OAKA

Cilt:3, Sayı: 6, ss. 161-183, 2008

THE RELATIONSHIP BETWEEN POPULATION AND ECONOMIC GROWTH: EMPIRICAL EVIDENCE FROM THE CENTRAL ASIAN ECONOMIES

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ABSTRACT

This research paper aims to investigate the causal relationship between population and per capita economic growth in the Central Asian Economies (CAEs). Using the ARDL approach to cointegration, we find evidence of a long-run relationship between population and real per capita income and provide strong support for the hypothesis that population is driving growth. Overall, the relationship between population and economic growth is strong and positive in the CAEs over the period of the analysis. This suggests that the CAEs seem 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 the findings are clear. The decline of the rate of growth of population seems to be more obviously connected to the political and economic turmoil which followed the dismantling of the Soviet system. On the other hand, the various pieces of legislation introduced to control the relatively high growth rate of population in these countries may have not been entirely successful, as population still tends to respond to factors outside the direct control of the authorities.

Key Words: *Population, Economic Growth, Cointegration, Granger Causality, Central Asian Economies*

INTRODUCTION

The issue of population and economic growth is as old as the discipline of economics itself. The debate on the relationship between population and

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economic growth could be traced back to 1798 when Thomas Malthus published the book *An Essay on the Principle of Population*. Malthus claimed that there is a tendency for the population growth rate to surpass the production growth rate because population increases at a geometrical rate while production increases at an arithmetic rate.[1] Thus, the unfettered population growth in a country could plunge it into acute poverty. However, the pessimist view has proven unfounded for developed economies in that they managed to achieve a high level of economic growth and thus, both population and the real gross domestic product (GDP) per capita were able to increase.[2] The debate between positive and negative sides of population growth is ongoing. Population growth enlarges labour force and, therefore, increases economic growth. A large population also provides a large domestic market for the economy. Moreover, population growth encourages competition, which induces technological advancements and innovations. Nevertheless, a large population growth is not only associated with food problem but also imposes constraints on the development of savings, foreign exchange and human resources. Generally, there is no consensus whether population growth is beneficial or detrimental to economic growth in developing economies. Moreover, empirical evidence on the matter for developing economies is relatively limited.

The issue of population and economic growth is also closely related to the issue of minimum wage. Population growth enlarges labour force and, therefore, will push wage down. The standard economic labour demand model predicts that low wage will raise the demand for labour. As a result, the welfare of the economy is likely to increase. Moreover, low wage would encourage industries that are labour intensive. Low wage is said to be an important factor that has contributed to the industrialization of the Central Asian Economies (CAEs), namely, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. Conversely, the conventional labour demand model predicts that

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1 Thomas R. Malthus, *An Essay on the Principles of Population*, (Cambridge: Cambridge University Press, 1992).

2 Gerald M. Meier, *Leading Issues in Economic Development*, (New York: Oxford University Press, 1995), p. 276. Tim Dyson, Robert Cassen and Leela Visaria, *Twenty-first Century India: Population, Economy, Human Development,and the Environment*, (Oxford: Oxford University Press: 2004). Allen C. Kelley & Robert M. Schmidt, "Economic and Demographic Change: A Synthesis of Models, Findings, and Perspectives", in N. Birdsall, Allen C. Kelley and Steven Sinding (Ed.), *Population Matters: Demographic Change, Economic Growth, and Poverty in the Developing World*, (New York: Oxford University Press, 2001), pp. 67–105.

the introduction or rising of minimum wage will break the mechanism, i.e., there would be no link between population and economic growth. Nonetheless, a range of monopsony, efficiency wage, and search models shows that in some circumstances minimum wage could indeed raise employment. The empirical evidence on the matter is mixed, with some studies showing negative effects and others showing positive or zero effects of minimum wage. Thus, there is no clear relationship between population and economic growth. Nevertheless, the studies regarding minimum wage and employment are conducted mainly for developed economies. The relationship between population and economic growth is complex and the empirical evidence is ambiguous, particularly concerning the causes and impacts[3]. It can be demonstrated in a theoretical model that a large population growth could have both negative and positive impacts on productivity[4]. A large population may reduce productivity because of diminishing returns to more intensive use of land and other natural resources. Conversely, a large population could encourage greater specialization, and a large market increases returns to human capital and knowledge. Thus, the net relationship between greater population and economic growth depends on whether the inducements to human capital and expansion of knowledge are stronger than diminishing returns to natural resources. Therefore, it is important to examine the population and economic growth nexus.

