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Demography and economic growth in Spain: A time series analysis ♦

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Abstract

In this paper, advanced time series econometric tools are employed to test the existence of relationships among demographic and macroeconomic variables in Spain along the 1960-2000 period. Annual data for the total fertility rate, infant mortality rate, per capita gross domestic product and wages are used in the empirical analysis. We first examine the bivariate Granger causality to look for short run relations. Then, a multivariate cointegration analysis is carry out, showing that two long run relationships among the variables exist with statistically significant coefficients. From these cointegration vectors, the vector error correction model is estimated to test the endogenous or exogenous character of the variables, finding that total fertility and gross domestic product clearly are endogenous variables. This is an important result to choose the most suitable framework to model the Economy. Finally, the main results from the multivariate causality analysis and the generalized impulse-response function show that total fertility responds directly to a gross domestic product shock, an increase in wages has a negative effect on both total fertility and gross domestic product, and infant mortality doesn't cause total fertility. These combined results are useful to be compared with those expected from theoretical models of fertility.

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1 Introduction

This paper is a contribution to the debate about the relationships among demographic and socio-economic variables. Propositions from theoretical models of aggregate fertility have only found partial empirical support. We try to detect empirical evidence of these relationships in the Spanish case during the 1960-2000 period, using a time series methodology and data of fertility, infant mortality, gross domestic product and wages.[1]

The main demographic indicators in developed countries have substantially changed in the last decades. The total fertility rate has dramatically decreased while the life expectancy has increased in a remarkable way. The two factors have determined a significant deceleration in the speed of population's growth and have also altered the population's age structure, moving towards an aging population. The identification of the relationships between demographic variables and socio-economic ones is fundamental to be able to asses and be ready to confront the consequences of these structural demographic changes in future years.

The assignment of this paper is to provide additional time series econometric evidence on the short run as well as long run time series behaviour of demographic indicators and the economic growth for Spain. With the objective to research the relationships among these variables we use advanced time series econometric tools. The complex interactions among the variables involved in fertility decisions suggest a modelling approach that allows all the variables to be endogenous, as in multivariate time series analysis. A second concern with traditional studies of demographic and economic growth interactions is the causal treatment of non-stationary data. The key variables in fertility studies are either trended or follow long swings characteristic of non-stationary processes that must be differenced to become stationary. However, traditional approaches either ignore the non-stationarity of the regressors or use deterministic trend removal. Unfortunately, either strategy will produce regression statistics that, at least, have non-standard distributions, or at worst may be completely spurious.

Furthermore, the various views on the relationship between infant mortality, fertility and economic growth do not explicitly define whether these variables should be treated as endogenous or exogenous to their models. The utilization of Vector Error Correction Models has several advantages over the methods used in the past by several researches in Spain, since this type of multivariate analysis can clearly identify multiple cointegration relationships and hence error correction terms and distinguish between exogenous and endogenous variables.

The empirical discuss on the dynamic relationship between demographic indicators and economic growth has yielded miscellaneous results. In the study of the relationships among these variables, we not only try to find out the existence of common trends in the long run but we also seek if causality exists. Economic-policy implications may vary depending on whether the changes in fertility rates are caused by changes in per capita income or, on the contrary, the changes in fertility rates are the ones that cause the changes in income per capita. Likewise, it is important to determine the endogenous or exogenous nature of the variables, in a global environment to develop a coherent theory that explains the economic growth. In this sense, the conclusions drawn from a rigorous study of the time series, guide us to the best theoretical model to represent the Economy: a classic model where the economic growth is determined by the exogenous technical progress and the population must adapt to it in the long run, a neoclassic model in which the economic growth is equal to the (exogenous) population growth, or a model where the economic growth and the population are endogenous variables. This last case seems to be the most accepted in the current literature about economic growth, being Becker the most important author in the beginnings of the treatment of the fertility as an endogenous variable.[2]

This paper is organized as follows. The next section presents a brief of the economic theories of fertility and reviews the main empirical studies. In Section 3, the objectives of the paper are enunciated. Section 4 describes the variables, data set and deals with time series methodological aspects. Section 5 contains the empirical analysis, and the main results of the stationarity analysis, causality, cointegration, vector error correction model and dynamics of the system are presented. Finally, we conclude in section 6.

2 Literature Review

The modern economic theories of fertility emphasize the role of a variety of determinants. For Becker and the "New Home Economics", the fertility rate is a consequence of the demand for children. Then, a positive income effect and a negative substitution effect must exist when price of children change. So, factors affecting this price, specially female wages, become the key variables to predict the fertility behaviour. On the other hand, Cigno's asset theory thinks that children are investment goods for parents and not consumption goods. So, capital market development, high interest rates and improvements in old-age public pension schemes produce a lower fertility rate. For Easterlin's theory a low relative income in young adults implies an increase in female education and/or labour force participation with negative effects on fertility. Despite these alternative theories, McNown and Rajbhandary (2003) argue that their predictions are quite similar in evaluating the substitution and income effects on the fertility. Theoretical relations between infant mortality and total fertility have been studied by Sah (1991) and Cigno (1998) showing that an infant mortality decline should produce a decrease in total fertility. Finally, for the classic theory of demographic transition the declining fertility is a consequence of the whole process of economic development: industrialization, medical advances, mortality decline, urbanization, etc.

The complex interaction among the evolving variables in the fertility decision suggests a model where the endogenous character of all the variables is allowed, like in a multivariate time series analysis. This work is part of a literature that increasingly use more time series techniques to analyze the relationships among macroeconomic variables. Without a doubt, this fact is taking place given the diffusion of more information for these variables along wide periods and for most countries. In this sense, the relationships of causality between infant mortality and fertility have been analyzed empirically in several papers, providing ambiguous results. However, this greater flexibility requires a higher number of observations.

