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Population and Income: Is There a Puzzle?

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ABSTRACT *This note presents wide evidence on the relationship between population and income for 125 countries for which data was available for the period 1950–2000. The main result is that there is a weak but negative relationship between population growth and per capita GDP, as income increases population expands at a slower rate. This relationship appears to be stronger for African countries and for Asian countries before 1970.*

I. Introduction

One of the stylised facts about population in all contemporary developed nations is that over the past couple of centuries it has passed through three stages (called demographic transition). The first stage is characterised by high birth rates and high death rates, resulting in a slow population growth. In the second stage there was a reduction in death rates, however the birth rates remained high, as a consequence population growth increased. 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.[1] 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 income per capita and population.

Indeed, the main theories put forward by economists to explain the evolution of population relates it to per capita income. For instance, according to Malthus (1992)

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population grows whenever per capita income is above the subsistence level (see Samuelson, 1988). 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.

A more modern approach to the relationship between income and population is found in the microeconomics theory of fertility (see Becker, 1991). 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.

In both theories, 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). In the Solow and Ramsey models of economic growth, for example, 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.

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 stylised 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 with data for all countries (whenever available) from 1950 to 2000. 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 stylised facts that can be used as the basic evidence on which theory models can build. So far, it is difficult to find evidence in which this relation is analyzed in a systematic way for such a large sample of countries and years. In the next section we present the empirical evidence and the analysis of the results and last section concludes.

II. Population and Growth: The Evidence

In this section we present evidence on the relationship between population and income for a complete sample of countries for which data was available for the period 1950–2000. The sample is made of a panel of 125 countries and 5,398 observations. The panel is unbalanced given that for some countries data was not available until the 1960s. The data source used is the Penn World Table 6.1.

We regressed the *rate of growth* of population on the log of per capita GDP (LGDPpc) and its squared value (LGDPpc2). The introduction of the squared term is to capture any possible non-linearity arising from the transition effects commented earlier when discussing the theory models. In previous estimates we added higher polynomials up to an order of 4 of the independent variable to test for other possible functional forms of non-linearity. These tests showed that these higher order polynomials were just marginally significant and not robust to the inclusion of regional dummies. In order to control for the possible endogeneity of the per capita income variable we also used instrumental variables estimators using lags of LGDPpc and LGDPpc2 as instruments. The results did not change substantially. As expected, standard errors became slightly larger, but the significance and parameters of the variables were not affected in an important way.[2]

Table 1 provides some descriptive statistics for the data by region. We can observe that the average rate of growth of population is higher in Africa and Asia and lower in Europe and the OECD, where they are not significantly different from zero. Both population growth and level show significant variation between the different regional groups. This variation is most evident in per capita income that ranges from the 13,161 PPPUS$ in the OECD to the 2,134 PPPUS$ in Africa. There is also a large variability of income per capita within groups as evidenced by the standard deviations. Apart from Oceania, which only contains two countries, the variability is higher in the OECD and lower in Africa.

We present the results of the regression in Table 2. Apart from LGDPpc and LGDPpc2 we included regional dummies in some of the regressions to account for any time invariant effect of the different world regions (Africa, North and Central America, South America, Asia, Europe, Oceania and OECD countries). The OECD countries were withdrawn from their geographical location group because given their level of development their behavior is likely to be more similar. We used 6 different estimators to show the deficiencies of the pooled OLS regression and as a robustness check. The former problem is supported by the Breusch-Pagan test that indicates the misspecification of using pooled data. The 5 panel data estimators used were the fixed effects estimator (FE), the random effects estimator (RE), the between estimator (BE), the maximum likelihood estimator (MLE) and the population averages estimator (PA).[3] The Hausman test indicates a preference for the fixed

Table 1. Descriptive statistics for the period 1950–2000*

Variables	South America	North and Central America	Ocean	Africa	Asia	Europe	OECD
Population growth	0.0212	0.0198	0.0213	0.0249	0.0245	0.0069	0.0089
	(0.0100)	(0.0120)	(0.0091)	(0.0110)	(0.0108)	(0.0067)	(0.0079)
Total population	20,400,000	2,560,150	1,902,243	10,100,000	127,000,000	10,300,000	32,000,000
	(3.22e + 07)	(2,420,874)	(1,423,433)	(1.48e + 07)	(2.65e + 08)	(1.05e + 07)	(4.61e + 07)
GDP per capita	4,862.12	4,460.18	3,639.26	2,134.88	4,403.84	5,324.21	13,161.49
	(2,386.2)	(2751.5)	(824.2)	(1,973.8)	(5,218.8)	(3,531.1)	(6,544.4)
Number of countries	11	17	2	47	18	2	28
Number of observations	546	607	78	1970	784	86	1327

Note: *the values in parentheses are the standard-deviations.

