ON THE LONG-RUN RELATIONSHIP BETWEEN POPULATION AND ECONOMIC GROWTH:

SOME TIME SERIES EVIDENCE FOR DEVELOPING COUNTRIES

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INTRODUCTION

The relationship between population and economic growth has recently spawned a large number of empirical studies, with remarkably mixed results. While many studies argue that population growth impedes economic development, others contend that the economic effects of population are rather stimulative, and some maintain that the two variables are not related at all [Perlman, 1975; Simon, 1977; 1989; Bairoch, 1983; McNicoll, 1984; Rodgers, 1984; Ahlburg, 1987; Chesnais, 1987; Blanchet, 1988; 1991; Horlacher and MacKellar, 1988; Barlow, 1994]. Indeed, there are at least three alternative schools of thought regarding this relationship [Hodgson, 1988; and Blanchet, 1991]. The first is the "Orthodox" or "Malthusian" view that rapid population growth leads to poverty. Under this scenario, family planning to control fertility is an important policy to foster economic growth in over-populated countries. Against this position, "Revisionism" holds that higher population growth increases the stock of human capital and will thus positively contribute to economic development. If true, attempts to curtail population growth become unnecessary or perhaps even harmful to the economic development process. Both of these hypotheses imply that population causes (negative or positive) changes in per capita income. On the other hand, the "Transition" theory takes an opposing stand and maintains that population growth, at least partially, is itself driven by income changes. That is, countries tend to have large population as a result of being economically poor. This view implies that developing countries with large and expanding population should instead focus on improving the technical skills of their labor force and on enhancing the stock of human capi-

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Eastern Economic Journal, Vol. 25, No. 3, Summer 1999

tal for economic prosperity. This, the hypothesis contends, is the way to control excessive population.

Clearly, the correlation-based analyses typically used in previous studies are inadequate to identify the cause-and-effect relationships between the two variables. However, little has been done to analyze the causal links between population and economic development. In two recent papers, Jung and Quddus [1986] and Kapuria-Foreman [1995] rightfully shift the focus from the common (but largely irrelevant) correlation between population growth and economic development to the more pertinent issue of causality. These two studies employ standard Granger-causality tests to examine the linkage between population growth and economic development with annual data from several developing countries. Jung and Quddus find no clear evidence for any causal relationship between the two variables. However, Kapuria-Foreman claims otherwise and reports that population growth and economic development display a distinct pattern of causal characterization (primarily from the former to the latter).

Although useful and illuminating, both studies appear flawed for they ignore the cointegration (long-run) relationship between the two variables. As Engle and Granger [1987] and Toda and Phillips [1993] point out, standard Granger-causality tests of the type used by Jung and Quddus and Kapuria-Foreman will be misleading if no allowance is made for possible cointegratedness.[1] This aspect assumes particular importance in light of Simon's [1989] plausible theoretical argument that population and economic development are essentially related over the long-run horizon and should possess minimal tendency for a short-run relationship. Simon contends that the short-run economic effects of population, if and when they exist, operate mainly through capital dilution and the cost of raising children. However, population has more pronounced effects on economic growth through several channels like productivity changes and the contribution of new ideas, and these channels require a relatively long time to bring in their full effects. Therefore, standard regression analyses, with their typical emphasis on short-run effects, are biased against revealing the true and complete long-run relationship between population and economic growth.

To foreshadow what follows, our results from the Johansen [1988] robust cointegration tests for many developing countries are consistent with Simon's theoretical contention and indicate the presence of a potent long-run relationship between population and economic development across all countries in the sample. Regression results accord well with this finding and suggest the presence of a significant long-run causal relationship. Interestingly, the results reveal no systematic evidence for short-run dynamics underlying the two variables, further supporting Simon's hypothesis.

METHODOLOGY AND DATA

We test for the intertemporal relationship between population growth and economic development in a sample of twenty developing countries.[2] These countries appear suitable for testing the alternative hypotheses given their different stages of economic development, population densities, and institutional setups. In addition,

consistent data on both variables are available for these developing countries over a period spanning almost four decades. When testing long-run hypotheses, the availability of a long span of data assumes particular importance. The data are annual (generally over 1950-1996, see details below) and are obtained from the *International Financial Statistics, CD-ROM Database*. In congruence with previous research, we define the two variables by the natural logarithms of population (denoted by P) and the natural logarithms of per capita real GDP (denoted by G). Of course, first-differencing the two variables yields population growth (DP) and the growth rate of per capita real GDP (economic growth, DG).