The causal relationships between demographic and economic variables have been empirically examined by various researchers. Yamada (1985), Rostow (1990) and Barlow (1994) among others, find in their empirical works that both fertility and infant mortality tend to decrease with an increase in per capita real product. Barro and Sala-i-Martin (1995) empirically identify a negative relationship between fertility and product per capita, with panel data for 87 countries for the period 1965-1975 and 97 countries for the interval 1975-1985. This result is also obtained from a theoretical model proposed by Becker and Barro (1988), but in continuous time and with families with an infinite temporary horizon.

However, Kelley and Schmidt (1995) empirically detect that the relationship between the population's growth and the economic growth changes over time and it can be positive in developed countries. Panopoulo and Tsakloglou (1999), with a sample of 68 countries (13 developed and 55 developing), find that per capita income has a negative coefficient in the regression to estimate the fertility when that is the only explanatory variable but it becomes positive when other variables like infant mortality, education and urbanization index, among others, are incorporated.

The relationships between demographic and economic variables have also been investigated in a short and long run analysis environment. This way, Hondroyiannis and Papapetrou (2001, 2002a, 2002b) study the case of Greece in the period 1960-1996, detecting cointegration between both types of variables. Also, they find evidence that the fertility and the gross domestic product should be considered as endogenous, and they detect a positive income effect on the demand for children as well as an inverse relationship between the gross domestic product and the infant mortality rate. Masih and Masih (1997, 1999 and 2000), studies the long run trends in Asian countries like India, Bangladesh and Thailand, including in the analysis additional decisive variables on the fertility decision like family planning programs, level of education, woman's participation in the labour market and percentage urban population. In general, they find that family planning programs have a greater impact on the fertility than the socio-economic variables. Bailey and Chambers (1998) analyze the response of fertility and nuptiality rates to shocks of real wages and mortality rate during the period 1542-1800 in England. Their results indicate that these shocks predict the fertility rate and nuptiality, advancing in two or three years their behaviour. On the other hand, McNown (2003) find a negative relationship between fertility rate and female wages with United States data for the 1948-1997 period. Finally, Alam et al. (2003) analyze the dynamics among fertility, family planning programs and female education for Pakistan during the period 1965-1998. The findings appeared to be consistent with theoretical statements that maintain that although in the long-run the sufficient condition of fertility decline may be the result o a complex dynamic interaction with planned family planning and significant socio-economic structural changes.

3 Objectives

The goal of this paper is the study of the relationships among demographic and macroeconomic variables. Specifically, we first verify the existence of a long run relationship among the chosen variables. This would imply that the variables share common trends in the long run and each of them influences the other ones.

Second, in the case the existence of this long run relationship is confirmed, the long run effects of changes in one variable should be analyzed in a context of multivariate causality. We study the directions of causality and the signs in the relationships among variables. It is useful to compare these signs with theoretical results to verify their consistency. In this sense, fertility models expect positive income effects and negative substitution effects of wages on the demand for children, while a direct effect between infant mortality rate and fertility rate is also expected.[3]

Third, we try to determine the endogenous or exogenous nature of the variables inside this long run relationship. This result is crucial to choose the best theoretical model to represent the Economy. In the economic growth literature, models have evolved toward those of endogenous growth with endogenous fertility, so that the endogeneity-exogeneity results can be used to confirm if the use of these more advanced models is justified.

Lastly, the dynamic interaction between the demographic and economic variables will be investigated, by means of the response of each variable to shocks on the other ones. This provides us with a better understanding of the whole interrelation process between economic and demographic change.

4 Data and Methodology

The demographic and macroeconomic variables used in the empirical analysis are: yearly data of the Total Fertility Rate (TFR), the Infant Mortality Rate (IMR), the real per capita Gross Domestic Product (GDP) and the real average Wages (WAG) for the period 1960 to 2000. A detailed description of the series is given in the Table 1, while its evolution is represented in the Figure 1. All the variables are expressed in logarithmic terms. Given the period and the frequency of the sample, the number of observations to carry out the study is quite small, especially if other explanatory variables, like the female labour market participation, the female enrolment rate, the interest rates and stock market indexes, among others, are incorporated.[4] Also, it could be thought that the cointegration technique loses power with so few observations. However, this is not a problem as, according to the works of Campbell and Perron (1991) and Hakkio and Rush (1991), the most important thing is not the frequency but the width of the analyzed period.

To accomplish the objectives, we follow five methodological steps in our empirical analysis. First, to solve the problems in the treatment of non-stationary series, the order of integration of the time series is obtained testing the existence of a unit root. If the series are integrated of the same order, we are allowed to look for bivariate or multivariate long run relationships among the variables.

Second, the causality in Granger sense is examined to contrast if a variable causes or helps to predict better another one. The Granger causality test (Granger, 1969) which is based in Vector Autoregressive models (VAR), is used in a preliminary way. This methodology investigates the interactions across the data, expressed as logarithmic differences, with the past values of the same variable and with those of the rest of variables. The detected causality relationships in the bivariate environment refers to a short run time horizon; then, we proceed to the study of the long run relationships to complete the analysis.

