Economic Analysis and Policy 46 (2015) 43–58

Contents lists available at ScienceDirect

Economic Analysis and Policy

journal homepage: www.elsevier.com/locate/eap

Full length article

The non-linear effect of population growth and linear effect of age structure on per capita income: A threshold dynamic panel structural model

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ARTICLE INFO

Article history:
Received 4 May 2014
Received in revised form 25 April 2015
Accepted 26 April 2015
Available online 7 May 2015

Keywords:
Per capita income
Population growth rate
Population age structure
Threshold dynamic panel model
Bootstrap method

ABSTRACT

This paper investigates the non-linear effect of population growth and linear effects of age structure on per capita income, using the threshold dynamic structural panel (TDSP) and non-linear generalized method of moments (NGMM) Models. A data set from 81 countries (both developing and developed) covering a 50-year period is used. The results indicate that there is a non-linear relationship between population growth and per capita income. Population growth rate before the zero percent threshold has a significant and positive impact on per capita income, while no significant impact is found after the threshold. Therefore, the *optimistic* view can be adopted for developed countries where population growth rate is low. In contrast, the *neutralist* view is applicable in countries where population growth is relatively high. The model's results also indicate that changes in population age structure affect per capita income—changes which describe a linear relationship. The 'young dependency' ratio has a consistently significant and negative effect on per capita income while the participation rate has a significant and positive effect on per capita income. However the 'old dependency' ratio has a fragile and contradictory effect on per capita income. Therefore, the view of *proponents of age structure* is generally acceptable.

1. Introduction

The changes in world population and its impact on per capita income have been a matter of controversial debate. In recent decades, the substantial theoretical and empirical literature on this issue has produced no consensus, with a range of *pessimistic*, *optimistic*, *neutralist* views and *age structure* being empirically supported. However most of these studies have focused on a single equation linear model with exogenous demographic variables. The lack of a consensus is therefore not surprising given a lack of recognition of the endogeneity of demographic variables and the non-linearity of relationships.

The purpose of this paper is therefore to investigate the effects of changes of *population growth* and *population age structure* on per capita income. Two main methodological contributions are made in this investigation. Firstly, the non-linear effect of *population growth* and *age structure* on per capita income is examined drawing on the threshold dynamic panel structural (TDSP) model. This model provides for a range of different views: specifically *pessimistic*, *optimistic*, and *neutralist* and *proponents of age structure* using *Tong's threshold autoregressive (TAR) model*. Secondly, all the determinants of long-term economic growth are considered to be endogenous. Consequently to eliminate *Nickell's bias* and *simultaneous bias*, the TDSP model is estimated by the non-linear generalized method of moments (NGMM).

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http://dx.doi.org/10.1016/j.eap.2015.04.002

The remainder of the paper is organized as follows. Section 2 presents a review of discussions on the relationship between population and per capita income. Section 3 provides a description of the model, the empirical methodology and data. Section 4 analyzes the results, and Section 5 concludes the paper.

2. Population and economic growth

Literature on population and economic growth is as old as the discipline of economics itself. Growth has been considered as a key determinant in classical (such as Malthus, 1798), neo-Keynesian (such as Lewis, 1954), neo-classical (such as Solow, 1956), and endogenous (such as Romer, 1986) growth models. Based on these models, three views emerge—*pessimistic*, *optimistic*, and *neutralist*. Population growth is a restrictive influence in the pessimistic scenario a positive influence in the second optimistic scenario and is independent of economic growth in the neutralist scenario. Revealed in recent literature is a further scenario which has gained popularity—that of analyzing the issue as one of demographic transition rather than of simply population growth.