It is well known that Granger-causality tests require stationary time series.[3] The use of non-stationary variables in any given model leads to the "spurious regression" phenomenon [Granger and Newbold, 1974; Phillips, 1986]. Moreover, Stock and Watson [1989] also show that the usual test statistics (t, F, DW, and R^2) will not possess standard distributions if some of the variables in the model have unit roots and are thus non-stationary. However, Engle and Granger [1987] demonstrate that using stationary series, although desirable, can also filter out low-frequency (long-run) information if the variables are in fact cointegrated. A non-stationary variable, by definition, tends to wander extensively over time, but a pair of non-stationary variables may have the property that a particular linear combination would keep them together, that is, they would not drift too far apart. Under this scenario, the two variables are said to be cointegrated, or possess a long-run (equilibrium) relationship. Examples of possibly cointegrated economic variables are short-term and long-term interest rates, prices and wages, prices and money supply, and consumption and income. Equations estimated with stationary variables but without regards to the underlying cointegration are also inappropriate due to model misspecification (an omitted-variable bias).

Engle and Granger [1987] show that a system of cointegrated variables can be represented by a dynamic error-correction model (ECM). To the model containing stationary variables, we add another regressor; namely, the residuals (lagged once) obtained from the cointegrating (long-run) relationship, called the error correction (EC) term. The coefficient on this EC term reflects the process by which the dependent variable adjusts in the short run to its long-run position. Interestingly, this EC term provides another channel through which Granger-causality can occur *in addition* to the traditional channel through lagged independent variables [Granger, 1986]. It is also possible, though not yet well established in the literature, that the EC term could be used to represent long-run Granger-causality, while the traditional channel represents short-run Granger-causality.[4]

The preceding discussion, then, suggests that we need to begin the empirical analysis by testing for non-stationarity (unit roots) in our variables across countries. To that end, we apply two tests; namely, the Phillips-Perron (PP) and the Weighted-Symmetric (WS) tests. The PP test generalizes the common Dickey-Fuller procedure by allowing for fairly mild assumptions of the distribution of the errors, particularly with regard to serial correlation and/or heteroskedasticity [Enders, 1995]. Pantula *et al.* [1994] have recently reported extensive Monte Carlo evidence supporting the empirical power of the WS test against several alternative procedures. We perform both unit-root tests to guarantee that our inferences on the important issue of stationarity are unlikely to have been driven by our choice of the testing procedures. We determine the proper lag structure on the basis of Akaike's Information Criterion (AIC). In addition, we also check the residuals to ensure that they are free from significant serial correlation.

Once the variables across countries are converted to stationary time series, we then test for possible cointegration between the variables in their non-stationary profile. To that end, we use the Johansen [1988] efficient maximum-likelihood procedure. Studies by Cheung and Lai [1993] and Gonzalo [1994], among others, provide ample evidence supporting the use of the Johansen approach over alternative tests.[5] Whenever cointegration between population and economic development is found, we construct an error-correction model that can capture the short- and the long-run dynamics of the relationship.

EMPIRICAL RESULTS

Table 1 displays the list of countries examined, the time period for each, and the unit root results we obtain from the PP and WS tests. The evidence in the table suggests that, for most of the countries, the two variables achieve stationarity with first-differencing. However, first-differencing fails to induce stationarity in four countries in the sample (Bolivia, Chile, Mexico, and Thailand). According to both the PP and WS tests, the two variables require second-differencing to achieve stationarity in these four countries. Such a finding underscores the risk of uniformly applying the first-difference operator to induce stationarity in *all* economic time series.

Next, we test for possible cointegration and Table 2 reports the results from the Johansen approach.[6] Without exception, the null hypothesis of no cointegration is soundly rejected across all twenty countries examined. Clearly, these results support Simon's [1989] theoretical contention, as they imply the presence of a potent long-run relationship between population and per capita real income in all countries.[7] Therefore, previous studies that ignore the cointegrating relationship binding population with economic development are suspect due to a serious misspecification. Based on these results, we invoke Granger's Representation Theorem and specify ECMs to examine the short- and the long-run intertemporal relationships between population and economic development.

