TEMPORAL CAUSALITY BETWEEN POPULATION AND INCOME IN TURKEY: AN ARDL BOUNDS TESTING APPROACH

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ABSTRACT

This paper aims to investigate the causal relationship between population and per capita economic growth in Turkey. Using the ARDL approach to cointegration, we find evidence of long-run bi-directional causality between per capita economic growth and population.

Key Words: *Causality; Population; Economic Growth; Cointegration; Turkey*
JEL Classification Codes: *C22, J10, J11, O12*

ÖZET

Bu çalışma Türkiye'de, nüfus ve kişi başına ekonomik büyüme arasındaki nedensellik ilişkisini araştırmayı amaçlamaktadır. ARDL eşbütünleşme yaklaşımı kullanılarak, uzun dönemde kişi başına ekonomik büyüme ve nüfus arasında çift yönlü nedensellik ilişkisi kanıtlanmıştır.

Anahtar Kelimeler: *Nedensellik; Nüfus; Ekonomik Büyüme; Eşbütünleşme; Türkiye*
JEL Sınıflaması: *C22, J10, J11, O12*

1. INTRODUCTION

The debate on the relationship between population and economic growth could be traced back to Malthus (1992). According to Malthus, population tends to grow geometrically, whereas food supplies grow only arithmetically. Thus, the unfettered population growth in a country could plunge it into acute poverty. According to the Malthusian model, the causation goes in both directions. Higher economic growth increases population by stimulating earlier marriages and higher birth rates, and by cutting down mortality from malnutrition and other factors. On the other hand, higher population also depresses economic growth through diminishing returns. This dynamic interaction between population and economic growth is the centre of the Malthusian model, which implies a stationary population in the long-run equilibrium (Becker, Glaeser, and Murphy, 1999:145).

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Malthus's concern created quite a stir in the early nineteenth century England, leading to widespread calls for restraints on population growth. Still, the English population expanded quite rapidly throughout the nineteenth century, but by most evidence real income rose and the spectre of mass starvation declined (Meier, 1995).

One of the stylized facts about population in all contemporary developed nations is that over the past couple of centuries it has passed through three stages (i.e., *demographic transition*). The first stage is characterized by high birth rates and high death rates, resulting in a slow population growth. In the second stage there was a decrease in death rates, however the birth rates remained high as a consequence of increases in population. Finally, in the third stage, fertility rates fell and combined with low mortality rates resulted in very low or no population growth. The usual explanations for the time evolution of population relies generally on the idea that the improvement of economic conditions – which includes massive improvements in public health – led first to a reduction in the mortality rates, and finally to a decrease in the birth rates. As income per capita is a good proxy for economic conditions because it reflects, among other things, the impact of technology, education and health, the usual explanations therefore suggest that there is a strong link between per capita income and population. Indeed, the main theories put forward by economists to explain the evolution of population relates it to per capita income not aggregate output. This implies that there is a direct relation between per capita income and population size, an increase in income per capita leads to an increase in the size of population (Samuelson, 1988).

Extending Malthus's work researchers such as Blaug (1962), Mill (1965), Schumpeter (1954) and Smith (1976) developed the so-called “classical” model. They adopt the view that economic growth is determined exogenously and population growth must adjust to it in the long-run period. However, they argue that in the short-run there is a positive relationship between deviations of per capita income and the rate of economic growth from their long-run values. Extension of the “classical” model is the development of the “neoclassical growth model” by Solow (1956). According to this model economic growth is an endogenous variable that depends on population growth. In the Solow and Ramsey models of economic growth, the equilibrium per-capita stock of capital decreases with the population growth rate, as a consequence, output per capita also falls with population growth, which is assumed to be constant and exogenous. In the neoclassical growth model, population growth reduces economic growth due to capital dilution.