The main aim of this study is to investigate the relationship between population and economic growth in the CAEs over the post-Soviet era during the period between 1989 and 2007. Those countries vary in the size of population; economic growth and the stage of economic development (see Table 1). The empirical study on the relationship between population and economic growth in the CAEs is limited. This is probably due to the lack of suitable data and the poor quality of the existent data[5]. Thus, this paper provides unique evidence of the relationship between population and growth in those countries. Moreover, the empirical studies on the relationship between population and economic growth in the literature are mainly conducted using

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3 Anthony P. Thirlwall, *Growth and Development*, (Basingstoke: Macmillan Press, 1994), p. 143.

4 Gary S. Becker, Edward L. Glaeser, and Kevin M. Murphy, "Population and Economic Growth", *American Economic Review, Papers and Proceedings: 89*, No. 2, 1999, pp. 145–149.

5 The statistical system of the CAEs, inherited from the former Soviet Union, continues to have problems, and data collected continue to be weak.

cross-section data[6]. Nevertheless, some studies are conducted using time series data[7].

This paper evaluates the relationship between population and per capita income in the Central Asian transition economies. 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 two 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 the CAEs. 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[8]. Following this introduction, next section gives a discussion of the dynamics of economy and population of the Central Asian countries. Antepenultimate section gives a discussion of theoretical and empirical issues on population and economic growth. The econometric methodology and empirical results are set out and discussed in the penultimate section, and finally we offer some conclusions.

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6 John Thornton, "Population Growth and Economic Growth: Long-run Evidence from Latin America", *Southern Economic Journal,* Vol. 68, No. 2, 2001, pp. 464–468.

7 P. J. Dawson, and Richard Triffin, "Is there a Long-run Relationship between Population Growth and Living Standards The Case of India", *Journal of Development Studies*, Vol. 34, No. 5, 1998, pp. 149–156.
João R. Faria, Miguel A. Leon-Ledesma and Adolfo Sachsida, "Population and Income: Is There a Puzzle?", *Journal of Development Studies,* Vol. 42, No. 6, 2006, pp.909-917. Wong H. Tsen & Fumitaka Furuoka, "The Relationship Between Population and Economic Growth in Asian Economies", *ASEAN Economic Bulletin*, Vol: 22, No: 3, 2005, pp. 314-330.

8 M. Hashem Pesaran, Yongcheol Shin and Richard J. Smith, "Bounds Testing Approaches to the Analysis of Level Relationships", *Journal of Applied Econometrics,* Vol. 16, 2001, pp. 289–326. M. Hashem Pesaran & Yongcheol Shin, "An Autoregressive Distributed Lag Modelling Approach to Cointegration", in S. Strom (Ed.), *Econometrics and Economic Theory in 20th Century: The Ragnar Frisch Centennial Symposium,* (Cambridge: Cambridge University Press, 1999). M. Hashem Pesaran & Bahram Pesaran, *Working with Microfit 4.0: Interactive Econometric Analysis,* (Oxford: Oxford University Press, 1997).

Dynamics of Economy and Population of the Central Asian Countries: The Post-Soviet Context

Since the fall of the iron curtain, research on population and economic growth relationship in CAEs, with the exception of migration, has lost ground in the academia, and little is known about the population-income nexus in this region beyond the findings of the handful of studies carried out under the auspices of international organizations. Therefore, the purpose of this section is to briefly outline the main traits of the population-income nexus in the CAEs, namely, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan. The analysis of population and economic growth allows us to formulate expectations on countries' potential for future economic expansion. The process of fertility decline in most of the Former Soviet Union (FSU) accelerated conspicuously since the demise of the Soviet system[9]. Unlike the case in most developed countries, this decline took place suddenly, and within a few years, the rate of growth of population in many republics had reached a level which may be considered as very low even by Western European standards (see Table 1). Modest natural population increase was soon converted into decrease. The decline seems to be more obviously connected to the economic turmoil which followed the dismantling of the Soviet system[10].