We assemble the results from the ECMs in Table 3. Following recent literature on lag length selections in Granger-causality tests [Hafer and Sheehan, 1991], we employ the Akaike final prediction error (FPE) criterion for determining the proper lag structures in the ECMs.

Consistent with our earlier cointegration findings, the ECMs indicate the presence of potent long-run causal relationships (significant EC terms) across *all* twenty countries. Interestingly, the vast majority of the countries reveal *no* significant short-run causal relationships between population and economic development.[8] Therefore, the empirical evidence from ECMs concur with Simon's theoretical contention that population and per capita real income in developing countries are primarily bound over the longer-run horizon.

TABLE 1
Nonstationarity (Unit Root) Test Results

Country	Period	Variables	PP[Lag]	WS[Lag]
Argentina	1948-96	G	-10.75 [2]	-2.27 [2]
		P	-4.04 [2]	-1.35 [10]
		DG	-47.56 [3][a]	-4.98 [2][a]
		DP	-42.40 [2][a]	-4.03 [2][a]
Bolivia	1960-95	G	-2.88 [5]	-2.15 [5]
		P	-8.54 [2]	-2.17 [2]
		DG	-17.50 [4]	-2.48 [9]
		DP	-17.38 [10]	-2.63 [2]
		DDG	-37.45 [3][a]	-2.97 [3][a]
		DDP	-43.11 [2][a]	-4.05 [3][a]
Brazil	1963-97	G	-2.28 [2]	-0.40 [3]
		P	-0.76 [2]	-0.33 [4]
		DG	-28.84 [2][a]	-2.52 [2][a]
		DP	-11.79 [2][b]	-1.43 [2]
Chile	1960-95	G	-3.37 [2]	-1.95 [3]
		P	-4.42 [2]	-1.79 [3]
		DG	-0.78 [2]	-2.63 [2]
		DP	-12.16 [2]	-2.73 [2]
		DDG	-31.66 [7][a]	-3.38 [7][a]
		DDP	-36.60 [4][a]	-4.86 [3][a]
China	1960-95	G	1.15 [2]	0.81 [4]
		P	-0.20 [8]	-2.08 [8]
		DG	-23.46 [2][a]	-3.53 [3][a]
		DP	-29.21 [7][a]	-2.13 [5]
Ghana	1950-95	G	-1.99 [3]	-2.08 [2]
		P	-8.39 [2]	-9.68 [2]
		DG	-35.54 [3][a]	-3.89 [2][a]
		DP	-34.71 [4][a]	-4.88 [2][a]
Guatemala	1951-96	G	-2.64 [3]	-1.81 [3]
		P	-7.07 [2]	-1.96 [2]
		DG	-22.17 [2][a]	-2.49 [2][a]
		DP	-35.84 [3][a]	-3.30 [3][a]
India	1960-95	G	-3.74 [2]	-1.08 [2]
		P	-14.65 [2]	-2.63 [2]
		DG	-27.46 [6][a]	-4.06 [5][a]
		DP	-38.54 [2][a]	-3.57 [2][a]
Indonesia	1958-97	G	1.04 [4]	-1.11 [4]
		P	-0.55 [2]	-0.003 [4]
		DG	-15.63 [2][a]	-1.05 [4]
		DP	-31.43 [2][a]	-2.67 [2][a]
Mexico	1948-96	G	3.52 [3]	-0.29 [3]
		P	0.99 [9]	-0.01 [10]
		DG	-27.96 [2][a]	-2.59 [5]
		DP	-1.89 [8]	-0.94 [3]
		DDG	-47.76 [3][a]	-4.79 [3][a]
		DDP	-117.78 [7][a]	-3.17 [2][a]
Morocco	1964-97	G	-1.12 [4]	0.03 [4]
		P	-0.69 [2]	0.07 [4]
		DG	-45.10 [2][a]	-2.47 [3][b]
		DP	-27.51 [2][a]	-2.97 [2][a]
Nepal	1960-95	G	-2.47 [2]	-1.12 [2]
		P	-10.47 [4]	-2.67 [2]
		DG	-34.36 [3][a]	-3.80 [2][a]
		DP	-28.17 [3][a]	-3.34 [3][a]