Table 2. Regression results for ΔLPop. All countries. Period: 1950–2000*,**

Variable	OLS	FE (within)	RE (GLS)	BE	MLE	PA
Constant	−.0406	.0410	.0368	−.0469	.0368	.0362
	(−4.79)	(3.14)	(2.97)	(−1.02)	(2.67)	(2.90)
LGDPpc	.0210	.00008	.0011	.0227	.0011	.0013
	(10.08)	(0.03)	(0.39)	(2.00)	(0.39)	(0.44)
LGDPpc2	−.0016	−.0003	−.0003	−.0017	−.0003	−.0004
	(−12.96)	(−1.77)	(−2.26)	(−2.53)	(−2.25)	(−2.30)
Regional dummy#	No	No	No	No	No	No
Breusch-Pagan		17154 [p-value = .0000]				
Hausman		5.34 [p-value =.0693]				
R^2	.2791	.2656	.2671	.2790	—	—
Constant	−.0281	—	.0267	−.0336	.0265	.0259
	(−3.15)		(2.13)	(−0.71)	(2.11)	(2.06)
LGDPpc	.0140	—	.0021	.0145	.0021	.0022
	(6.27)	—	(0.71)	(1.20)	(0.72)	(0.77)
LGDPpc2	−.0010	—	−.0004	−.0010	−.0004	−.0004
	(−7.79)		(−2.44)	(−1.42)	(−2.45)	(−2.49)
Regional dummy#	Yes	—	Yes	Yes	Yes	Yes
Breusch-Pagan		13557 [p-value = .0000]				
Hausman		7.40 [p-value =.0247]				
R^2	.3401	—	.3287	.3344	—	—

Note: *t-statistics in parenthesis; **the panel is made up of 125 countries and 5398 observations; #changing the seven regional dummies (Africa, North and Central America, South America, Asia, Europe, Oceania, and OECD) for a single dummy that takes the value of 1 for OECD and 0 for the rest does not affect the results qualitatively.

effects over the random effects specification as we would expect from the kind of data we are working with.

The results in Table 2 show that the relation between income and population growth is not too robust between different estimation methods. At a first glance the general picture shows that the higher LGDPpc the higher will population growth be, but at a decreasing rate. That is, there is an inverted U-shape relationship. In most cases the LGDPpc variable is not significant but LGDPpc2 is and the coefficients are rather small. In fact, and given the values of the data we are dealing with, we can hardly observe any relationship between both variables but, if any arises, it is a negative impact of per capita income on population growth. This is because the increasing part of the inverted U-shape is not significant. This seems to indicate that most countries in the sample, for most of the period, have already entered the stage in which demographic transition has finished (third stage). To cross-check these

results, we also carried out the same regression but using the log *level* of population as the dependent variable.[4] The relationship found between income and the level of population has a significant inverted U-shape. That is, as income increases population increases but at a decreasing rate. At a point in time the increase in income would lead to a decline of the level of population. However, given the size of the coefficients, the negative part of the relation does not appear to be economically significant given the values of the population and income variables we are working with. Hence, in line with the relationship we found between population growth and income, there is a positive but decreasing relationship between the level of population and income.

A question that may arise from these results is whether these hold for every sub-group of countries and all the periods considered. It may be inappropriate to pool all countries at different stages of development and demographic transition together. To shed light on this question we present the results of the same regression separately for each region and decade. For reasons of space we now just report the estimations obtained using the FE and RE estimators. These can be found in Table 3. There is considerable variation between the different regions. For Africa, in most sub-samples and the complete sample period the inverted-U relationship appears to be strongly significant. Although the coefficients are relatively small, we can observe that as income increases population growth increases at a decreasing rate. For both American regions the relationship is very weak as for the whole sample. In Asia we observe an inverted U shape for the period between 1950 and 1969. This relationship is inverted in 1970–79, indicating a strong negative impact of income on population growth for this period. This may precisely reflect again the completion of the demographic transition process. For Europe and the OECD we find that the dominant effect is a negative impact of income on population growth, reflecting the population aging process in these two regions. What is a common pattern in all results is that the GDPpc2 variable always shows the opposite sign of GDPpc, hence entering as a deceleration effect that prevents explosive or implosive population dynamics.