Since 1991, all CAEs have experienced a prolonged period of economic turmoil, resulting in a very substantial drop in the standard of living of the population of all five republics. Since the late 1990s, the economies of the region have been showing some positive signs, especially Kazakhstan's, whose recent remarkable per capita GDP growth can be attributed to high oil and other natural resource prices, coupled with a swift and brusque adaptation of the countries' institutions to the market (see Table 1). The fate of Tajikistan, and to a certain extent Kyrgyzstan, has not been as positive. Lacking the resource endowments of the three other CAEs, these two countries' main asset is their hydropower potential. Given their competing water claims of the downstream states of Uzbekistan, Turkmenistan and Kazakhstan, as well as the hydropower infrastructure's current state of disrepair, this potential cannot be exploited to the best of its extent.[11] Furthermore, the economic development

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[9] Hans P. Kohler & Iliana Kohler, "Fertility Decline in Russia in the Early and Mid-1990s: The Role of Economic Uncertainty and Labour Market Crises", *European Journal of Population*, Vol. 18, 2002, pp. 233-262.

[10] UNICEF, *Poverty and Welfare Trends in Kyrgyzstan over the 1990s*, Country Paper, (Florence: UNICEF Innocenti Research Centre, 2002).

[11] Necati Polat, *Boundary Issues in Central Asia,* (New York: Transnational Publisher, 2002).

of Tajikistan was jeopardized by a bitter civil war between Islamic factions and communists until 1997, and the situation remains tense today. In addition to this, the political instability in Tajikistan has occasionally spread to the southern part of Kyrgyzstan and to the Ferghana Valley (mostly located in Uzbekistan), exacerbating existing ethnic tensions. In general, the unstable political situation in the southern CAEs inhibits the region's prospects for development. Blessed with oil, natural gas, cotton, gold, and hydroelectric potential, the CAEs are also growing strongly and stepping away from their post-Soviet decline. In the CAEs, economic growth has been strong in the post-Soviet era, fueled by gas and oil deposits in Kazakhstan, and Turkmenistan; gold in the Kyrgyz Republic; cotton in Uzbekistan. However, the CAEs remain relatively poor, and a gap is opening up between those countries with oil and gas, and those without. Per capita incomes (GDPs) in the oil producers in 2007 were already more than double those in the Kyrgyz Republic, Tajikistan, and Uzbekistan (see Table 1). For instance, in Kazakhstan's case, per capita GDP was US$10926 in 2007, compared with Uzbekistan's US$4873 in the same year. Agriculture accounted for about 35 per cent of the Kyrgyz economy in 2006, but for just 5.7 per cent of Kazakhstan's. The value of exports as a percentage of GDP increased 50 per cent in Kazakhstan in 2007 with proven oil reserves of 0.8 per cent of the world total. Turkmenistan has less oil, measured at about 0.3 per cent of world reserves, but also accounts for about 2.1 per cent of global natural gas production in the same year. If the CAEs are to sustain strong growth, they will have to direct more attention to the nascent private sector. In these countries, the private sector is still being overshadowed by large state enterprises; afflicted by weak support for services; and hamstrung by poor policy, legal, and regulatory frameworks.

Table 1. Population and Economic Statistics for the CAEs[12]

	1990	1995	2000	2005	2006	2007
Kazakhstan						
Population (million)	16,4	15,8	14,9	15,1	15,3	15,5
Population (annual percentage change)	-1,6	-2	-0,3	0,9	1,1	1,2
GDP per capita	7458	4729	5648	9156	10104	10926
GDP per capita (annual percentage change)	-1,8	-6,4	10,1	9,3	10,3	8,1
Industry as percentage of GDP	n/a	31,2	40,1	39,2	40,8	38,8
Services as percentage of GDP	n/a	56	51,3	54,2	53,5	55,4
Agriculture as percentage of GDP	n/a	12,8	8,6	6,6	5,7	5,8
Exports as percentage of GDP	n/a	39	56,6	53,5	51,1	49,8
Imports as percentage of GDP	n/a	43,5	49,1	44,7	40,4	42,9
Kyrgyzstan						
Population (million)	4,4	4,6	4,9	5,1	5,2	5,2
Population (annual percentage change)	2	1	1,1	1	0,9	0,8
GDP per capita	3602	1766	2168	2459	2503	2672
GDP per capita (annual percentage change)	2,8	-6,4	4,2	-1,5	1,8	6,8
Industry as percentage of GDP	35,3	19,4	31,3	22	19,6	n/a
Services as percentage of GDP	31	37,5	31,1	46,7	48,4	n/a
Agriculture as percentage of GDP	33,6	43,1	36,6	31,3	32	n/a
Exports as percentage of GDP	29,2	29,5	41,8	38,3	41,7	44,7
Imports as percentage of GDP	49,5	42,4	47,6	56,8	79	89,9
Tajikistan						
Population (million)	5,3	5,7	6,2	6,8	7	7,2
Population (annual percentage change)	2,3	1,1	2,1	2,1	2,1	2,1
GDP per capita	2979	1068	908	1317	1379	1450
GDP per capita (annual percentage change)	-2,5	-7,2	6,3	4,7	4,7	5,1
Industry as percentage of GDP	37,4	39	38,5	30,9	30,9	27,4