TABLE 1
Nonstationarity (Unit Root) Test Results

Country	Period	Variables	PP[Lag]	WS[Lag]
Pakistan	1953-97	G	-0.54 [2]	0.03 [2]
		P	-4.08 [2]	-1.31 [2]
		DG	-42.77 [2][a]	-4.04 [2][b]
		DP	-43.05 [2][a]	-3.87 [2][a]
Peru	1950-96	G	0.06 [4]	-1.79 [3]
		P	-0.24 [2]	-1.84 [6]
		DG	-53.91 [5][a]	-3.65 [5][a]
		DP	-21.92 [5][a]	-3.07 [0][a]
Philippines	1948-95	G	0.92 [3]	0.99 [3]
		P	1.00 [2]	1.00 [2]
		DG	-24.22 [2][a]	-4.08 [2][a]
		DP	-47.06 [2][a]	-3.98 [2][a]
Sri Lanka	1965-95	G	-1.80 [10]	-1.33 [2]
		P	-6.16 [4]	-0.02 [3]
		DG	-17.64 [2][a]	-3.04 [2][a]
		DP	-18.35 [2][a]	-2.46 [0][a]
Syria	1960-95	G	-6.18 [9]	-1.52 [2]
		P	-17.53 [9]	-2.77 [2]
		DG	-38.46 [2][a]	-2.61 [2][a]
		DP	-37.11 [2][a]	-3.44 [2][a]
Thailand	1950-95	G	-0.55 [10]	0.27 [2]
		P	2.17 [2]	1.47 [2]
		DG	-5.91 [2]	-0.51 [10]
		DP	-10.77 [5]	-0.61 [3]
		DDG	-47.19 [10][a]	-2.60 [10][a]
		DDP	-53.98 [4][a]	-4.78 [4]
Turkey	1960-96	G	-5.89 [9]	-2.12 [2]
		P	2.31 [2]	0.75 [2]
		DG	-32.85 [8][a]	-2.80 [2][a]
		DP	-20.21 [2][a]	-3.31 [1][a]
Uruguay	1955-97	G	1.48 [4]	0.01 [4]
		P	-1.36 [2]	0.76 [4]
		DG	-42.18 [3][a]	-1.87 [2]
		DP	-42.18 [2][a]	-1.09 [2]

PP is the Phillips-Perron test, WS is the weighted-symmetric test, the numbers in brackets are the proper lag lengths chosen by the AIC procedure and serial correlation tests, G is the natural logarithm of per capita real GDP, P is the natural logarithm of population, D is the first-difference operator, DD is the second-difference operator, b indicates rejection of the null hypothesis of nonstationarity at the 10 percent level of significance, and a indicates rejection at the 5 percent level.

TABLE 2
Cointegration Test Results

Country	The Johansen (trace) Test Null Hypotheses	Test Statistics
Argentina	r = 0	24.86[a]
	r ≤ 1	0.11
Bolivia	r = 0	14.13[a]
	r ≤ 1	1.07
Brazil	r = 0	24.48[a]
	r ≤ 1	3.25
Chile	r = 0	16.89[a]
	r ≤ 1	1.77
China	r = 0	15.99[a]
	r ≤ 1	2.04
Ghana	r = 0	23.32[a]
	r ≤ 1	0.33
Guatemala	r = 0	24.15[a]
	r ≤ 1	0.75
India	r = 0	29.19[a]
	r ≤ 1	2.11
Indonesia	r = 0	27.82[a]
	r ≤ 1	5.60
Mexico	r = 0	20.83[a]
	r ≤ 1	1.34
Morocco	r = 0	25.68[a]
	r ≤ 1	4.71
Nepal	r = 0	14.58[a]
	r ≤ 1	2.30
Pakistan	r = 0	26.70[a]
	r ≤ 1	3.10
Peru	r = 0	26.34[a]
	r ≤ 1	0.15
Philippines	r = 0	21.15[a]
	r ≤ 1	3.39
Sri Lanka	r = 0	16.57[a]
	r ≤ 1	2.14
Syria	r = 0	24.97[a]
	r ≤ 1	0.15
Thailand	r = 0	14.47[a]
	r ≤ 1	5.92
Turkey	r = 0	14.36[a]
	r ≤ 1	0.65
Uruguay	r = 0	23.55[a]
	r ≤ 1	8.18

See notes to Table 1. **r** denotes the number of cointegrating vectors.

