FERTILITY, HUMAN CAPITAL, AND MACROECONOMIC PERFORMANCE: LONG-TERM INTERACTIONS AND SHORT-RUN DYNAMICS

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1. Introduction

The relation between fertility and economic development has attracted an outpouring of research [see, for example, Perlman (1975); McNicoll (1984); Chesnais (1987); Simon (1989); Blanchet (1991); and Barlow (1994)]. Although the literature advances many explanations and conclusions regarding this relation, not one of them is unanimously accepted.

Theoretically, there are three alternative views regarding fertility (population)/ economic development nexus [Hodgson (1988) and Blanchet (1991)]. The first is the "Malthusian" or "Orthodox" view that rapid population leads to poverty primarily because population expansion implies a declining capital to labor ratio and leads to chronic food shortages and foreign exchange bottlenecks. These negative economic consequences of population growth become much more apparent, some researchers contend, when governments in densely populated countries fail to grant sufficient economic freedom to their citizens (e.g., the rights to own private property and the right to engage in trade with minimal government controls). Thus, high rates of population growth may depress living standards, particularly if combined with economic coercion. Judged by recent news bulletins and conferences organized by the Economic Research Forum (ERF) [e.g., ERF's *Newsletter*, December 1998/January 1999], many countries in the MENA (Middle East and North Africa) region show genuine concerns about the possible deleterious economic consequences of high fertility (population expansion). Under this pessimistic "Orthodox" scenario, family planning to control (or limit) fertility becomes a proper national policy to spur economic growth, especially in over-populated areas.

Of course, population expansion may not necessarily retard economic growth. In the theoretical models proposed by Becker *et al*. (1990), Tamura (1994), and Beauchemin (2001), higher fertility might promote growth depending on key parameters in the theoretical model. Models advanced by these authors show that expanding population can induce higher labor participation and may thus enhance the overall productive capacity of the nation. Population growth may also enlarge the breadth and depth of domestic markets, encouraging more economies of scale. In the words of Adam Smith (1976), "The most decisive mark of the prosperity of any country is the increase in the number of its inhabitants". This proposition receives conceptual and empirical support from Ram and Schultz (1979). Using data from the populous India, Ram and Schultz report that higher population tends to enhance (rather than inhibit) economic growth through stimulating savings and capital formation. More recently, Galor and Weil (2000) outline a theoretical paradigm, which they call "the Post-Malthusian Regime," where higher population growth rates produce rising national income. Under this scenario, public policies should not aim at curtailing population and discouraging fertility since this would hurt, rather than improve, living standards. Indeed, theory is as consistent with positive effects of population expansion on economic growth as it is consonant with negative economic consequences.

Another interesting feature of the literature is that demographic forces are typically assumed exogenous to economic development. It is possible, of course, that population expansion itself is driven by income changes and, as such, countries would have larger population but only as a result of being economically poor. In other words, rapid population growth is a consequence, rather than a cause, of poverty. If this notion were valid, family planning and birth control policies would not necessarily promote economic growth. Rather, promoting economic growth (e.g., improving the technical skills of the labor force) is the correct policy action in order to curb population expansion. Indeed, Becker's (1981) theory is consistent with this line of reasoning since it hypothesizes that, with rising per capita income, families tend to prefer quality over the quantity of children and thus become willing to invest more on their children's education, health and other related needs. The resultant increase in the per-child cost should induce smaller family sizes and push the fertility rate down. Hence, improved economic conditions themselves lead to a slower population growth.

The preceding discussion clearly suggests that a fruitful inquiry into the fertility/ economic development nexus should focus not on whether these two variables are correlated over time or across countries. The emphasis should instead be on the pattern of directional causality between them. Thus, simple statistical associations in most previous studies in this area are inadequate to identify the cause-and-effect relationship between population size and economic growth. Consequently, a central objective of this empirical paper is to take a fresh look at the casual link between fertility and economic growth.