Third, we test the existence of cointegration relationships, both in the bivariate and multivariate environment, among the four demographic and economic variables. The cointegration concept was introduced by Granger (1981), with the purpose of determining if two or more variables are following parallel growth paths, that is, if they present common trends in the long run. Later, Engle and Granger (1987) developed estimate procedures and cointegrated systems tests, proposing a simple two-stage model that presents several problems. Additional works like Johansen (1988 and 1991) and Johansen and Juselius (1990) try to solve them. Johansen and Juselius (*op.cit.*) develop a strategy that treats the estimation and test problems in cointegrated systems in a context of maximum likelihood under the normality assumption. This strategy is tested on the principle of the likelihood ratio, with the purpose of not only discerning if cointegration exists, but also to determine the cointegration range. This procedure leans on the general representation of the multi-equation error correction model in which, the order of the causality among the variables is not imposed a priori.[5]

The cointegration analysis allows the possibility that the deviations from the equilibrium conditions of two or more economic variables are stationary, provided they are not stationary separately. What is behind this concept is the existence of economic forces that impede persistent deviations from the long run equilibrium conditions, although deviations can be observed in the short run. Economic theory frequently suggests the existence of long run relationships among variables, although they can fluctuate individually outside of the equilibrium during some time. The economic models indicate that certain forces act to restore equilibrium and, therefore, some long run relationship should exist among the groups of variables.[6]

Fourth, if cointegration exists, a vector error correction model is estimated. This model incorporates parameters that allow us to analyze the causality relationships without incurring in a specification error.[7] We test the significance of the error correction term, using the weak exogeneity test, and the Wald test is also applied to the significance, individually and combined, of the lagged explanatory variables, determining the short run causality among the time series.

Lastly, the dynamic properties of the multivariate system are investigated. Using the generalized Impulse-Response Function proposed by Pesaran and Shin (1998),[8] we get an estimation of the response of one variable to innovations in another variable, giving bigger robustness to the results. In this sense, and following Lütkepohl (1993), this technique can be interpreted as a type of causality different to that of Granger because of the isolated impulses in a variable cause response in another variable and so we can determine if the first one causes the second one.

The impulse-response function also provides the dynamic relationship among the time series, since it computes the impact that is derived from the interaction of all the variables. In this sense, this function is a much more useful analytic tool than the individual analysis of the parameters of the model, since it resumes all the outstanding information that these parameters contain (Lütkepohl and Reimers, 1992). In conclusion, the impulse-response function reflects in what grade the shocks in the different variables are transitory or persistent in terms of their impact on the rest.

5 Empirical Analysis

Next, the main results extracted form the implementation of the methodology proposed in the previous section are presented.

5.1. Stationarity

The existence of unit root has been tested with the purpose of identifying the order of integration of each time series. The test has been used from Kwiatkowski *et al*. (1992) - KPSS -. The results are reported in Table 2. In all cases, the hypothesis of level and trend stationarity is rejected. For the first differences of the time series, the KPSS test accepts the stationarity with different levels of significance. So, the combined results suggest that all the series are I(1).

5.1 Bivariate Causality

The short run bivariate causality is made with the Granger causality test. The results are reported in Table 3 and it highlights the power of GDP mainly to cause in Granger sense or help to predict better WAG and TFR, and not being rejected the null hypothesis that the product per capita does not cause IMR. Wages, however, only cause the total fertility rate for three lags. Lastly, a causality relationship between the demographic variables exists, going from the variable IMR toward the variable TFR.

5.2 Cointegration

First, the existence of bivariate cointegration relationships is tested. The results are presented in Table 4 and they suggest that long run equilibrium relationships exist between the pairs GDP-TFR, GDP-WAG, IMR-TFR and TFR-WAG. However this approach does not tell us anything about the combined relationship among all the demographic and economic variables.[9] As a consequence, the long run relationships between demographic and economic variables can only be settled down in a complete way with a multivariate cointegration analysis that shows all the possible connections, among demographic phenomena and socio-economic changes.

With this premise, we study the cointegration relationship in a multivariate environment. The results are presented in Table 5 and they indicate that one cointegration vector exists according to the maximum eigenvalue test, and two cointegration vectors exist according to the trace statistic test with significance at the 5% level. According to Harris (1995, p.89), in the case of mixed results, that one provided by the trace statistic test will be preferred, so we accept that two cointegration vectors exist.[10] Anyway, the cointegration analysis suggests that a long run relationship between economic and demographic variables exists.

Restrictions on the cointegration vectors have been imposed to determine if the variables are statistically significant. Table 6 presents the results of the maximum likelihood ratio test described by Johansen (1992) and Johansen and Juselius (1992). The results suggest that all the variables enter in a statistically significant way into the cointegration vector, although in the case of IMR a 10% level should be considered to accept its inclusion in the cointegration vector.

5.3 Vector Error Correction Model (VECM)

Since the variables are cointegrated and the number of cointegration vectors has been determined in a multivariate environment, the corresponding VECM is estimated. The results of the VECM are reported in Table 7. The error correction term (ECT) measures the proportion in which the long run movements in the dependent variable are corrected in every short run period. The size and the statistical significance of the ECT measure the speed to return to the long run equilibrium for each dependent variable. To obtain this, first we test the significance of the ECT in the two cointegration equations, using the weak exogeneity test, which analyzes if the imposed restrictions are identified for each one of the two cointegration vectors and for each possible range.[11] The results are reported in Table 8, showing that weak exogeneity is rejected for all the variables at 5% level (IMR at 10%).

Then, extending the analysis to the short run causality, the Wald test is applied to the significance, individually and combined, of the lagged explanatory variables, determining the short run causality among the time series. The results are in Table 9 and show that TFR and GDP clearly are endogenous variables.

5.4 Impulse-Response Function (IRF)

Although the VECM allows us to determine the existence of causality (both in the short run and long run), it does not say anything about the dynamic properties of the system. In this sense, the IRF is analyzed. The purpose is to measure the response of each demographic and economic variable to each one-standard deviation shock. This analysis says if a transmission of significant influences exists over the time series and measures its persistence.