TABLE 3
Granger-Causality Test Results from ECMs

Country	Dependent Variable	F-statistics for the EC term H_0: No Long-Run Causality	Long-Run paramenters (t-statistics)		F-stastistics for Distributed Lagged Coefficients of Independent Variables [Lag] H_0:No Short-Run Causality
Argentina	DG	5.10[a]	2.11	(2.28)[a]	0.72 [1]
	DP	1.42	—	—	2.74 [2][b]
Bolivia	DDG	0.53	—	—	2.27 [3]
	DDP	3.31[b]	-0.10	(-9.56)[a]	0.26 [1]
Brazil	DG	3.01[a]	1.31	(17.33)[a]	1.68 [3]
	DP	0.005	—	—	0.41 [1]
Chile	DDG	8.35[a]	5.35	(1.68)[b]	2.28 [3]
	DDP	10.43[a]	0.01	(1.61)[b]	1.60 [3]
China	DG	1.54	—	—	1.15 [2]
	DP	7.56[a]	-0.06	(-8.19)[a]	0.22 [1]
Ghana	DG	5.24[a]	0.74	(1.32)	0.47 [1]
	DP	4.97[a]	0.06	(1.49)	1.24 [1]
Guatemala	DG	4.93[a]	8.13	(192.48)[a]	0.44 [2]
	DP	1.54	—	—	2.52 [1]
India	DG	3.84[b]	-7.04	(-3.80)[a]	9.82 [1][a]
	DP	9.80[a]	-0.03	(-2.88)[a]	1.19 [1]
Indonesia	DG	8.94[a]	1.79	(22.87)[a]	1.31 [2]
	DP	0.23	—	—	0.16 [1]
Mexico	DDG	6.55[a]	0.40	(3.03)[a]	1.55 [1]
	DDP	0.88	—	—	0.01 [1]
Morocco	DG	9.20[a]	0.80	(27.79)[a]	0.49 [2]
	DP	5.18[a]	1.20	(27.80)[a]	0.01 [1]
Nepal	DG	0.02	—	—	0.78 [4]
	DP	8.76[a]	0.07	(0.81)	0.87 [3]
Pakistan	DG	4.38[a]	0.74	(1.80)[b]	1.35 [1]
	DP	1.56	—	—	1.09 [1]
Peru	DG	4.58[a]	0.06	(0.69)	1.72 [1]
	DP	27.00[a]	0.31	(0.66)	0.23 [1]
Philippines	DG	4.88[a]	7.55	(7.00)[a]	0.54 [1]
	DP	2.59	—	—	0.07 [1]
Sri Lanka	DP	5.60[a]	-0.93	(-2.93)[a]	0.08 [1]
	DG	0.71	—	—	0.37 [4]
Syria	DP	3.88[b]	0.77	(14.22)[a]	0.09 [1]
	DG	0.55	—	—	2.73 [4][b]
Thailand	DDG	16.40[a]	-1.24	(-3.45)[a]	0.17 [1]
	DDP	0.48	—	—	0.61 [1]
Turkey	DP	5.90[a]	4.53	(3.60)[a]	4.69 [3][a]
	DP	1.59	—	—	2.62 [1]
Uruguay	DG	4.47[a]	1.57	(9.35)[a]	2.07 [2]
	DP	5.32[a]	0.43	(9.36)[a]	1.27 [1]

See notes to Table 1.

With regard to the direction of long-run Granger-causality, the results from the ECMs generally tend to suggest causality flowing from population to economic development. In particular, based on the statistical significance of EC terms, population unidirectionally Granger-causes economic development in more than half of the countries. However, the results appear somewhat mixed since a few countries reveal reverse causality from economic development to population, while others exhibit bidirectional causality. Such lack of a uniform finding on the direction of long-run causality is supportive of Wheeler's [1984] theoretical presumption that the essence of the population/economic development relationship can vary across developing countries, perhaps due to different structural and institutional details. Moreover, these results further suggest that it is improper to assume *a priori* that population growth is an exogenous variable in economic growth models in all countries, as is typically assumed in many previous studies. This is because economic growth is also capable of inducing demographic changes in some countries, and it is also possible that endogeneity characterizes both variables in other countries, as evident in our results.[9]