A more contemporary approach to the relationship between income and population is found in the microeconomics theory of fertility (see Becker, 1992). This theory adapts the conventional theory of consumer by introducing the number of children in the utility function. The theory of fertility derives the demand for children as an increasing function of family income, decreasing function of the cost of children and increasing function of the tastes for children relative to other goods. Based on these theoretical arguments, the benefits of fertility control have been discussed extensively in the literature, keeping in mind the negative effect of fertility on population growth (see Bloom and Williamson, 1998; and Bloom *et al.*, 2001). Barro and Becker (1989) in their pioneer study support the notion that fertility growth is an endogenous variable to an economic system and develops the theoretical framework to explain that the relationship between the two variables depends on a number of socioeconomic factors such as the incentive for having children, the "quality of children", the efficiency of private capital markets and the intergenerational transfers within the family. Recently, many economists such as Becker and Barro (1988), Becker, Murphy, and Tamura (1990), Ehrlich (1990), Ehrlich and Lui (1991) and Wang, Yip, and Scotese (1994), based on micro-foundations of economic theory, treat both population and income growth as endogenous variables in an effort to develop a coherent model of economic growth and explain the process of dynamic economic growth.

In both theories, namely the Malthusian and the theory of fertility, population is a function of per capita income, that is, population is the dependent variable and income is the explanatory variable. However, the relationship between population and income need not to be this way. Actually, Malthus reversed the arguments of mercantilists who posited that the level of population determined the nation's resources (Currais, 2000). According to this view, per-capita income is a function of population, i.e., population is considered an exogenous variable. In fact, this view is a common feature of the modern models of economic growth (Johnson, 1999).

The aforementioned demographic transition is currently explained (see Galor and Weil, 1999, 2000; Lagerlof, 2003) by a combination of all elements of the theories reviewed above. The first stage, or regime, is called the Malthusian regime. The relationship between per capita income and population growth is positive, where small increases in income lead to increase in population growth. In the second stage, called post-Malthusian regime, the relationship between income and population growth remains positive. In the final stage, called modern growth regime, there is a rapid growth in per capita income whereas population growth declines. As a result, there is a negative relationship between the two.

Therefore, according to the literature and stylized facts a strong relationship between income per-capita and population is expected to exist, no matter how simple or complex this relationship can be. However, empirical evidence on the relation between population growth and per capita income seems, paradoxically, not to suggest this. Easterlin (1967), Kuznets (1967) and Thirlwall (1972) find a weak or insignificant relation between population growth and per capita income. Kelley and Schimidt (1994) find a negative and significant relation, at least for less developed countries. Thornton (2001) finds no long-run relation for a group of seven Latin American countries, while Dawson and Triffin (1998) find, for the case of India, no long-run relation between the variables. The empirical evidence seems puzzling *vis-à-vis* the expected existence of a strong relationship between population and per capita income.

This paper evaluates the relationship between population and per capita income in Turkey. The main objective is to verify if there is and what is the relationship between population and per-capita income. Although we are not directly testing the available theories of the relation between population and growth, this paper provides us with a set of stylized facts that can be used as the basic evidence on which theory models can build. This research paper makes three contributions to the existing literature on the relationship between the population-real income nexus. The first contribution is that it is the first study to examine the population-growth nexus using causality testing within a multivariate cointegration and error-correction framework for Turkey. Second, we use relatively new, and yet little used, estimation technique, which is bounds testing approach to cointegration, with an Autoregressive Distributive Lag (ARDL) framework, developed by Pesaran and others (Pesaran and Pesaran, 1997; Pesaran and Shin, 1999; Pesaran *et al*., 2001). Third, we also examine whether the parameter estimates are stable over time. To test for parameter stability we use a test developed by Pesaran and Pesaran (1997). Following this introduction, the econometric methodology and results are set out and discussed in the next section, and finally section 3 concludes.

2. EMPIRICAL RESULTS

The data is annual and spans the time period 1924 to 2006. The real per capita GDP (Y_t) and the rate of growth of population (POP_t) data is the series produced by Maddison (1982) and also available on his website. Both of the variables are in logarithms.

2.1 Integration

A three-stage procedure was followed to test the direction of causality. In the first stage, the order of integration was tested using the Augmented Dickey-Fuller (ADF) unit root test. Table 1 reports the results of the unit root tests. The ADF statistics for the levels of real per capita income and market capitalization [POP_t, Y_t] do not exceed the critical values (in absolute terms). However, when we take the first difference of each of the variables, the ADF statistics are higher than their respective critical values (in absolute terms). Therefore, we conclude that [POP_t, Y_t] are each integrated of order one or I (1).