Moreover, our paper aspires to make two additional contributions. First, in studying the relation between fertility and economic development, it seems that the dimension of human capital (educational attainment) should not be ignored. Established theoretical reasoning suggests that human capital influences demography as well as economic growth. Specifically, the endogenous growth theory argues that a rapid accumulation of human capital can spur economic growth, and numerous recent studies provide support for this hypothesis [Lucas (1988), Romer (1989), and Fafchamps and Quisumbing (1989)]. Improved educational levels enable the population to acquire more knowledge and sharper skills that provide economic benefits both to the individual (higher earning and job security), as well as to the society as a whole (higher productivity and sustained economic growth). A recurrent puzzle in early research on Cobb-Douglas production functions is the finding of an implausible coefficient of the capital input that is too large to be consistent with the common assumption of a constant return-to-scale. Barro and Sala-i-Martin (1992) assert that part of this unreasonably large coefficient could reflect the effect of a missing variable in the traditional Cobb-Douglas specification; and suggest that this missing link is human capital. Mankiw *et al*. (1992) and Jorgenson and Stiroh (2000) support that line of thinking and argue that human capital is a major contributor to economic growth in the U.S. as well as in many other nations. In fact, empirical support for a strong positive correlation between human capital and economic growth is very impressive [Barro (1991), Jorgenson and Fraumeni (1992), Benhabib and Spiegel (1994), Bashir and Darrat (1994), Barro and Sala-i-Martin (1995), and Sala-i-Martin (1997), among others]. Of course, the possible contribution of human capital is not restricted to the macro performance of nations. As recent findings from the human resource literature suggest, human capital accumulation is also vital for firm outcomes and individual welfare [Huselid (1995), Pennings *et al.* (1998), Fafchamps and Quisumbing (1999), and Hitt *et al.* (2001)]. In this paper, we attempt to investigate whether the results in support of human capital at the micro level can be generalized to the overall macro level in a sample of developing countries.

Another interesting aspect of many previous studies in this area is their misplaced emphasis on the correlation between human capital and growth, which has no bearing on whether human capital "causes" growth. Indeed, Bils and Klenow (2000) recently propose a theoretical framework in which economic growth stimulates the accumulation of human capital. Economic prosperity improves the scope and breadth of the material resources available for the promotion of human development. Bils and Klenow's posture is that higher growth operates similar to lower market interest rates. That is, when people receive higher income, they tend to place more weight on future human capital, i.e. more schooling. Bils and Klenow examine the validity of this hypothesis across several developed and developing countries. They find that the commonly hypothesized effect from schooling (human capital) to economic growth is very weak and explains only a small fraction of the observed correlation between the two variables. Bils and Klenow suggest instead that much of the observed correlation in their sample is consistent with the alternative hypothesis that economic growth drives the accumulation of human capital. Becker's (1981) theory can also be extended to rationalize the presence of this reverse effect from improved economic conditions to the accumulation of human capital (better quality of children). With economic prosperity, families become more able to afford the full cost of bearing children and their education needs, and governments too will be able to finance more and better-equipped institutions of learning.

In sum, while human capital is potentially an important growth ingredient, the reverse is equally plausible whereby higher economic growth and the concomitant enlargement in available resources can itself enhance education, both in numbers and in quality. Similar bi-directional causality could also characterize the relation between human capital and fertility. In particular, a rapid population expansion could hamper the process of human capital accumulation due to the consequent demand pressures on scarce educational resources and infrastructure. However, a counter theoretical argument can also be advanced in which fertility itself tends to rise in families with poor educational backgrounds. As Backer *et al*. (1990) contend, with scarce human capital, rates of return from working children tend to be higher than the rates of return from investing in human capital, and the reverse is equally likely when human capital is abundant. Under this hypothesis, countries with limited human capital are expected to have sizable families and larger population. Lam and Duryea (1999) report results supportive of this hypothesis. Accordingly, this paper examines the possibility of a *triangular* causal interrelationship among population size, human capital accumulation, and economic performance. Focusing on only two of the three elements of this triangular, as in most previous bivariate studies, appears seriously flawed and could lead to incorrect inferences due to a an omitted variable bias.

Another contribution of this paper is the emphasis it places on whether there is a reliable long-run relation linking together the three main variables of the model. Generally, existing studies on the fertility/economic growth nexus, and/or on the human capital/economic growth relation confine their attention to short-run dynamics and overlook possible long-run (cointegrating) relationships binding the variables of interest. This deficiency in previous research is especially critical in light of Simon's (1989) well-known hypothesis that population and economic development are primarily related over the long-run horizon, and possess little or no tendency for a short-run relationship. According to Simon, 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. Thus, simple regressions of previous studies are likely biased and perhaps unable to reveal the true and complete relation between population and economic development. Similar arguments can be made regarding the long span of time required for the accumulation of human capital to exert its influence upon economic growth. Indeed, as Miller and VanHoose (2001) suggest, the endogenous growth theory implies that human capital and economic growth are related primarily in the long run.