When, as mentioned before, we use population *level* as the dependent variable by region and period, the same pattern appears. The only exception was Africa for the 1980–2000 period, where the relationship appears to be inverted. This may reflect the impact of exogenous effects such as the AIDS epidemic. As population is depleted by these events at a faster rate than its impact on output, we find a negative relationship between income and population levels.[5] This may be the case because AIDS affects harder poor families that suffer a substantial increase in mortality rates.

III. Conclusions

There are several well know and 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 relation between these two variables of key economic relevance. However, empirical work has lagged behind and there is very little systematic evidence on the relationship. In this paper we provide a set of general results for a very large sample of countries during the 1950–2000 period that serves as a set of stylised facts on the relation between population growth and income.

Table 3. Regression results for ΔLPop by region*

	Constant		LGDPpc		LGDPpc2	
Region/period	RE	FE	RE	FE	RE	FE
Africa:						
1950–59	−.0436	−.0194	.0216	.0177	−.0016	−.0015
C = 14; n = 106	(−0.31)	(−0.10)	(0.56)	(0.34)	(−0.62)	(−0.45)
1960–69	**−.2237**	**−.2118**	**.0687**	**.0628**	**−.0047**	**−.0041**
C = 46; n = 432	**(−3.00)**	**(−2.27)**	**(3.35)**	**(2.45)**	**(−3.37)**	**(−2.35)**
1970–79	**−.3963**	**−.5038**	**.1148**	**.1430**	**−.0077**	**−.0096**
C = 47; n = 465	**(−6.26)**	**(−7.44)**	**(6.83)**	**(7.95)**	**(−6.98)**	**(−8.04)**
1980–89	−.0889	−.0391	.0320	.0147	**−.0021**	−.0007
C = 47; n = 470	(−1.29)	(−0.41)	(1.74)	(0.57)	**(−1.81)**	(−0.44)
1990–2000	−.0890	**−.4355**	**.0328**	**.1180**	**−.0023**	**−.0074**
C = 47; n = 497	(−1.67)	**(−2.26)**	**(2.35)**	**(2.22)**	**(−2.557)**	**(−2.03)**
1950–2000	**−.1075**	**−.1254**	**.0381**	**.0432**	**−.0027**	**−.0030**
C = 47; n = 1970	**(−3.37)**	**(−3.48)**	**(4.52)**	**(4.57)**	**(−4.88)**	**(−4.94)**
Central and North America:						
1950–59	.2147	−.6919	−.0502	.1726	.0034	−.0102
C = 8; n = 71	(0.47)	(−1.13)	(−0.43)	(1.12)	(0.45)	(−1.05)
1960–69	−.0258	−.1871	.0076	.0408	−.0001	−.0017
C = 10; n = 93	(−0.07)	(−0.30)	(0.08)	(0.26)	(−0.03)	(−0.19)
1970–79	.1016	.1509	−.0154	−.0263	.0006	.0012
C = 14; n = 111	(0.64)	(0.86)	(−0.41)	(−0.63)	(−0.28)	(0.51)
1980–89	−.0373	−.0929	.0154	.0257	−.0010	−.0015
C = 16; n = 159	(−0.19)	(−0.48)	(0.33)	(0.45)	(−0.39)	(−0.45)
1990–2000	−.1064	−.00001	.0381	.0044	−.0027	−.0003
C = 17; n = 173	(−0.90)	(−0.00)	(1.32)	(0.13)	(−1.58)	(−0.14)
1950–2000	**.1318**	**.1456**	−.0210	−.0239	.0008	.0010
C = 17; n = 607	**(2.38)**	**(2.59)**	(−1.58)	(−1.78)	(1.09)	(1.31)
South America:						
1950–59	.1481	.0697	−.0258	−.0062	.0013	.0001
C = 11; n = 96	(0.78)	(0.35)	(−0.55)	(−0.12)	(0.46)	(0.03)
1960–69	**.4699**	**.4155**	**−.0953**	−.0775	.0049	.0036
C = 11; n = 110	**(2.15)**	**(1.87)**	**(−1.81)**	(−1.44)	(1.58)	(1.12)
1970–79	.0752	.0878	−.0151	−.0183	.0010	.0012
C = 11; n = 110	(0.45)	(0.51)	(−0.37)	(−0.44)	(0.42)	(0.49)
1980–89	−.2690	−.2070	.0637	.0482	−.0035	−.0025
C = 11; n = 110	(−1.43)	(−1.08)	(1.42)	(1.06)	(−1.32)	(−0.95)
1990–2000	.7645	2.3250	−.1688	−.5105	.0094	.0280
C = 11; n = 110	(1.24)	(3.27)	(−1.17)	(−3.10)	(1.12)	(2.93)
1950–2000	**.4883**	**.4906**	**−.1039**	**−.1042**	**.0057**	**.0057**
C = 11; n = 546	**(4.08)**	**(4.07)**	**(−3.59)**	**(−3.57)**	**(3.29)**	**(3.26)**
Asia:						
1950–59	**−.4185**	**−1.283**	**.1154**	**.3692**	**−.0073**	**−.0257**
C = 11; n = 83	**(−2.15)**	**(−5.66)**	**(2.19)**	**(6.03)**	**(−2.06)**	**(−6.25)**
1960–69	**−.6714**	**−1.009**	**.1819**	**.2724**	**−.0117**	**−.0177**
C = 17; n = 165	**(−3.69)**	**(−3.80)**	**(3.81)**	**(3.99)**	**(−3.75)**	**(−4.05)**
1970–79	**.2719**	**.6591**	**−.0623**	**−.1574**	**.0038**	**.0096**
C = 17; n = 170	**(2.35)**	**(4.00)**	**(−2.14)**	**(−3.88)**	**(2.14)**	**(3.90)**