Table 1: Results of ADF Unit Root Tests

Variables	ADF-statistic	Critical Value	Lag Length
$\ln POP_t$	-3.1458	-3.4666	3
$\Delta\ln POP_t$	-5.4384*	-3.4666	2
$\ln Y_t$	-3.3361	-3.4673	4
$\Delta\ln Y_t$	-5.7765*	-3.4666	4

Notes: * denotes rejection at the 1% critical values. The critical values for ADF (4) tests are from MacKinnon (1991). The maximum available sample is used and varies across null order. Performing the ADF tests, the optimum lag length was chosen based on the evidence provided by Schwarz Bayesian Criterion (SBC) - up to four lags.

2.2 Cointegration

The second stage involves for the existence of a long-run equilibrium relationship between population and real per capita income within a multivariate framework. To examine the long run relationship between population and real per capita income, we employ bound testing approach to cointegration within the framework of ARDL developed by Pesaran *et al*. (2001). There are several reasons for the use of bounds test. Firstly, the bi-variate cointegration test introduced by Engle and Granger (1987) and the multivariate cointegration technique proposed by Stock and Watson (1988), Johansen (1988, 1991) and Johansen and Juselius (1990) may be appropriate for large sample size. However, Carruth *et al*. (2000:289) argue that "single equation methods have been criticized because they ignore the possibility of multiple vectors but, in practice, they can give eminently sensible results (albeit of a reduced form nature) and generate adequate dynamic models". Carruth *et al*. (2000) suggest that the likelihood of multiple cointegrating vectors does not facilitate the identification of the possible static long-run cointegration between the variables. They further argue that the possibility of multiple cointegration vectors can lead to severe identification problems, requiring researcher to provide an economic interpretation of the relationships that are identified. Moreover, the number of significant cointegrating vectors found is often dependent on the length of the lags chosen for the VAR, so careful reduction tests are called for (Carruth *et al*., 2000:289). The ARDL approach is more robust and performs better for small sample sizes than other cointegration techniques [Pesaran *et al*. (2001); Tang (2001, 2002)]. Secondly, the bounds testing approach avoids the pre-testing of unit roots. Thirdly, the long run and short run parameters of the model are estimated simultaneously to tackle with the problem of endogeneity and simultaneity. Fourth, all the variables are assumed to be endogenous. Finally, this method does not require that the variables in a time series regression equation are integrated of order one. Bounds test could be implemented regardless of whether the underlying variables are $I(0)$, $I(1)$, or fractionally integrated. The ARDL bounds testing approach to cointegration involves investigating the existence of a long-run relationship using the following unrestricted error-correction models (UECM):

$$\Delta \ln POP_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i \Delta \ln POP_{t-i} + \sum_{i=1}^{p} \alpha_i \Delta \ln Y_{t-i} + \sigma_1 \ln POP_{t-1} + \sigma_2 \ln Y_{t-1} + \varepsilon_{1t} \quad (1)$$

$$\Delta \ln Y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i \Delta \ln Y_{t-i} + \sum_{i=1}^{p} \alpha_i \ln POP_{t-i} + \sigma_1 \ln Y_{t-1} + \sigma_2 \ln POP_{t-1} + \varepsilon_{1t} \quad (2)$$