The IRF results are plotted in Figures 2 to 5. The graphic analysis suggests that a positive shock to TFR (Fig. 2) has little (positive) effects on GDP and WAG, in the short run, while the effect on IMR changes from negative to positive as time goes on. A negative shock to IMR (Fig. 3) increases the TFR at all horizons. However, TFR only cause GDP and IMR does not cause TFR, in the short run, as we can see from the multivariate causality test (Table 9).

A positive shock to GDP (Fig. 4) increases the TFR, which suggests a positive income effect on the demand for children, and therefore that the children are treated as consumption goods instead of investment goods. This is a relevant result because a previous causality from GDP to TFR has been detected (Table 9). In addition, this positive income effect is plausible according to the theoretical models of fertility. Also, a positive shock to GDP increases WAG in a significant way, while a short run inverse response in IMR is observed, although this last effect is little and vanishes in the medium run. However, this is not a crucial result because GDP does not cause WAG and IMR in the multivariate causality test (Table 9).

Finally, a positive shock to WAG (Fig. 5) causes a TFR and GDP decline, mainly in the long run, showing a substitution effect between wages and fertility. This result, once the multivariate causality from WAG to TFR has been verified (Table 9), gives empirical support to the predictions of the main economic theories of fertility, showing the key role of wages on the demand for children.

The combined results of the IRF also suggest that mainly TFR and GDP responds to shocks in the rest of variables, what reaffirms its endogenous character. However, IMR and WAG are not significantly influenced by changes in the rest of variables, revealing that they are the most exogenous variables.

6 Conclusions

This work investigates the relationships between demographic variables (Total Fertility Rate and Infant Mortality Rate) and economic variables (per capita real Gross Domestic Product and real Wages), for the Spanish case, during the period 1960-2000. In short, the existence of long run equilibrium relationships among them is studied, both in a bivariate and multivariate environment. At the same time, the endogenous or exogenous nature of the variables is examined, using a vector error correction model that considers the relationships in the short run and long run previously detected in the cointegration analysis.

The results can be summarized as follows: first, the existence of a long run relationship among the four variables is statistically verified. Second, a positive income effect on the demand for children is observed, deriving from the sign of the bidirectional relationship between gross domestic product and fertility. Third, an opportunity cost of time due to childcare exists, because of the negative response of total fertility to shocks in wages. Finally, the endogenous character of fertility and per capita income finds statistical support.

These results are useful to be compared with those expected from theoretical models of fertility. The propositions of the "New Home Economics" about a positive income effect and a negative substitution effect of wages are confirmed for the case of Spain in the 1960-2000 period in our multivariate environment. However, we do not detect empirical evidence of the proposition of Sah (1991) and Cigno (1998) about a positive effect of infant mortality to fertility, because no causality between these two variables exists.

Finally, the endogenous character of total fertility and gross domestic product has important theoretical implications. It suggests that the most suitable framework to model the Economy is one with endogenous growth and endogenous fertility, against alternative models with exogenous population growth or those with exogenous technical progress as the only source of growth. So, the use of more advanced models is justified.

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Table 1.- Data Description

Variables	Description	Source
TFR	Total Fertility Rate. It's the average number of children that would be born to a woman if she were to pass through all her childbearing years conforming to the age-specific fertility rates of a given year.	Period 1960-1974: New Cronos (Eurostat). Theme: Population and social conditions Domain: Demography Collection: Fertility Demographic indicator: Total Fertility Rate Period 1975-2000: INE. Indicadores demográficos básicos.
IMR	Infant Mortality Rate. Number of children under one year died per 1000 live births.	Period 1960-1974: New Cronos (Eurostat). Theme: Population and social conditions Domain: Demography Collection: Mortality Demographic indicator: Infant Mortality Rate Period 1975-2000: INE. Indicadores demográficos básicos.
GDP	Gross Domestic Product per capita	New Cronos (Eurostat). Theme: Economy and finance Domain: National Accounts Historical Data (ESA79) Collection: National Accounts-Aggregates-Annual Data Group: ESA Aggregates at constant prices 1990 Table: ESA Aggregates at constant prices in current PPS (Purchase Power Parity units) Aggregate: Gross domestic product at market prices (GDPmp) (N1). Measure unit: current PPS per capita at constant prices of 1990.
WAG	Real average wage	New Cronos (Eurostat). Theme: Economy and finance Domain: Historical data of national bills (ESA79) Collection: National Accounts-Aggregates-Annual Data Group: ESA Aggregates at constant prices 1990 Table: ESA Aggregates at constant prices in current PPS (Purchase Power Parity units) Attaché: Compensation of employees (R10). Measure unit: current PPS per employee at constant prices of 1990 The data of 1999 and 2000 has been calculated with the Real compensation per employee (% yearly variation) series. The data up to 1979 come with a measure unit different to those of 1980-1998 period. They have been homogenized calculating the 1979 data from 1980 data using the same series of % yearly variation.

Table 2.- Unit Root Test

We use the KPSS stationarity test (Kwiatkowski et al, 1992). The same procedure has been used both in levels and in differences: First, the test with time trend and intercept in the model (a) has been carried out and, in case the time trend is not significant, we proceed to estimate the model only with intercept (b). The critical values to 1% and 10% are, for the model with intercept and time trend, 0.216 and 0.119, and for the model only with intercept 0.739 and 0.347, respectively. The number of lags in each variable has been 2. (*) and (**) indicate that the stationarity H_0 is accepted for a significance level of 1% and 10%, respectively.