In addition to addressing the pattern of directional causality, the estimated ECMs may also provide information on the nature (positive or negative) of the long-run causal linkages. Given the presence of potent cointegrating relationships between population and per capita real income across all countries, we focus on the sign of the long-run parameters in the significant cointegrating vectors. These results show that in the majority of cases (14 out of 20 countries), higher population growth leads to higher long-run economic growth [these countries are Argentina, Brazil, Chile, Ghana, Guatemala, Indonesia, Mexico, Morocco, Pakistan, Peru, Philippines, Syria, Turkey, and Uruguay].[10] Thus, labor participation in these countries seems to be a key determinant of their overall productive capacity. Rapid population growth can also significantly enlarge the breadth and depth of domestic markets, encourage further economies of scale, and induce technical improvement. Clearly, our finding of a positive long-run causal effect of population on economic growth in the majority of our sample countries is supportive of the Revisionistic view and of its presumption that policies in these countries should not aim at curtailing population and discouraging fertility since that would hurt, rather than improve, living standards.

Of course, the same policy prescription cannot be applied uniformly across all countries in the sample. For example, our results for two countries (Sri Lanka and Thailand) suggest that population growth exerts unidirectionally a significant negative long-run impact upon economic growth in accordance with the Orthodox view.[11] Several factors may be responsible for such a negative role of population expansion in economic development. For example, an extremely high population density combined with a general lack of adequate resources outside the labor sector (a rapidly declining capital to labor ratio) can partly explain the negative economic impact of population. Another possible reason, as Miller and Van Hoose [1998] contemplate, could be the failure of governments in densely populated countries to grant sufficient economic freedom to their citizens (e.g., the rights to own private property and to engage in trade with minimal government controls). Thus, high rates of population growth, when combined with economic coercion, can depress living standards.

As we stated earlier, results from the ECMs indicate that a reverse causal impact (from per capita real income to population changes) is present for a few countries. Of these countries, China and India (both densely populated and with mediocre property rights) show highly significant long-run reverse causality (at the 5 percent level). Moreover, the long-run causal effects are negative in both countries. This implies that current family planning and birth control policies in China and India may not necessarily contribute to their economic well-being. Rather, the results suggest that promoting faster economic growth in both countries is an important step towards curbing their population size. Interestingly, these results are consistent with Becker's [1981] hypothesis that as per capita income rises, families tend to prefer quality over quantity of children. The resultant increase in the cost per child would then induce smaller family sizes, and consequently fertility declines.

Finally, our results further suggest, in accordance with the "Transition" theory, that the pattern of causal relation between population growth and economic growth across counties appears somewhat sensitive to the stage of economic development. In particular, with a few exceptions, the majority of the middle-income group exhibit causality from population to per capita income. In contrast, most low-income countries in our sample generally show evidence of reverse causal effects running from per capita income to population. Thus, at the early stage of development, it appears that rapid population growth is merely a consequence of the country's poverty. However, as the economy develops, the size of population tends to become an exogenous factor and plays an independent role in the economic growth process.[12]

CONCLUSIONS

This paper uses the cointegration and error-correction modeling technique to investigate the intertemporal relationship between population and economic growth in the case of twenty developing countries. While the majority of previous studies on the demographic-economic relationship focused their attention simply on whether the variables are correlated, two recent studies examined the more pertinent issue of causality [Jung and Quddus, 1986; Kapuria-Foreman, 1995]. However, both studies appear flawed, for they did not investigate the stationarity of their time series prior to causality testing and, perhaps more critically, they did not consider possible cointegratedness underlying the process. This latter aspect is particularly critical in light of Simon's [1989] theoretical argument that population and economic development should be expected to possess a long-run (rather than a short-run) relationship.

Our empirical results from the Johansen efficient test of cointegration as well as from error-correction models provide decisive support for Simon's theoretical contention. Across all twenty countries examined, the results reveal the presence of a potent cointegrating (long-run) relationship between population and economic growth. Therefore, failure to account for such a pronounced long-run linkage between population and economic growth in developing countries can lead to serious biases and incorrect inferences.[13] Also consistent with Simon's theory, the short-run relationships prove very tenuous in the vast majority of the developing countries studied.