where Δ is the first difference operator, *lnPOP* is the log of rate of growth of population, and *lnY* is the log of real per capita GDP. The *F* test is used to determine whether a long-run relationship exists between the variables through testing the significance of the lagged levels of variables. When a long-run relationship exists between the variables, the *F* test indicates which variables should be normalized. In Eq. (1), where *lnPOP* is the dependent variable, the null hypothesis of no cointegration between the variables is ($H_0 : \sigma_{1POP} = \sigma_{2POP} = 0$) against the alternative hypothesis ($H_1 : \sigma_{1POP} \neq \sigma_{2POP} \neq 0$). This is denoted as F_{POP} ($POP_t \mid Y_t$). In Eq. (2), where real per capita GDP is the dependent variable, the null hypothesis for cointegration is ($H_0 : \sigma_{1Y} = \sigma_{2Y} = 0$) against the alternative ($H_1 : \sigma_{1Y} \neq \sigma_{2Y} \neq 0$). This is denoted as F_Y ($Y_t \mid POP_t$). The hypothesis can be examined using the standard *F*-statistics. The *F* test has a non-standard distribution which depends upon: (i) whether variables included in the ARDL model are *I* (1) or *I* (0), (ii) the number of regressors and (iii) whether the ARDL model contains an intercept and/or a trend. Pesaran *et al*. (2001) report two sets of critical values, which provide critical value bounds for all classifications of the regressors into purely *I* (1), purely *I* (0) or mutually cointegrated. If the computed *F*-statistics falls outside the critical bounds, a conclusive decision can be made regarding cointegration without knowing the order of cointegration of the regressors. If the estimated *F*-statistic is higher than the upper bound of the critical values then the null hypothesis of no cointegration is rejected regardless of the order of integration of the variables. Alternatively, if the estimated *F* statistic is lower than the lower bound of critical values, the null hypothesis of no cointegration cannot be rejected. Narayan and Smyth (2006) present a detailed procedure to explain if one needs to implement the bounds *F*-test with or without a time trend. It is possible that at the end of this testing procedure one may end up more than one possible cointegration relationship one with a time trend and one without a time trend. As Narayan and Smyth (2006:116) argue that "in the spirit of the bounds test, model two with a time trend is invalid because for the model to be valid there should be only one long-run relationship." In order to avoid a possible selection problem at this stage, one may follow the procedure of Bahmani-Oskooee and Goswami (2003) which sequentially tests the long-run cointegration relationship in Eqs. (1) and (2) on the basis of different lag lengths. This study adopts the second approach which implicitly assumes that Eqs. (1) and (2) are free from a trend due to the differenced variables. We tested for the presence of long-run relationships in Eqs. (1) to (2). As we use annual data, all tests include a maximum of 4 lags to ensure lagged explanatory variables are present in the ECM; according to Gonzalo (1994), the cost of over-parameterization in terms of efficiency loss is marginal. The order of lags on the first-differenced variables for Eqs. (1) to (2) was obtained from unrestricted VAR by means of SBC, whilst ensuring there was no evidence of serial correlation, as emphasized by Pesaran *et al*. (2001). The calculated *F*-statistics are reported in Table 2. For Eq. (1), F_{POP} $(POP_t \mid Y_t) = 6.6469$; and for Eq. (2), F_Y $(Y_t \mid POP_t) = 6.7826$. From these results, it is clear that there are long-run relationships between the variables because its calculated *F*-statistics are higher than the upper bound critical value of 5.58 at the 1 % level. This implies that the null hypothesis of no cointegration between the variables in Eqs. (1) and (2) cannot be accepted. Evidence of cointegration relationships between the variables in Eqs. (1) and (2) also rules out the possibility of estimated relationship being 'spurious'.

Table 2: *F*-statistics for cointegration relationship

Critical value bounds of the *F*-statistic						
k	**90% level**		**95% level**		**99% level**	
	I **(0)**	***I*** **(1)**	***I*** **(0)**	***I*** **(1)**	***I*** **(0)**	***I*** **(1)**
1	3.02	3.51	3.62	4.16	4.94	5.58
Calculated *F*-statistics						
F_{POP} $(POP_t \mid Y_t)$ = 6.6469*						
F_Y $(Y_t \mid POP_t)$ = 6.7826*						

Notes: * refers statistical significance at 1% level. Critical values are obtained from Pesaran *et al*. (2001). *k* denotes the number of regressors.

2.3 Granger Causality

The third stage involves constructing standard Granger-type causality tests augmented with a lagged error-correction term where the series are cointegrated. Eqs. (1) and (2) are estimated with an error-correction term because we find evidence of cointegration for these variables in each of the equations. Therefore, given that the bounds test suggest that $[POP_t, Y_t]$ are cointegrated, we augment the Granger-type causality test when POP_t and Y_t are the dependent variables with a lagged error-correction term. Thus, the Granger causality test involves specifying a multivariate *p*th order VECM as follows:

$$\begin{bmatrix} \Delta \ln POP_t \\ \Delta \ln Y_t \end{bmatrix} = \begin{bmatrix} \sigma_1 \\ \sigma_2 \end{bmatrix} + \sum_{i=1}^{p} \begin{bmatrix} \gamma_{11}\gamma_{12} \\ \gamma_{21}\gamma_{22} \end{bmatrix} \begin{bmatrix} \Delta \ln POP_{t-i} \\ \Delta \ln Y_{t-i} \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix} \left[ECT_{t-1} \right] + \begin{bmatrix} v_{1t} \\ v_{2t} \end{bmatrix} \quad (3)$$