	Level	**Model**	**Difference**	**Model**
GDP	0.2492	(a)	0.1854*	(a)
WAG	0.3551	(a)	0.1728*	(a)
TFR	0.2437	(a)	0.3333**	(b)
IMR	0.2339	(a)	0.1551**	(b)

Table 3.- Short run Bivariate Causality

The null hypothesis to contrast is that X does not cause Y in the Granger sense. "F" is the value of the F-snedecor statistic that test the short run bivariate causality. "p-value" indicates the probability to accept the null hypothesis. (*) Rejection of the H_0 at 10% level.

			Lags			
Y	**X**		**1**	**2**	**3**	**4**
	GDP					
WAG		F	**5.4457***	**4.6909***	**4.0296***	**3.4144***
		p-value	0.0253	0.0161	0.0160	0.0220
TFR		F	**12.0198***	**4.7675***	**2.8132***	**2.3481***
		p-value	0.0014	0.0152	0.0561	0.0797
IMR		F	1.7648	1.2274	0.5589	0.3153
		p-value	0.1924	0.3061	0.6462	0.8652
	WAG					
GDP		F	0.3361	0.7694	0.9277	0.4031
		p-value	0.5657	0.4715	0.4393	0.8046
TFR		F	2.7898	1.5835	**2.7758***	**3.0028***
		p-value	0.1035	0.2205	0.0584	0.0358
IMR		F	0.4512	0.1776	0.2735	0.5094
		p-value	0.5061	0.8381	0.8440	0.7292
	TFR					
GDP		F	0.0462	1.4425	1.5061	1.8683
		p-value	0.8310	0.2508	0.2330	0.1450
WAG		F	2.0811	0.4313	1.0530	0.7311
		p-value	0.1578	0.6533	0.3835	0.5786
IMR		F	1.8281	1.7163	1.5243	0.8695
		p-value	0.1848	0.1954	0.228	0.4948
	IMR					
GDP		F	0.0039	0.3332	0.1182	0.2639
		p-value	0.9507	0.7190	0.9486	0.8985
WAG		F	0.0149	**2.8508***	1.2766	0.9438
		p-value	0.9034	0.0721	0.3002	0.4538
TFR		F	**6.3509***	1.2980	**3.2355***	**2.2908***
		p-value	0.0163	0.2867	0.0360	0.0855

Table 4.- Bivariate Cointegration Test

The bivariate cointegration is made using the trace statistic test that tests the null hypothesis (H_0) that there are r cointegration vectors, against the alternative hypothesis (H_1) that exist, at least, r+1 cointegration vectors, where r goes from 0 to 1; and also the maximum eigenvalues test that tests the null hypothesis (H_0) that there is, as maximum, r cointegration vectors, against the alternative hypothesis (H_1) that exist, as maximum, r+1 cointegration vectors, where r goes from 0 to 1. The models have been chosen following the Schwarz criterion. The optimum number of lags has been 1, obtained from the estimation of a VAR in levels. (*) H_0 is rejected at 5% level.

	H_0	H_1	Trace	λ Max	Time trend in data	Test		Lag
						Const.	Trend	
GDP-TFR	r=0	r>0	**26.6412***	**18.7234***	No	Yes	No	2
	r<=1	r>1	7.9177	7.9177				
GDP-IMR	r=0	r>0	14.7880	12.3170	Yes	Yes	No	2
	r<=1	r>1	2.4709	2.4710				
GDP-WAG	r=0	r>0	**36.6013***	**28.9368***	Yes	Yes	Yes	1
	r<=1	r>1	7.6646	7.6646				
TFR-IMR	r=0	r>0	**29.1376***	**21.8570***	Yes	Yes	Yes	2
	r<=1	r>1	7.2806	7.28056				
TFR-WAG	r=0	r>0	**21.8603***	13.2044	No	Yes	No	2
	r<=1	r>1	8.6558	8.6558				
IMR-WAG	r=0	r>0	13.7927	10.8073	Yes	Yes	No	2
	r<=1	r>1	2.9854	2.9854				
Critical Values 95%	r=0	r>0	19.96	15.67	No	Yes	No	
	r<=1	r>1	9.24	9.24				
	r=0	r>0	15.41	14.07	Yes	Yes	No	
	r<=1	r>1	3.76	3.76				
	r=0	r>0	25.32	18.96	Yes	Yes	Yes	
	r<=1	r>1	12.25	12.25				

Table 5.- Multivariate Cointegration Test

The multivariate cointegration analysis is made using the trace statistic test that tests the null hypothesis (H_0) that there are r cointegration vector, against the alternative hypothesis (H_1) that exist, at least, r+1 cointegration vectors, where r goes from 0 to 3; and also the maximum eigenvalue test that tests the null hypothesis (H_0) that there is, as maximum, r cointegration vectors, against the alternative hypothesis (H_1) that exist, as maximum, r+1 cointegration vectors, where r goes from 0 to 3. The model incorporates intercept but not time trend and has been chosen following the Schwarz criterion. The optimum number of lags has been 2. (*) H_0 is rejected at 5% level.

TFR-IMR-GDP-WAG			
H_0	**H_1**	**Trace**	**λ Max**
r=0	**r>0**	**80.2565***	**41.266***
r<=1	**r>1**	**38.9904***	20.0655
r<=2	**r>2**	18.9254	10.8099
r<=3	**r>3**	8.11547	8.1155
Critical Values 95%			
r=0	**r>0**	53.12	28.14
r<=1	**r>1**	34.91	22
r<=2	**r>2**	19.96	15.67
r<=3	**r>3**	9.24	9.24

Table 6.- Restrictions Test

H_0: β_i=0	χ^2	p-value
TFR	**6.8768***	0.0321
IMR	**5.0731****	0.0791
GDP	**9.8115***	0.0074
WAG	**12.9018***	0.0015

(*), (**) Rejection Ho at 5% and 10% level, respectively.