As to the direction of causality between the two variables, the body of evidence tends to support the view that higher population spurs economic development, at least in more than half of the countries examined. Nevertheless, other patterns of causality (reverse and bi-directional) still characterize several countries in the sample. Therefore, our results lend some credence to Wheeler's [1984] contention that no uniform policy conclusion can be derived for the population/economic development relationship across countries with different institutional setups. The results also seem to suggest that in the early stage of economic development, population expansion is more a consequence rather than a cause of poverty. However, as the country develops economically, the size of its population tends to assume a more independent (exogenous) role in the economic growth process. This implies that appropriate policies in any given country may be critically contingent upon the particular stage of its economic development.

NOTES

We wish to thank the editor, an anonymous referee of this *Journal*, and John Barkoulas for several helpful comments and suggestions. The usual caveat applies.

1. Besides overlooking cointegration, another problem with both studies is the absence of any explicit evidence on the stationarity of the variables used. We provide further discussion of this below.
2. These twenty countries include those examined by Kapuria-Foreman for comparability. Moreover, we expanded the data period for each country in the Kapuria-Foreman sample in order to enhance the reliability of the results. See Hakkio and Rush [1991] for the need of a long span of data in cointegration tests. Note that using data periods similar to Kapuria-Foreman's leaves intact all conclusions reached in the text. (These results are available upon request). Our sample includes only one country from Sub-Saharan Africa (Ghana) due to data limitations; and since Bangladesh's 1971 independence, data for Pakistan refer to West Pakistan. We also focused on population and per capita income using bivariate models to keep our tests simple and manageable. However, incorporating more variables (like policy reform or commodity prices) and performing the tests in a multivariate context seem fruitful, albeit difficult due to data unavailability for many countries in the sample.
3. A variable becomes stationary if its stochastic properties (mean, variance, and covariance) are time invariant.
4. See Jones and Joulfaian [1991] and Granger and Lin [1995] for useful discussion and some caveats.
5. To check the robustness of our results, we also tested for cointegration using the simple Engle and Granger [1987] two-step procedure. Generally, the Engle-Granger test yielded qualitatively similar (though not identical) conclusions to those obtained from the Johansen test. Observe that the Engle-Granger procedure suffers from many problems, including poor finite sample properties. [Enders, 1995].
6. Cheung and Lai [1993] reported extensive Monte Carlo evidence in support of the trace version over the maximal eigenvalue version of the Johansen test, particularly under conditions of non-normality. Therefore, and following Harris [1995], we only discuss here inferences from the trace test. Note that the cointegration tests are performed on the non-stationary form of the variables (i.e., for the I(1) series, the tests were run on the *levels* of the data).
7. Strictly speaking, long-run relationships for countries with I(2) variables are between the growth rates (not the levels) of the variables.
8. Among all countries in the sample, only India and Turkey yielded significant (at 5 percent level) evidence for a short-run relationship between population and economic development.
9. We derived a similar conclusion from tests of the common long-memory components of the cointegrated vector [Gonzalo and Granger,1995]. In particular, the test results are not consistent across countries

as to whether population or economic development is the *sole* force driving the cointegrating space. These results are available upon request.

10. Clearly, such causality inferences ignore several important details of the countries studied, including the initial sizes of population and the sizes of their economies.
11. One explanation for the alternate sign of the long-run relationship may be in the possibility that the cointegrating relationship is non-linear. To address this possibility, we included a quadratic EC term in the ECMs to approximate the non-linear relationship as suggested by Muscateli and Papi [1990]. However, none of these quadratic EC terms proved statistically significant.
12. Given the finding of potent cointegrating relationships across all countries, it may also be useful to estimate the convergence speed (length of time) of such long-run impacts. Following Pindyck and Rubinfeld [1991] and Obstfeld and Taylor [1997], we calculate the half-life (median lag) underlying the significant long-run impacts which measures the number of years required to complete half of the long-run adjustment. It is calculated as [log(1/2)/logλ] where λ is the estimated coefficient from an AR1 of the error term in the cointegrating relationships. The results show that the convergence speed greatly varies across countries, and is in the range of many months to several years. For example, while the half-life is estimated at about two years for Argentina, China, Ghana, Guatemala, and the Philippines, it is only one half year for Bolivia, Mexico, and Thailand; but for Peru, Sri Lanka and Syria, the half-life estimate is almost four years.
13. Using a longer time span covering a century's worth of data is likely to prove more fertile for testing Simon's hypothesis. Such data may exist for many industrialized countries like the U.K. or the U. S. and is worth pursuing in future research.

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