In addition to the variables defined above, Δ is the lag operator, ECT_{t-1} is the lagged error-correction term derived from the long-run cointegrating relationship, and v_{1t} and v_{2t} are serially independent random errors with mean zero and finite covariance matrix. In each case the dependent variable is regressed against the past values of itself and other variables. The optimal lag length p is based on the SBC. The existence of cointegrating relationships between [POP_t, Y_t] suggests that there must be Granger causality in at least one direction, but it does not indicate the direction of temporal causality between the variables. We examine both short-run and long-run Granger causality. Table 3 summarizes the results of the long-run and short-run Granger causality. The short-run causal effects can be obtained by the F-statistics of the lagged explanatory variables in each of the two equations, while the t-statistics on the coefficients of the lagged error-correction terms in Eqs. (1) and (2) indicate the significance of the long-run causal effect.

Table 3: Results of Granger Causality

Dependent Variable	$\Delta lnPOP_t$	ΔlnY_t	ECT_{t-1} *[t-stat.]*
$\Delta lnPOP_t$	—	5.7180* (0.037)	-0.0169** [-2.6191]
ΔlnY_t	2.1889 (0.079)	—	-0.8651* [-3.6103]

Notes: * refers statistical significance at 1% level and, ** refers statistical significance at 5% level. The probability values are in brackets. t-ratio of ECT_{t-1} is in square bracket.

Beginning with the results for the long-run, the coefficients on the lagged error-correction terms are significant with the expected signs and plausible magnitudes in population equation at 5 per cent, and in the real per capita income equation at 1 per cent. This confirms the result of the bounds test for cointegration. The coefficient on the lagged error correction term measures the speed of adjustment to obtain equilibrium in the event of shock(s) to the system. The result suggests that changes in real per capita GDP are a function of disequilibrium in the cointegrating relationship. That the lagged error correction term is negative and significant which implies that the series is non-explosive and that long-run equilibrium is attainable. Because the ECM_{t-1} measures the speed at which the endogenous variable adjusts to changes in the explanatory variables before converging to its equilibrium level, the coefficient of -0.01 suggests that convergence to equilibrium after a shock to population in Turkey takes slightly over some ten years. Thus, in the long run real per capita income Granger-causes population, meaning that causality runs interactively through the error correction term from real per capita income to population. The feedback coefficient of -0.86 suggests that when real per capita income is above or below its equilibrium level, population adjusts by almost entirely within the first year. In other words, 86 percent of the disequilibria of the previous period's shock adjust back to the long run equilibrium in the current year. The full convergence process to its equilibrium level takes slightly over one year. Thus, the speed of adjustment is considerably fast in the case of any stochastic shock to the real per capita GDP. Overall, in the long-run there is a bi-directional Granger causality between population and real per capita income in Turkey over the period of the analysis. In the short-run, the *F*-statistics on the explanatory variables suggest that at the 1 % level or better there is a uni-directional Granger causality running from real per capita income to population (when population is dependent variable), and neutrality between population and real per capita income (when real per capita income is dependent variable).

2.4 Parameter Stability

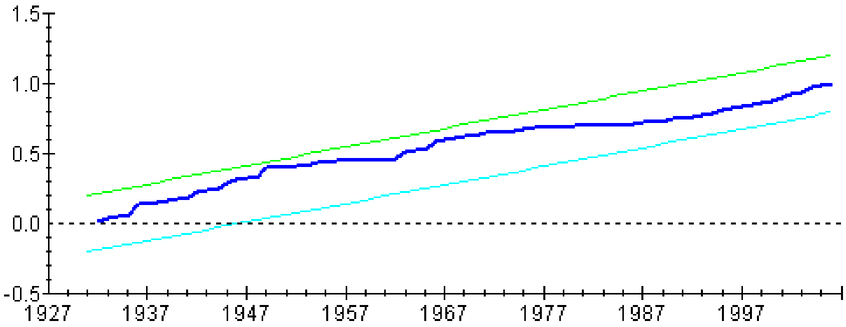
One problem with time series regression models is that the estimated parameters may change over time. Unstable parameters can result in model misspecification and, if left undetected, have the potential to bias the results. To account for this, here, we examine whether the estimated coefficients are stable over time. To do this we use the Pesaran *et al.* (1997) test for parameter instability. The Pesaran *et al.* (1997) test amounts to estimating following the error correction models through taking each differenced variable as a dependent variable together with the lagged error correction terms:

$$\Delta \ln POP_t = \alpha_0 + \sum_{i=1}^{p} \alpha_1 \Delta \ln POP_{t-i} + \sum_{i=0}^{p} \alpha_2 \Delta \ln Y_{t-i} + \vartheta ECT_{t-1} + \varepsilon_t \quad (4)$$

$$\Delta \ln Y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_1 \Delta \ln Y_{t-i} + \sum_{i=0}^{p} \alpha_2 \Delta \ln POP_{t-i} + \vartheta ECT_{t-1} + \varepsilon_t \quad (5)$$

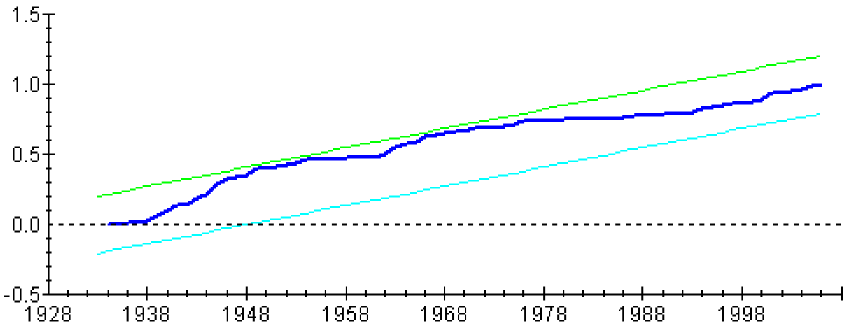
This exercise is performed for both of the equations (4) and (5), which has population and real per capita income as the dependent variables respectively. The error correction terms are calculated from the long run cointegrating vectors. Once the model has been estimated, Pesaran *et al.* (1997) suggest applying the cumulative sum of recursive residuals (CUSUM) and the CUSUM of square (CUSUMSQ) tests proposed by Brown *et al.* (1975) to assess the parameter constancy. The models were estimated by OLS and the residuals subjected to the CUSUMSQ test. For brevity of presentation, CUSUM tests are not reported here. Figure 1 plots the CUSUMSQ statistics where population is the dependent variable (Eq. 4). Figure 2 plots the CUSUMSQ statistics for Eqs. (5), where the real per capita income is dependent variable. The results indicate no instability in the coefficients as the plots of the CUSUMSQ statistics are confined within the 5% critical bounds of parameter stability. This indicates that the structure of the parameters have not diverged abnormally over the period of the analysis.

Figure 1. Plot of Cumulative Sum of Squares of Recursive Residuals of Eq. (5)



The straight lines represent critical bounds at 5% significance level

Figure 2. Plot of Cumulative Sum of Squares of Recursive Residuals of Eq. (6)



The straight lines represent critical bounds at 5% significance level

3. CONCLUSIONS

There are a number of well-known and well-developed theories that relate population growth and income levels from the original Malthusian hypotheses to the more recent micro-founded theories of fertility with Malthusian elements. These theories give a clear-cut way of thinking about the relationship between these two variables of key economic relevance. However, empirical work has lagged behind, and there is very little systematic evidence on the relationship. Our findings support the existence of a long-run relationship between population and real per capita income and provide strong support for the hypothesis that population is driving growth. The results of causality tests suggest that there appears bi-directional causality between population and real per capita income in the long run, while there are feedback effects from real income to population in the short run. Overall, the relationship between population and economic growth is strong and positive in Turkey over the period of the analysis. This suggests that Turkey seems to be in the second stage of the demographic transition, called *post-Malthusian regime*, in which the relationship between income and population growth remains highly strong and positive. The policy implications of our findings are clear. This result may suggest the various pieces of legislation introduced to control the relatively high growth rate of population in Turkey have not been entirely successful, as population still tends to respond to factors outside the direct control of the authorities. However, further research is required into this relationship, possibly, by incorporating additional variables, such as fertility rates, age dependency ratios and labour force that will help to illuminate the channels through which population causes growth (and *vice-versa*) and contribute to broader efforts in the literature to tease out the complex relationship between population and economic growth.

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