Table 7.- Vector Error Correction Model

t-student statistic in parenthesis. (*) Significance at 5% level

	ΔTFR_t	ΔIMR_t	ΔGDP_t	ΔWAG_t
ECT_1	**0.0999***	0.0827	0.0555	**0.1044***
	(3.3087)	(1.2909)	(1.8852)	(3.4734)
ECT_2	**-0.0936***	**-0.1181***	-0.0061	-0.0045
	(-4.3838)	(-2.6066)	(-0.2933)	(-0.2111)
ΔTFR_{t-1}	-0.0195	0.3189	-0.2788	-0.1954
	(-0.1093)	(0.8404)	(-1.5967)	(-1.097)
ΔIMR_{t-1}	0.0751	-0.1618	-0.0777	-0.0755
	(1.0911)	(-1.1080)	(-1.1565)	(-1.1013)
ΔGDP_{t-1}	**0.2963***	0.0511	**0.5562***	-0.0404
	(2.1535)	(0.1749)	(4.1408)	(-0.2946)
ΔWAG_{t-1}	0.2379	-0.1016	**-0.2890***	-0.0326
	(1.6111)	(-0.3241)	(-2.0048)	(-0.2217)

Table 8.- Weak Exogeneity Test

(*), (**) Rejection Ho with significance at 5%, 10% level, respectively.

		Endogenous Variables			
		ΔTFR_t	ΔIMR_t	ΔGDP_t	ΔWAG_t
Weak Exogeneity					
H_0: $\alpha_i=0$	χ^2	**11.0949***	**5.9599****	**6.3394***	**18.5607***
	p-value	0.0039	0.0508	0.0420	0.00009

Table 9.- Short run Causality Test

(*), (**) and (***) Rejection Ho with significance at 5%, 10% and 15% level, respectively.

		Endogenous Variables			
H_0: δ_i=0		**ΔTFR_t**	**ΔIMR_t**	**ΔGDP_t**	**ΔWAG_t**
δ_i					
ΔTFR_{t-1}	χ^2		0.7063	**2.5495*** **	1.2038
	p-value		0.4007	0.1103	0.2726
ΔIMR_{t-1}	χ^2	1.1905		1.3376	1.2129
	p-value	0.2752		0.2475	0.2708
ΔGDP_{t-1}	χ^2	**4.6375***	0.0306		0.0868
	p-value	0.0313	0.8611		0.7683
ΔWAG_{t-1}	χ^2	**2.5956*** **	0.1051	**4.0192***	
	p-value	0.1072	0.7458	0.0450	
All	χ^2	**7.4603** **	0.7559	**7.8338***	1.8014
	p-value	0.0586	0.8600	0.0496	0.6146