(*continued*)

Table 3. (*Continued*)

	Constant		LGDPpc		LGDPpc2	
Region/period	RE	FE	RE	FE	RE	FE
1980–89	−.1097	−.1212	.0343	.0417	−.0021	−.0029
C = 18; n = 174	(−1.11)	(−1.05)	(1.44)	(1.51)	(−1.53)	(−1.75)
1990–2000	.1191	.2441	−.0216	−.0320	.0011	.0006
C = 18; n = 192	(0.65)	(0.77)	(−0.51)	(−0.43)	(0.47)	(0.15)
1950–2000	.0415	.0495	.0015	.0005	−.0004	−.0004
C = 18; n = 784	(1.45)	(1.71)	(0.22)	(0.08)	(−1.05)	(−1.07)
Europe:						
1950–59	Insufficient number of observations					
C = 2; n = 09						
1960–69	−.1053	−.2685	.0295	.0590	−.0019	−.0030
C = 2; n = 19	(−0.25)	(−0.67)	(0.27)	(0.58)	(−0.27)	(−0.46)
1970–79	−.3231	−.1265	.0909	.0368	−.0061	−.0025
C = 2; n = 20	(−0.83)	(−0.33)	(0.97)	(0.39)	(−1.09)	(−0.43)
1980–89	.4026	.1937	−.0960	−.0429	.0057	.0024
C = 2; n = 20	(1.52)	(0.60)	(−1.55)	(−0.55)	(1.61)	(0.53)
1990–2000	**−2.751**	**−2.546**	**.6022**	**.5700**	**−.0327**	**−.0317**
C = 2; n = 18	**(−3.08)**	**(−2.80)**	**(3.02)**	**(2.84)**	**(−2.94)**	**(−2.86)**
1950–2000	**.3486**	**.3599**	**−.0815**	**−.0820**	**.0048**	**.0047**
C = 2; n = 86	**(3.61)**	**(3.97)**	**(−3.54)**	**(−3.80)**	**(3.54)**	**(3.69)**
Oceania:						
1950–59	Insufficient number of observations					
C = 0; n = 0						
1960–69	Insufficient number of observations					
C = 2; n = 18						
1970–79	−1.042	−.8671	.2722	.2192	−.0173	−.0135
C = 2; n = 18	(−0.63)	(−0.64)	(0.68)	(0.66)	(−0.71)	(−0.67)
1980–89	12.52	7.474	−3.038	−1.885	.1844	.1189
C = 2; n = 18	(2.07)	(1.36)	(−2.06)	(−1.42)	(2.06)	(1.48)
1990–2000	−3.075	−2.574	.7891	.6647	−.0501	−.0423
C = 2; n = 20	(−0.50)	(−0.28)	(0.53)	(0.30)	(−0.56)	(−0.31)
1950–2000	**−2.757**	**−2.857**	**.6997**	**.7250**	**−.0439**	**−.0455**
C = 2; n = 78	**(−1.84)**	**(−1.85)**	**(1.92)**	**(1.93)**	**(−1.98)**	**(−1.99)**
OECD:						
1950–59	−.0425	−.2112	.0133	.0521	−.0007	−.0030
C = 25; n = 220	(−0.29)	(−1.32)	(0.38)	(1.39)	(−0.39)	(−1.38)
1960–69	.1415	.0638	−.0228	−.0045	.0009	−.0001
C = 25; n = 250	(1.31)	(0.55)	(−0.93)	(−0.17)	(0.67)	(−0.09)
1970–79	.1257	−.0336	−.0185	.0128	.0006	−.0008
C = 28; n = 269	(0.60)	(−0.14)	(−0.41)	(0.25)	(0.26)	(−0.31)
1980–89	**.9488**	**.8683**	**−.1961**	**−.1793**	**.0101**	**.0093**
C = 28; n = 280	**(6.58)**	**(5.68)**	**(−6.39)**	**(−5.54)**	**(6.24)**	**(5.43)**
1990–2000	**.5921**	**.6018**	**−.1186**	**−.1178**	**.0059**	**.0058**
C = 28; n = 308	**(3.33)**	**(2.85)**	**(−3.22)**	**(−2.73)**	**(3.16)**	**(2.64)**
1950–2000	**.0893**	**.0863**	**−.0128**	**−.0120**	.0004	.0004
C = 28; n = 1327	**(3.68)**	**(3.56)**	**(−2.41)**	**(−2.27)**	(1.53)	(1.39)