Pessimistic theories can be traced back to the end of the 18th century, when Thomas Malthus published his now famous treatise "*An Essay on the Principle of Population*" in 1798. According to the Malthusian model, the causation between population growth and economic growth acts in both positive and negative directions. On the one hand higher economic growth increases population by stimulating earlier marriages, raising birth rates, and cutting mortality from malnutrition and other factors. On the other hand, higher population growth depresses economic growth through diminishing returns because the supply of land, physical capital, and knowledge remain unchanged or rise at a slower pace compared to the population (Ehrlich and Lui, 1997; Glaeser et al., 1999). The dynamic interaction between population and economic growth is at the center of the Malthusian model, which implies a stationary population in the long-run equilibrium. Researchers have since improved on Malthus's work to develop what is now called the classical model. They adopt the view that economic growth is determined exogenously and that in the long run therefore population growth has to adjust to it (Ehrlich and Lui, 1997; Savaş, 2008).

Population optimists, in contrast to *population pessimists*, count population growth as an essential ingredient for stimulating economic growth. According to neo-Keynesian models larger populations stimulate consumer demand while expanding the supply of low-cost labor which in turn provides the means for achieving higher output levels and lower production costs (Keynes, 1937; Lewis, 1954). In addition, the *optimists* emphasize that population growth encourages competition and greater economies of scale, which induces technological advancements and institutional innovations (Boserup, 1981; Imhoff, 1988; Bloom and Williamson, 1998; Savaş, 2008). Optimists also argue that larger populations are likely to produce larger number of 'geniuses': exceptional individuals who have a transforming effect on a country's prospects (Jones, 1997, 2002; Jones and Romer, 2010).

A contrasting view is provided by the neoclassical growth model developed by Solow (1956) and Swan (1956). According to this model, economic growth is an endogenous variable that depends on a constant and exogenous population growth. Under this scenario the equilibrium per capita stock of capital will decrease as the population growth rate increases leading to a corresponding decrease in output per capita. Population growth will therefore reduce economic growth due to capital dilution.

Subsequent studies have indicated that the simple neoclassical model does not fully describe changes in economic growth. Augmented neoclassical and endogenous growth models have been proposed and developed by Romer (1986) and Lucas (1988) in which human capital accumulation, technology, and ideas are directly related to population growth. Thus population growth can influence economic growth through two channels – the quantity and the quality of the labor supply – which can in turn be affected by economic growth.

Therefore, population growth and its interaction with economic growth are important features of growth models. However, there is no consensus whether population growth is beneficial or detrimental to economic growth. Furthermore, the results of empirical studies are ambiguous. A number of the empirical studies have found a negative relation between population and economic growth (Hazledine and Moreland, 1977, McNicoll, 1984, Rossi, 1989, Barlow, 1994, Brander and Dowrick, 1994, Kelley and Schmidt, 1994, Kelley and Schmidt, 1995, Darrat and Al-Yousif, 1999, Ahituv, 2001, Li and Zhang, 2007). However, some other researchers could not prove a negative effect of population growth on economic growth (see Kuznets, 1973; Perlman, 1975; Boserup, 1976, 1981; Simon, 1981; Bloom and Freeman, 1986; Kelley, 1988; Lee and Lin, 1994; Dasgupta, 1995; Dawson and Tiffin, 1988; Glaeser et al., 1999; Johnson, 1999, 2000; Galor and Weil, 2000; Thornton, 2001; Faria et al., 2006; Headey and Hodge, 2009).

Yet other studies –An and Jeon (2006), Azomahou and Mishra (2008), Jaeger and Kuhle (2009), and Valli and Saccone (2011) – have indicated a non-linear relationship between population and economic growth which can be represented by an inverted U-shape curve.

Since the mid 1980s the *neutralist* theory has been a dominant school of thought whose proponents argue that the rate of population growth appears to have no significant effect on economic growth (Bloom and Freeman, 1986; Bloom et al., 2001). Yet another school – *proponents of age structure* – emerged in the late 1990s. Its members criticize growth models for focusing on *population growth* and ignoring the important role of population dynamics and in particular the changing age distribution within growing populations. What matters for economic growth, it is claimed, is not the rate of population growth per se, but rather the changing age distribution of population as countries pass through demographic transition. They emphasize that economic behaviors and needs vary at different stages of life: the young require intensive investment in health and