Figure 1.- Time series in logarithmic rates

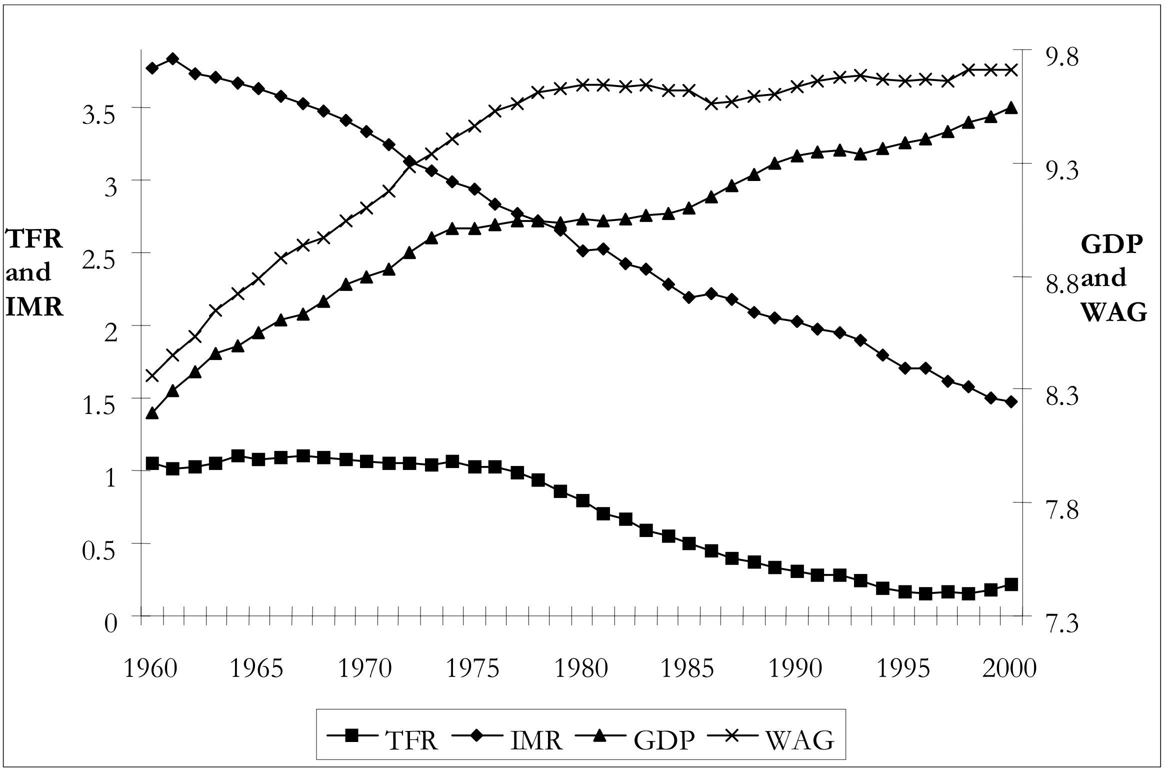

Figure 2.- Impulse-Response Function to a shock in TFR

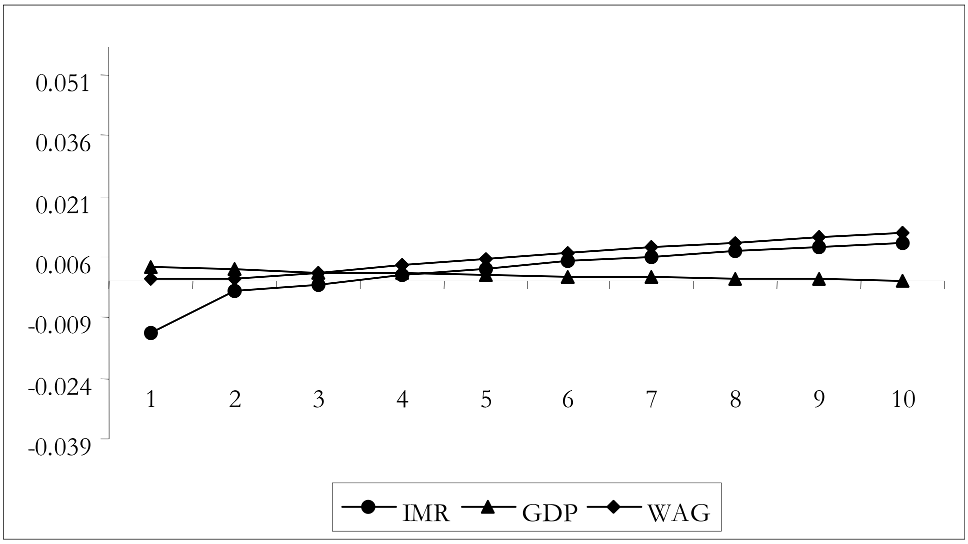

Figure 3.- Impulse-Response Function to a shock in IMR

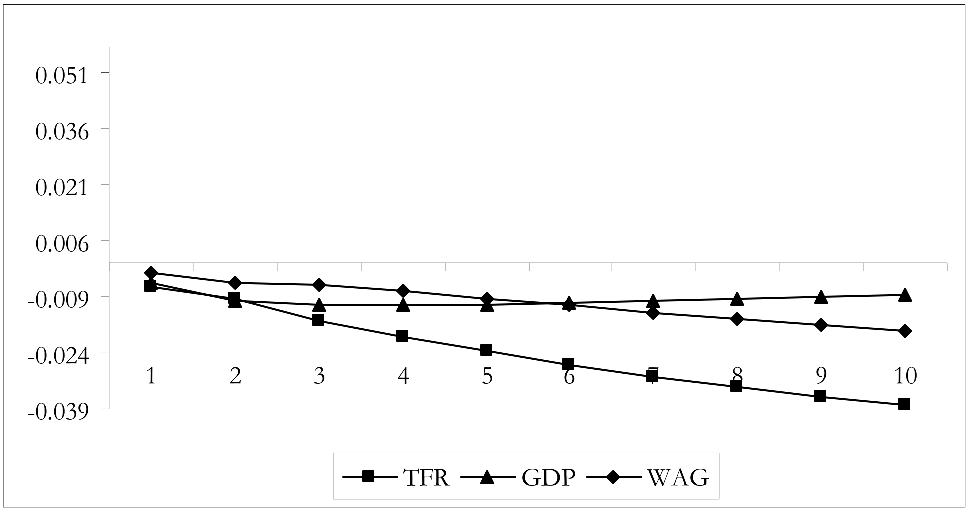

Figure 4.- Impulse-Response Function to a shock in GDP

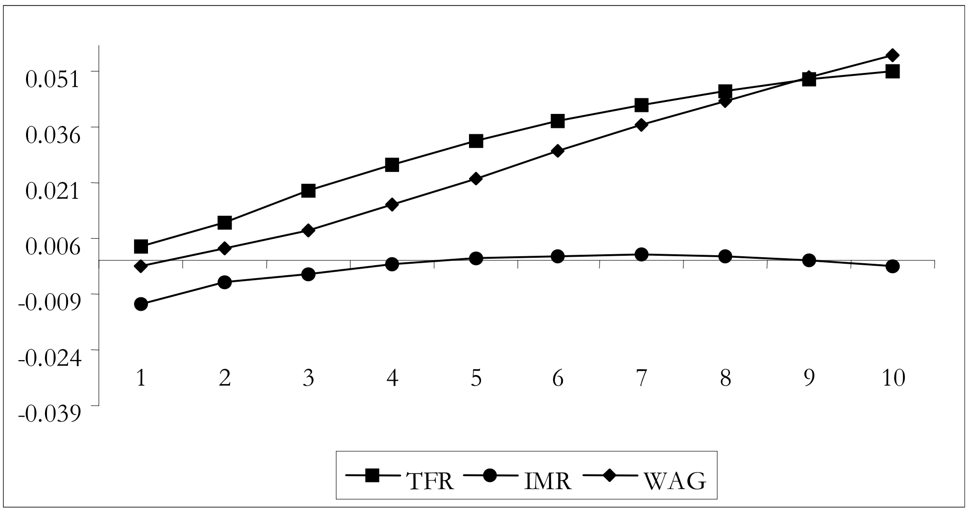

Figure 5.- Impulse-Response Function to a shock in WAG

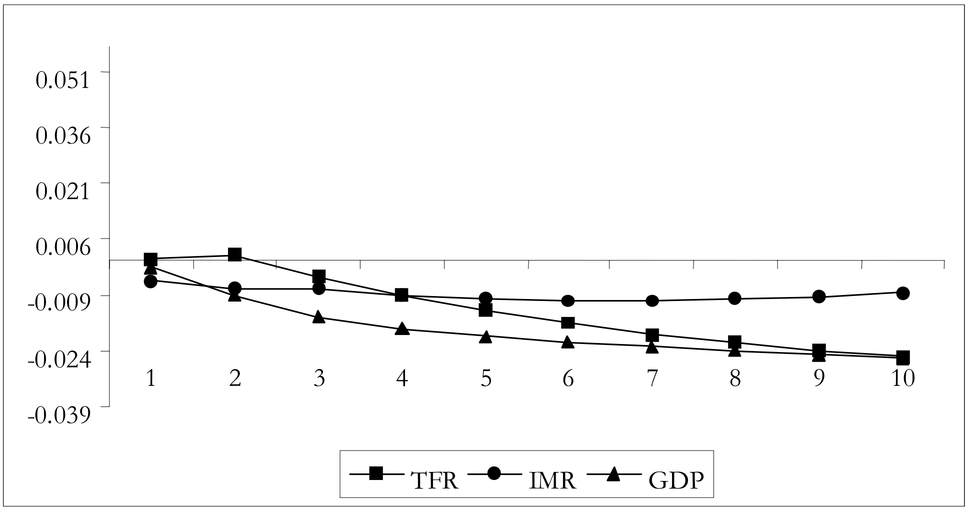

Figure Legends

Figure 6.- Time series in logarithmic rates
Figure 7.- Impulse-Response Function to a shock in TFR
Figure 8.- Impulse-Response Function to a shock in IMR
Figure 9.- Impulse-Response Function to a shock in GDP
Figure 10.- Impulse-Response Function to a shock in WAG

Footnotes

[1] Additional variables like female labour market participation, female enrolment rate and social security benefits, among others, are not included in this study because a lack of data for the whole period.

[2] For Becker, children are an argument of the parents' utility function like any other good. Therefore, the decision of having children interacts with the consumption-saving decision, and so with the level of capital of the Economy. This point of view means that the fertility and the economic growth are endogenous variables. References of this author's models are Becker and Barro (1988) and Becker *et al.* (1990). From this basic idea, authors like Wigger (1999), Morand (1999), Zhang and Zhang (2001) or Kalemli-Ozcam (2003) among other, have analyzed the economic effects of variables like social security, intergenerational transfers, investment in education, etc. An excellent survey of papers about the incorporation of the population to economic growth models is Ehlrich and Lui (1997).

[3] Sah (1991) describes that if parents have a target fertility level, dominates the positive effect ("hoarding effect") in the relationship between the two variables since the decrease in the infant mortality implies bigger survival and smaller incentive for having more children to achieve the objective of fertility. Otherwise, the "cost effect" can be dominant, resulting in a negative effect. This is because a fixed cost exists in each birth, regardless of whether or not they survive. Then, the greater net profit derived from an increase in children survival, with smaller infant mortality rates, would generate some fertility rate increase.

[4] A high number of variables would take to estimation problems since the number of coefficients to estimate (including lags) can approach to the number of observations (we remember that we have 41 annual observations) disappearing the grades of freedom. For further details see Johnston and Dinardo (1997).