The rest of the paper is structured as follows. Section 2 outlines the research design and testing procedures. Section 3 discusses the data and the behavior of key economic indicators of the countries studied. Section 4 addresses long-term interactions among the variables, while Section 5 focuses on short-term dynamics. Section 6 concludes and offers policy implications.

2. Research Design

The paper focuses on long-term interrelationships and short-term dynamics among fertility, human capital, physical capital, and economic growth in selected developing countries. For testing causality, we use the procedure originally proposed by Granger (1969) that has since been extensively used in applied economics and finance literature. Briefly, a stationary time series (x_t) is said to Granger-cause[1] another stationary time series (y_t) if the prediction error from regressing (y_t) on (x_t) significantly declines by using past values of (x_t) along with past values of (y_t). Clearly, Granger-causality tests require stationary variables whose stochastic properties (mean, variance, and covariance) are time invariant. The use of non-stationary variables can lead to spurious regressions [Granger and Newbold (1974), and Phillips (1986)]. Stock and Watson (1989) also show that the usual test and diagnostic statistics (t, F, DW, and R^2) become invalid with non-stationary.

[1] We attach the name "Granger" to "cause" since controversy still surrounds the Granger concept of causality, which differs from the definition of causality in the strict philosophical sense. Indeed, Granger-causality tests are essentially tests of the "incremental predictive content" of economic time series. See Bishop (1979).

Granger (1986) shows that a non-stationary time series (Z_t) can achieve stationarity if differenced appropriately. The appropriate number of differencing is called the order of integration. Hence, Z is said to be integrated of order d (contains d unit roots) if it becomes stationary after being differenced d times, denoted as $Z \sim I(d)$. To determine the proper order of integration for any variable in the model, we use the Perron-Phillips (PP) and the Weighted-Symmetric (WS) testing procedures. The PP is a generalization of the augmented Dickey-Fuller procedure and is a robust test under conditions of serial correlation and time-dependent heteroskedasticity [Enders (1995)]. On the other hand, Pantula *et al.* (1994) report Monte Carlo results supportive of the empirical superiority of the Weighted-Symmetric test over several alternative tests of unit roots, including the augmented Dickey-Fuller test.

Converting the data to stationary series, although desirable, can also filter out low-frequency (long-run) information if the variables are in fact cointegrated. Consequently, equations estimated with stationary data, but without regards to possible cointegratedness are inappropriate due to an omission-of-variable bias. Non-stationary variables, by definition, tend 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 do 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.

To test for possible cointegration among the variables, we use the Johansen and Juselius (1990) efficient maximum-likelihood approach [see Harris (1995) for an elaborate account of this test]. Work by Cheung and Lai (1993) and Gonzalo (1994), among others, provides ample evidence favoring the JJ approach over the common two-step test of Engle and Granger (1987). Unlike the JJ approach, the Engle-Granger test suffers from poor finite sample properties and also exhibits low empirical power [Kramer *et al.* (1992), and Inders (1993)]. Moreover, the Engle-Granger test requires normally distributed errors [Noriega-Muro (1993), and Johanson and DiNardo (1997)], whereas the JJ test does not [Cheung and Lai (1993), and Johansen (1995)]. While most of the advantages of the JJ test are realized in multivariate models (that could possibly possess more than one cointegrating vector), Enders (1995) presents arguments in support of the JJ test over the Engle-Granger procedure even in bivariate models. Following tests of cointegration, we also use the Gonzalo and Granger (1995) approach to investigate whether a given variable in the model (say, human capital or population growth) is the main force driving the equilibrium (cointegrating) relation in the system.

3. Description of Data and Summary Statistics

3.1. An Historical Account

Our empirical analysis is based on annual, as well as quarterly, data over an 18-year period spanning 1980-1997, the longest possible time series for which data are available on all variables. The sample consists of four developing countries in the

Middle East and North African (MENA) region; namely, Jordan, Tunisia, Turkey, and Saudi Arabia. Among many other MENA countries, these four countries are appropriate for our analysis partially due to the availability of consistent data on all variables of the proposed model. Moreover, these four countries come from different parts of the MENA region, they exhibit a diversity of institutional and political set-ups, and they are also in different stages of economic development as we explain below. Therefore, it is hoped that studying the four MENA countries would provide inferences that are generalizable to other countries in the region. The discussion below provides further explanation.