[12] Sources and Notes: The Conference Board and Groningen Growth and Development Centre, *Total Economy Database*, September 2008, (http://www.conference-board.org/economics/); and Asian Development Bank (ADB), *Key Indicators for Asia and the Pacific*, 2008, (http://www.adb.org/statistics); and author's own calculations based on the aforementioned sources. Table 1 exhibits the average growth of total population, the average rate of growth of population, the average growth of GDP per capita and the average rate of growth of GDP per capita; and the structures of output in terms of percentages of GDP, namely agriculture, services, industry; and structure of demand, namely, exports and imports. Per capita GDP is measured in 1990 US Dollar (Converted at Geary-Khamis Purchasing Power Poverties).

Services as percentage of GDP	29,4	22,6	34,1	45,1	44,9	50,2
Agriculture as percentage of GDP	33,2	38,4	27,4	23,9	24,2	22,4
Exports as percentage of GDP	27,8	63,5	92,4	54,3	58,2	39,5
Imports as percentage of GDP	36,1	68,2	100,2	72,8	83	66,1
Turkmenistan						
Population (million)	3,8	4,5	5,29	6,59	6,68	6,77
Population (annual percentage change)	4,3	3	3,7	1,4	1,3	1,3
GDP per capita	3626	2045	2305	2598	2786	3059
GDP per capita (annual percentage change)	-0,8	-9,1	3,5	7,2	7,2	9,8
Industry as percentage of GDP	29,6	64,8	41,8	41,5	41,2	n/a
Services as percentage of GDP	38,2	18,3	35,2	37,8	38,5	n/a
Agriculture as percentage of GDP	32,2	16,9	22,9	20,7	20,3	n/a
Exports as percentage of GDP	111,2	142,5	97,2	65,3	63,4	n/a
Imports as percentage of GDP	123,7	145	82,4	48	55	n/a
Uzbekistan						
Population (million)	20,5	22,9	24,7	26,6	27	27,4
Population (annual percentage change)	2,4	2	1,4	1,5	1,5	1,4
GDP per capita	4241	3065	3424	4232	4495	4873
GDP per capita (annual percentage change)	-3,3	-2,9	2,6	5,9	6,2	8,4
Industry as percentage of GDP	33	27,8	23,1	28,8	30	32,6
Services as percentage of GDP	34	39,8	42,5	43,1	43,5	43,4
Agriculture as percentage of GDP	33,1	32,4	34,4	28,1	26,5	24
Exports as percentage of GDP	29	31,6	26,5	39,7	n/a	n/a
Imports as percentage of GDP	47,8	28,7	26,7	30	n/a	n/a

Population and Economic Growth

The debate on the relationship between population and economic growth could be traced back to Malthus. According to Malthus, population tends to grow geometrically, whereas food supplies grow only arithmetically. 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.[13] 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.[14]

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*).[15] 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.[16]

On the other hand, higher population depressed economic growth through diminishing returns. This dynamic interaction between population and

[13] Gary S. Becker, Edward L. Glaeser, and Kevin M. Murphy, "Population and Economic Growth", *American Economic Review*, *Papers and Proceedings: 89*, No. 2, 1999, pp. 145–149.

[14] Gerald M. Meier, *Leading Issues in Economic Development*, (New York: Oxford University Press, 1995), p.276.

[15] Ronald D. Lee, "The Demographic Transition: Three Centuries of Fundamental Change", *Journal of Economic Perspectives,* Vol.17, No. 4, 2003, pp. 167–190.