[5] Monte Carlo studies carried out by Gonzalo (1994) show that the procedure of Johansen (1988) works better than one-equation methods (ordinary minimum squares and non-lineal minimum squares), and even other multivariate methods (main components and canonical correlation) for the estimate of cointegration relationships. This seems to be true even when the normality assumption is not correct, the dynamics is ignored, and over-parameter derived from the introduction of additional lags exists.

[6] The concept of equilibrium in the cointegration literature means that two series have maintained a relationship along the analyzed period, but it does not mean that in some subperiod they can have evolved in a different way.

[7] This error would be made when analyzing the causality in an unrestricted VAR model (short run causality), since the part corresponding to the detected cointegration relationship would be ignored (long run causality) and would be incorporated in the vector error correction model through the error correction term.

[8] According to the decomposition of Cholesky, the variable entering first in the system operates as the most exogenous and its innovations affect to the remaining variables of the process without lags. In turn, the variable entering in second place is the second more exogenous and its shocks affect on the other series without lags, except the first one, which is affected in a lagged way, so the ranking of the variables is crucial and it can alter the dynamics of the VAR system. The generalized impulse-response function of Pesaran and Shin (1998) solve this problem building an orthogonal innovation matrix that depends on the ranking in the vector error correction model.

[9] According to Chou *et al.* (1994) an equilibrium relationship is multivariate by nature, so that a deviation from the long run relationship among more than two variables can only be built with a suitable combination of all the elements that can affect it directly or indirectly. Then, the results of the bivariate cointegration analysis can be wrong and, therefore, the absence of a cointegration relationship between two variables does not rule out the existence of long run equilibrium relationship if additional variables are considered.

[10] The bivariate and multivariate cointegration tests incorporate an intercept, given the time trend of the series. The number of lags has been determined starting from the estimation of a VAR of the series in levels (see Enders, 1995, for details).

[11] The identification condition is numerically tested by the appropriate range of the jacobian matrix. See Boswijk (1995) for further details.