During the estimation period, per capita incomes across the four MENA countries exhibit large variations, ranging from a low of $1,210 for Turkey, to a high of $8,198 for Saudi Arabia (per capita incomes are $1,270 for Jordan and $1,475 for Tunisia). The four countries also differ in regards to their physical capital infrastructures, whereby the shares of physical capital per person are relatively low in Jordan ($365), in Tunisia ($381), and in Turkey ($465), but quite high in Saudi Arabia ($1,816). As to population size (1997 estimates), Turkey has the largest population of 63 million people, while Jordan has the smallest population with 6 million (Tunisia has 9 million, and Saudi Arabia has 20 million).

In addition, the sizes of the real economies in the four MENA countries are also quite different. Turkey and Saudi Arabia possess by far the largest of the four MENA real economies, whose annual averages of real GDP (in 1995 prices during the estimated period of 1980-1997) are $135 billion and $120 billion, respectively. By contrast, the annual average of real GDP in Tunisia is $17 billion, and Jordan's annual average real GDP is only half as much at $8 billion. It is important to note that, over the estimation period 1980-1997, only Turkey enjoyed real economic growth, whereby her real GDP grew annually by 4.75 percent. The remaining three MENA countries were not as blessed. During the same period, Tunisia and Jordan suffered a negative real growth of more than 2 percent annually (-2.42 percent for Tunisia, and -2.23 percent for Jordan), and Saudi Arabia too sustained a negative real growth of -1.02 percent annually.

Observe, however, that the feeble economic performance of Jordan, Tunisia, and Saudi Arabia was confined to the years of the 1980s. All three MENA countries were inflicted with devastating recessionary conditions during 1980-1989, whereby their annual real GDP significantly plummeted by an annual average of -6.65 percent in Saudi Arabia, -6.38 percent in Jordan, and -5.87 percent in Tunisia. However, the three MENA countries then remarkably recovered. During 1990-1997, their real GDP positively grew by an annual average of 5.31 percent in Saudi Arabia, 2.44 percent in Jordan, and 1.46 percent in Tunisia. As these figures suggest, the countries that extensively suffered in the 1980s, they also gained the most in the 1990s.

Although several factors may explain this varied performance between the 1980s and 1990s, one plausible explanation may lie in the dramatic change in the world price of oil over these two periods. The world price of crude oil (in 1996 U.S. dollars) plummed from $54 per barrel in 1981 to as low as $16 per barrel in 1989. After that, and mainly as a result of uncertainty in the world oil market due to the Iraqi invasion of Kuwait and the ensuing Gulf War, the real price of crude oil began its upward spike, recovering to about $28 in 1996-1997. Of course, oil revenues are critical for the economic well being of the MENA region. This is particularly so for oil-producing countries like Saudi Arabia. In addition, spillovers from oil revenues have tremendous effects on other countries in the region, either directly through government grants and loans from oil-producing countries, or indirectly through increased capital flows and labor remittances [see Metwally and Rammadhan (2000) for further details]. Therefore, the severe decline in oil prices in the 1980s, and then their surge in most of the 1990s could explain, at least in part, the starkly different economic performance of the MENA countries over these two time periods.[2]

3.2. Variable Definitions and Data Sources

The theoretical model under study comprises four main variables. These are real output (RY, as measured by real GDP in millions of 1995 U.S. dollars), the accumulation of human capital (HC), and physical capital (PC, gross fixed capital formation, in millions of 1995 U.S. dollars). We include physical capital in the model since it represents another potentially important ingredient in the growth process. For fertility, adequate and consistent data are unavailable for all four MENA countries. In the absence of significant changes in migration and mortality in the MENA region during the sample period, we provisionally use population (POP, in millions) to represent fertility.

Except for human capital, all data series come from the *International Financial Statistics CD ROM* (produced by the International Monetary Fund). As to data on human capital, they are compiled from various sources, including *World Development Indicators 2000* (from the World Bank); *World Data on Education* (from the International Bureau of Education, UNESCO); *Indicators on Literacy* (from the United Nations, Statistics Division); and *International Data Base* (from the U.S. Bureau of Census). While data on RY, POP and PC are straightforward, data on HC may require some further discussion.