[16] Paul A. Samuelson, "Mathematical Vindication of Ricardo on Machinery", *Journal of Political Economy*, Vol. 96, 1988, pp. 274–282. Allen C. Kelley & Robert M. Schmidt, "Aggregate Population and Economic Growth Correlations: The Role of the Components of Demographic Change", *Demography*, Vol. 32, No. 4, 1995, pp. 543-555. Allen C. Kelley & Robert M. Schmidt, "Evolution of Recent Economic-Demographic Modeling: A Synthesis", *Journal of Population Economics*, Vol. 18, No. 2, 2005, pp. 275–300.

economic growth is the centre of the Malthusian model, which implies a stationary population in the long-run equilibrium. Generally, population growth is associated with food problem, i.e., malnutrition and hunger. Nonetheless, the food problem is more a problem of poverty and inadequate income than a matter of inadequate global food supplies. The population and food problem is solved when income is enough to buy adequate food as prices provide adequate incentives to produce. Developing economies are capable of producing surpluses of food for exports. On the other hand, developing economies would have to export more, receive foreign aid or borrow overseas to meet their increased demand for food by increased imports.

Population growth is much more than a food problem. A high rate of population growth not only has an adverse impact on improvement in food supplies, but also intensifies the constraints on development of savings, foreign exchange, and human resources. Rapid population growth tends to depress savings per capita and retards growth of physical capital per worker. The need for social infrastructure is also broadened and public expenditures must be absorbed in providing the need for a larger population rather than in providing directly productive assets.

Population pressure is likely to intensify the foreign exchange constraints by placing more pressure on the balance of payment. The need to import food will require the development of new industries for export expansion and/or import substitution. The rapid increase in school-age population and the expanding number of labour force entrants puts ever-greater pressure on educational and training facilities and retards improvement in the quality of education, which is a problem in developing economies as about 33 per cent of the children of primary school age are not enrolled in school and of those who enter school, 60 per cent will not complete more than three years of primary school.[17] Also, too dense a population aggravates the problem of improving the health of the population. In most developing economies, the working age population had roughly doubled in the past twenty-five years. At expected growth rates, it will double again in the next twenty-five years. This growth clearly intensifies pressure on employment and the amount of investment available per labour market entrant.

[17] Gerald M. Meier, *Leading Issues in Economic Development*, (New York: Oxford University Press, 1995), p.276.

A larger population may help overcome possibly diminishing returns to this generation's human capital in the production of the next generation's human capital because greater population growth induces more specialization and a larger market that raise returns to human capital and knowledge. If human capital per capita were sufficiently large, the economy would move to steady-state growth, whereby in the steady-state growth path, consumption per capita would increase at a slower rate than human capital if the population is growing and if the production of consumer goods has diminishing returns to population. However, consumption per capita can still be increasing, despite these diminishing returns, if the positive impact of the growth in human capital on productivity in the consumption sector more than offsets the negative impact of population growth. Thus, zero population growth is not necessary for sustainable growth in per capita consumption, even with diminishing returns to population in the production of consumer goods.[18]

Extending Malthus's work researchers developed the so-called "classical" model.[19] 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".[20] 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.[21] This theory adapts the conventional theory of consumer by introducing the number of

[18] Gerald S. Becker, Edward L. Glaeser, and Kevin M. Murphy, "Population and Economic Growth", *American Economic Review*, *Papers and Proceedings: 89*, No. 2, 1999, pp. 145–149.

[19] Mark Blaug, *Economic Theory in Retrospect*, (London: Heinemann, 1962).

[20] Robert M. Solow, "A Contribution to the Theory of Economic Growth", *Quarterly Journal of Economics*, Vol. 70, 1956, pp. 65–94.

[21] Gary S. Becker, "Fertility and the Economy", *Journal of Population Economics*, Vol. 5, 1992, pp. 185–201.

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.

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.[22] 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.

The aforementioned demographic transition is currently explained 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 the *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.

Empirical Results

The data is annual and spans the time period 1989 to 2007. The real per capita GDP (Y_t) and the rate of growth of population (POP_t) data is the series

[22] Luis Currais, "From the Malthusian Regime to the Demographic Transition: Contemporary Research and Beyond", *Economica,* Vol. 7, No. 3, 2000, pp. 75–101.

produced by *The Conference Board and Groningen Growth and Development Centre, Total Economy Database*.[23] Both of the variables are in logarithms.

