant and trend). Therefore, the results from the tests suggest that all the series appear to be non-stationary in the panel data set.

Next, since all the variables in the panel data are integrated of the same order, it is appropriate to look for a relationship among the variables. Kao (1999), and Pedroni (1997, 1999, 2000) developed several tests to examine the existence of cointegration in a multivariate framework. The proposed statistics test the null hypothesis of no cointegration versus the alternative of

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[1] The Augment Dickey Fuller (ADF), Phillips-Perron and KPSS tests for the four variables in levels and first differences on individual country bases have been performed. The combined results from all the tests suggest that all the series under consideration are I(1) processes.

[2] To determine the lag length of the VAR, three versions of the system were initially estimated: a four, a three and a two-lag version. Then, an Akaike Information criterion (AIC), a Schwarz Bayesian Criterion (SBC) and a likelihood ratio test (Sims’ test) were used to test whether all three specifications are statistically equivalent. All tests reject the null hypothesis that all the specifications are equivalent. In particular, the tests suggest different lag structure for each country. In most cases the appropriate lag structure was equal to two.

cointegration. However, pooling time series has resulted in a substantial sacrifice in terms of the permissible heterogeneity of the individual time series. It is important in the process of polling time series to permit as much heterogeneity as possible among individual time series. Therefore, testing for cointegration among the variables should permit for as much heterogeneity as possible among the individual countries of the panel. Pedroni (1997, 1999, 2000) developed several tests to test for no cointegration in dynamic panel allowing for heterogeneity among the individual countries. Seven tests are estimated to examine whether the error process of the estimated equation is stationary.

Table 3 summarizes the results of cointegration analysis among the four variables using the Pedroni statistics. All the statistics provide evidence of cointegration to support the long-run relationship among the variables. In particular, all the country-by-country and panel cointegration test results suggest that there is a cointegrating relationship among real per capita output, fertility, infant mortality and real wage in the sample of European countries. In addition the estimated results suggest that all the variables used in the analysis can be treated as “long-run forcing” variables for the explanation of the others.

Having established that the variables are structurally related the long-run equations are estimated using the fully modified OLS (FMOLS) for heterogeneous cointegrated panels (Pedroni 1997, 2000) (Table 4). From the estimated equations three main points can be concluded. First, real per capita income for the panel has a positive sign and is statistically significant which implies that an upward shock in real GDP per capita, due for example to an improvement in the terms of trade, leads to higher fertility. This implies a positive income effect on the demand for children. The estimated coefficient is positive and statistically significant for Italy (0.73), Spain (2.40). For the other countries, except for Ireland, Netherlands and Finland, is positive but not statistically significant. Second, the empirical results for the panel and for each country, except for Finland, imply that an upward shock in real wages, due for example to technological change, leads to lower fertility. This implies that the opportunity cost of time devoted to childcare has increased and consequently fertility has declined. Finally, the empirical results for the panel data indicate a downward shock to infant mortality, due for example to medical advances, leads to lower fertility. This result is consistent with the theoretical explanations provided by Sah (1991), Cigno (1998), Becker *et al.* (1999).

3. Conclusions

This paper provides an empirical model that supports a long-run relationship between fertility choice, infant mortality, real wages and real per capita output using panel cointegration techniques for a sample of European countries. In agreement with the theoretical findings of Sah (1991), Cigno (1998) and Becker *et al.* (1999) the results suggest that in industrial economies with low mortality reductions in infant mortality will further reduce fertility.

4. Acknowledgment

The views expressed in this paper are those of the authors and not those of the Bank of Greece. The authors wish to thank Chiang and Kao who offer the NPT 1.2 as public program and Peter Pedroni for providing his program for the estimation of FMOLS. All errors and deficiencies are the responsibility of the authors.

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Table 1				
Johansen and Juselius Cointegration Test based on Trace of the Stochastic Matrix Fertility Choice, Mortality Rate, Real Wages and Real Per Capita Output: Sample: nine European countries during 1960-1998				
Country	$r = 0$	$r \leq 1$	$r \leq 2$	$r \leq 3$
Germany	63.97**	35.57	19.57	6.30
France	58.84**	35.55	15.53	3.03
Italy	67.28**	36.14	17.52	3.90
U.K.	70.04**	31.08	12.96	4.09
Spain	69.60**	39.32*	14.75	2.82
Ireland	69.57**	31.20	16.55	5.82
Netherlands	64.05**	35.85	14.52	4.18
Finland	59.01**	30.87	12.92	3.37
Sweden	66.91**	29.35	13.39	2.61
Notes: r indicates the number of cointegrating relationships. **, * indicate rejection of the null hypothesis at 95 and 90 percent critical value, respectively.				

Table 2		
Unit Root Tests for Heterogeneous Panel		
Variable	Hadri (2000)	
	No time trend	With time trend
LFERT	18.79***	630.7***
LMORT	24.44***	10716.54***
LRWAGE	21.85***	3286.92***
LRCGDP	23.51***	4080.26***
Notes: *** indicates rejection of the null hypothesis of stationarity at 1% level of significance.		

Table 3				
Panel Cointegration Tests for Heterogeneous Panel				
Statistics	Dependent variable			
	Fertility rate	Infant mortality rate	Real per capita GDP	Real wage
Panel ?-Statistic	22.02***	19.12***	26.46***	17.17***
Panel ?-Statistic	-14.48***	-14.37***	-15.79***	-9.69***
Panel t-statistic: (non-parametric)	-4.78***	-4.63***	-4.86***	-3.96***
Panel t-statistic: (parametric)	-215.29***	-147.29***	-329.04***	-249.78***
Panel ?-Statistic	-16.54***	-15.25***	-18.01***	-10.77***
Group t-statistic: (non-parametric)	-5.05***	-4.32***	-4.95***	-3.94***
Group t-statistic: (parametric)	-4.97***	-3.74***	-4.94***	-4.08***

Notes: All statistics are from Pedroni (1999). NPT 1.2 is used in the estimation as Chiang and Kao (2001) developed it. *** indicates rejection of the null hypothesis of no-cointegration at 1% level of significance.

Table 4

Long-run Estimates (Fully Modified OLS)
Dependent Variable: Fertility choice

Country	LRCGDP	LRWAGE	LMORT
Germany	0.19 [0.49]	-1.06*** [-4.71]	-0.06 [-0.52]
France	0.08 [0.32]	-0.56*** [-3.32]	0.01 [0.16]
Italy	0.73*** [2.82]	-0.43*** [2.82]	0.56*** [6.99]
U.K.	0.42 [0.40]	-1.89*** [-2.08]	-0.38 [-1.43]
Spain	2.40*** [2.88]	0.67*** [7.72]	1.12*** [19.85]
Ireland	-0.15 [-0.76]	0.49*** [2.72]	0.66*** [4.38]
Netherlands	-0.01 [-0.01]	-1.18*** [-2.69]	0.05 [0.22]
Finland	-0.58 [-1.01]	-1.12 [-1.72]	-0.67*** [-2.88]
Sweden	0.55 [1.00]	-0.91* [-1.92]	0.23*** [1.09]
Panel	0.18** [2.04]	-0.66*** [-2.94]	0.17*** [9.28]

Notes: Figures in brackets are t-statistics. ***, ** indicate significance at 1% and 5% level respectively.