Notes: *t-statistics in parentheses. Bold numbers indicate significance at the 5% statistical level. C = number of countries in the group. n = number of observations in the regression.

Our results show that there is a weak but negative relationship between population growth and per capita GDP. Given our parameter values the economically relevant relationship is one in which as income increases population growth falls but at a slow rate. That is, as income increases population expands at a slower rate. This is reflected on a positive but decreasing relationship between income and population levels. We also find that the negative relationship between population growth and income is stronger for African countries and Asian countries before 1970 and weaker for the OECD group.

Notes

1. For the positive effect of income on health see Parkin et al. (1987) and Pritchett and Summers (1996).
2. We do not report these results for the sake of space, but they are available from the authors on request.
3. For details on these estimators see Baltagi (2002).
4. Results available from the authors.
5. See, for instance, World Bank (1997).

References

Baltagi, B. H. (2002) *Econometric Analysis of Panel Data* (London: Wiley & Sons).

Becker, G. S. (1991) *Treatise on the Family* (Cambridge: Harvard University Press).

Currais, L. (2000) From the Malthusian regime to the demographic transition: contemporary research and beyond, *Económica*, 7(3), pp. 75–101.

Dawson, P. and Triffin, R. (1998) Is there a long-run relationship between population growth and living standards? The case of India, *Journal of Development Studies*, 34, pp. 149–56.

Easterlin, R. (1967) Effects of population growth in the economic development of developing countries, *The Annals of the American Academy of Political & Social Science*, 369, pp. 98–108.

Galor, O. and Weil, D. (1999) From Malthusian stagnation to modern growth, *American Economic Review Papers & Proceedings*, 89, pp. 150–4.

Galor, O. and Weil, D. (2000) Population, technology, and growth: from the Malthusian regime to the demographic transition and beyond, *American Economic Review*, 90, pp. 806–28.

Johnson, D. G. (1999) Population and economic development, *China Economic Review*, 10, pp. 1–16.

Kelley, A. and Schimidt, R. (1994) Population and income change: recent evidence, World Bank Discussion Paper No. 249.

Kuznets, S. (1967) Population and economic growth, *American Philosophical Society Proceedings*, 3, pp. 170–93.

Lagerloff, N. P. (2003) From Malthus to modern growth: can epidemics explain the three regimes, *International Economic Review*, 44, pp. 755–77.

Malthus, T. R. (1992) *An Essay on the Principles of Population, original published in 1798* (Cambridge: Cambridge University Press).

Parkin, D., McGuire, A. and Yule, B. (1987) Aggregate health care expenditures and national income: is health care a luxury good?, *Journal of Health Economics*, 6, pp. 109–27.

Pritchett, L. and Summers, L. (1996) Wealthier is healthier, *Journal of Human Resources*, 31, pp. 841–68.

Samuelson, P. A. (1988) Mathematical vindication of Ricardo on machinery, *Journal of Political Economy*, 96, pp. 274–82.

Thirlwall, A. (1972) A cross section study of population growth and the growth of output and per capita income in a production function framework, *Manchester School*, 40, pp. 339–56.

Thornton, J. (2001) Population growth and economic growth: long-run evidence from Latin America, *Southern Economic Journal*, 68, pp. 464–8.

World Bank (1997) *Confronting AIDS: Public Priorities in a Global Epidemic* (Oxford: Oxford University Press).