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 2 reports the results of the unit root tests. The ADF statistics for the levels of population and real per capita income [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 $I(1)$ for all of the CAEs.

Table 2. Results of ADF Unit Root Tests[24]

	Variables							
Countries	**ln*POP***	**Lags**	**Δln*POP***	**Lags**	**ln*Y***	**Lags**	**Δln*Y***	**Lags**
Kazakhstan	-1.2358	1	-12.8409*	4	-1.9350	2	-5.3177*	1
Kyrgyzstan	-1.2881	4	-9.7251*	3	-1.9393	4	-9.3201*	4
Tajikistan	-0.9555	1	-6.6514*	1	-1.1221	1	-10.0317*	3
Turkmenistan	-1.3136	3	-6.0173*	2	-1.8879	2	-6.2283*	3
Uzbekistan	-1.1404	4	-7.5955*	3	-2.0728	3	-5.6296*	4

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

[23] The Conference Board and Groningen Growth and Development Centre, *Total Economy Database*, September 2008, (http://www.conference-board.org/economics/).

[24] * Denotes the rejection of the hypothesis at the 1% siginificance level. 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.

population and real per capita income, we employ bound testing approach to cointegration within the framework of ARDL. There are several reasons for the use of bounds test. Firstly, the bi-variate cointegration test and the multivariate cointegration technique proposed may be appropriate for large sample size. However, "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."[25] The likelihood of multiple cointegrating vectors does not facilitate the identification of the possible static long-run cointegration between the variables. 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. The ARDL approach is more robust and performs better for small sample sizes than other cointegration techniques. 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

[25] Alan Carruth, Andrew Dickerson, and Andrew Henley, "Econometric Modelling of UK Aggregate Investment: The Role of Profits and Uncertainty", *The Manchester School,* Vol. 3, 2000, pp. 276-300.

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 ($H_0 : \sigma_{1POP} = \sigma_{2Y} = 0$) against the alternative hypothesis ($H_1 : \sigma_{1POP} \neq \sigma_{2Y} \neq 0$). This is denoted as F_{POP} (POP_t | Y_t). In Eq. (2), where real per capita GDP is the dependent variable, the null hypothesis for cointegration is ($H_0 : \sigma_{1Y} = \sigma_{2POP} = 0$) against the alternative ($H_1 : \sigma_{1Y} \neq \sigma_{2YPOP} \neq 0$). This is denoted as F_Y (Y_t | 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. 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. 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. 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[26]. In order to avoid a possible selection problem at this stage, one may follow the procedure of 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; the cost of over-parameterization in terms of efficiency loss is

[26] P. K. Narayan & R. Smyth, "Higher Education, Real Income and Real Investments in China: Evidence from Granger Causality Tests", *Education Economics*, Vol. 14, 2006, pp. 107–125. Mohsen Bahmani-Oskooee & Goswami G. Goswami, "A Disaggregated Approach to Test the J-curve Phenomenon: Japan versus Her Major Trading Partners", *International Journal of Economics and Finance*, Vol. 27, 2003, pp. 102–113.

marginal[27]. 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[28]. The calculated *F*-statistics are reported in Table 3. From the results exhibited in Table 3, it is clear that there are long-run relationships between the variables because the calculated *F*-statistics are higher than the upper bound critical values at different significance levels. This implies that the null hypothesis of no cointegration between the variables in Eqs. (1) and (2) cannot be accepted for all of the countries. Evidence of cointegration relationships between the variables in Eqs. (1) and (2) also rules out the possibility of estimated relationship being 'spurious'.

Table 3. *F*-statistics for cointegration relationship[29]

	Calculated *F*-statistics	
Countries	$F_{POP}(POP_t / Y_t)$	$F_Y(Y_t / POP_t)$
Kazakhstan	13.3633* [.002]	25.7043* [.000]
Kyrgyzstan	5.4808*** [.044]	4.8149*** [.057]
Tajikistan	8.7534* [.017]	18.8092* [.003]
Turkmenistan	12.5595* [.035]	4.8286*** [.029]
Uzbekistan	10.7411* [.002]	22.6364* [.000]

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

27 Jesus Gonzalo, "Five Alternative Methods of Estimating Long-Run Equilibrium Relationships", *Journal of Econometrics*, Vol: 60, 1994, pp. 203–233.

28 M. Hashem Pesaran, Yongcheol Shin and Richard J. Smith, "Bounds Testing Approaches to the Analysis of Level Relationships", *Journal of Applied Econometrics,* Vol: 16, 2001, pp. 289–326.

29 The upper limits of the critical value for the *F*-test (all *I*(1) variables) are 7.84 (1%), 5.73 (5%) and 4.78 (10%). * refers statistical significance at 1% level and ** refers statitical significance at 5% level, and *** refers significance at 10% level. Critical values are obtained from Pesaran *et al.* (2001). *p*-values are in square brackets. *LM*(1) is the Lagrange Multiplier test of residual serial correlation. Critical value of χ^2 (1) is 3.841.

Granger causality test involves specifying a multivariate *p*th order VECM as follows:

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

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. 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 4 summarizes the results of the long-run and short-run Granger causality.

Table 4. Results of Granger Causality[30]

Countries	$\Delta lnPOP_t$=> ΔlnY_t	ECT_{t-1} [t-stat.]	ΔlnY_t=> $\Delta lnPOP_t$	ECT_{t-1} [t-stat.]
Kazakhstan	8.0998* (.015)	-0.0827* [-4.29]	5.8104* (.033)	-0.0948* [-4.04]
Kyrgyzstan	11.4027* (.006)	-0.3488* [-7.73]	39.6214* (.000)	-0.2832* [-5.89]
Tajikistan	35.9992* (.000)	-0.8788* [-6.31]	12.5306* (.004)	-0.1606* [-4.80]
Turkmenistan	0.1035 (.753)	-0.0416* [-5.24]	0.0454 (.835)	-0.4017* [-3.81]
Uzbekistan	0.1915 (.669)	-0.0350* [-8.32]	12.9449* (.004)	-0.0607* [-6.59]

30 * refers statistical significance at 1% level, and ** refers statistical significance at 5% level, and *** refers statistical significance at 10% 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, when causality is assumed to run from population to per capita GDP, there is evidence of a stable long-run relationship between the variables for each of the countries. The coefficients on the lagged error-correction terms are significant with the expected sign and plausible magnitude in population equation at 1 per cent significance level for all countries. 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 ECT_{t-1} measures the speed at which the endogenous variable adjusts to changes in the explanatory variables before converging to its equilibrium level, for instance, the coefficient of -0.87 suggests that convergence to equilibrium after a shock to population in Tajikistan takes slightly over one year. 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. When causality is assumed to run from per capita GDP to population, there is evidence of a stable long-run relationship between the variables for all of the countries.

For example, the feedback coefficient of -0.40 in the equation for Turkmenistan suggests that when real per capita income is above or below its equilibrium level, population adjusts by almost entirely within two years. In other words, 40 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 two years. Thus, for Turkmenistan 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 over the period of the analysis.

In the short-run, when causality is assumed to run from population to per capita GDP, the *F*-statistics on the explanatory variables suggest that at the 1 % level or better there is a Granger causality running from real per capita income to population (when population is dependent variable) in Kazakhstan, Kyrgyzstan and Tajikistan. When causality is assumed to run from per capita GDP to population, there is evidence of a stable short-run relationship between the variables for Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan, and neutrality between population and real per capita income as there is no short-run Granger causality for Turkmenistan when causality is assumed to run from income to population or *vice versa*. Overall, the causality results suggest that there is evidence of strong and positive causal relationship between per capita real GDP and population in all of the CAEs. There appears to be bi-directional Granger causality both in the short and long run in each of the countries.

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 to be bi-directional causality when causality is assumed to run from population to real per capita or *vice versa* in the long run for all of the countries, while there are no feedback effects from real income to population in the short run only for Turkmenistan and Uzbekistan. The feedback effect does not come from population to real income in the short-run only for Turkmenistan. Overall, the relationship between population and economic growth is strong and positive in the CAEs over the period of the analysis. This suggests that the CAEs seem 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 the findings are clear. The decline of the rate of growth of population seems to be more obviously connected to the political and economic turmoil which followed the dismantling of the Soviet system. On the other hand, the various pieces of legislation introduced to control the relatively high growth rate of population in these countries may 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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