In his pioneering work, Schultz (1961) theorizes that human capital can be approximated by improvement in labor quality through formal education. Therefore, and following Tallman and Wang (1994), Jorgenson and Stiroh (2000), and Hanushek and Kimko (2000), we approximate human capital in this paper by the educational-induced quality improvement in the labor force of the four MENA countries. Therefore, to the raw labor input, we add education attainment gained from primary school and tertiary enrollments. This human capital enhanced-labor index [also called "effective labor" by Tallman and Wang (1994) or "labor-force quality" by Hanushek and Kimko (2000)] assigns the weight of 1 to workers completing only a primary education, and weights higher than 1 for those workers completing higher

[2] The dramatic change in oil prices between the 1980s and 1990s did not markedly impact the Turkish economy, which continued to register positive annual real growth rate of 4.70 percent and 4.82 percent during 1980-1989 and 1990-1997, respectively. For further discussion of key economic indicators in the MENA region, see ERF (2000).

education (university levels). We experimented with various weights for workers with higher education attainments and found the weight of 8 to yield the best empirical results across the countries.[3] Note the models also include population as a separate variable, which is highly correlated with raw labor. Therefore, our estimates of the effect of human capital (quality-adjusted labor) should primarily reflect the quality of labor component of the measure. Of course, as with all econometric measurements, the construct we use here for human capital may not entirely or precisely reflect the true concept of human capital as commonly conceived (i.e., in terms of knowledge, skill achievements, and/or job training).

A final comment pertains to the construction of quarterly figures from the corresponding annual series. In time series analysis, the use of lags is necessary in most statistical tests (e.g., cointegration tests and causality tests). Therefore, it is important to use a sufficiently large sample to ensure the reliability of statistical results. Whenever extending the sample size by enlarging the time span is not possible (as is the case at hand), using shorter time frequencies (e.g., quarterly instead of annual) enhances the degrees of freedom in our estimates. Therefore, we use a quadratic interpolation technique outlined in Arize (1997) to obtain the corresponding quarterly figures.

4. Long-Term Interactions

4.1. Unit Roots Test Results

As mentioned earlier, the first step in our empirical analysis is to test whether the variables of interest contain unit roots, and are thus nonstationary.[4] Table 1 reports the results from the Phillip-Perron and the Weighted-Symmetric tests over the quarterly period 1980-1997 for the four MENA countries. As can be seen from the table, both tests consistently suggest that the levels of the variables in all countries are nonstationary. However, the variables become stationary when converted to first-differences, suggesting that each is integrated of order one [denoted as I (1)].

4.2. Cointegration Tests Results

Since the log-levels of the variables in each country exhibit unit roots, our next task is to check whether these variables share one or more unit roots, in which case they can be considered cointegrated. We use the maximum-likelihood efficient approach

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[3] As in Tallman and Wang (1994), we use a transformation function relating human capital to the educational level or labor skill proxy. That is, the human capital index, $HC = E^{\delta}$, where E is the measure of education level and δ is the return to education relative to raw labor input. One way to select the proper value of δ is by choosing that value for which the average annual growth rate of the effective labor input is equal to the average annual growth rate of the physical capital input over the estimation period. Note that other measures of human capital exist in the literature. However, we felt that the emphasis Tallman and Wang's measure gives to education- induced improvement in labor is an intriguing aspect. See also Jorgenson and Stiroh (2000) and Hanushek and Kimko (2000) for further discussion on the advantages of the measure used in this paper.

[4] We express the variables in logarithms to stabilize their variances over time. This transformation is also reasonable from a theoretical standpoint since logarithmic first-differences approximate percentage changes (growth rates).

of Johansen and Juselius (1990, JJ) to test for cointegration among the four variables in each of the four MENA countries, and report the results for the four MENA countries in Table 2. The results in Panel A for the quarterly period 1980-1997 clearly suggest that there is a robust cointegrating relation binding the four variables in each of the four countries at least at the 95 percent level of significance. Therefore, it can be concluded that real output in each of the four MENA countries is reliably linked in the long run to fertility, the accumulation of human capital, and physical capital. Of course, the presence of such a strong cointegrating relationship also implies, through the Granger's (1986) Representation Theorem, that there must be causality among the variables flowing in at least one direction, a key implication that will be discussed in more detail later in the paper.

Given the critical importance of the cointegration finding, we examine the reliability of the evidence on two fronts. First, we check whether the above strong cointegration inferences are sensitive to using annual (instead of quarterly) data? To do that, we apply the JJ test on the variables measured annually over the same estimation period (1980-1997), and Panel B in Table 2 reports the test results for the four MENA countries. The results there continue to support the presence of a significant cointegrating relationship across all four countries. This evidence provides support for the earlier conclusion derived from the quarterly data. They further indicate that there is one significant cointegrating vector linking the four variables in the case of Tunisia and Turkey. However, there appear to be two or more significant vectors for Jordan and Saudi Arabia. Of course, having several significant cointegrating vectors implies additional strengths for the underlying long-run relationships and suggests that the cointegrating relations are robust in more than one direction [see Dickey *et al*. (1991)].

Second, we also investigate whether the cointegrating relationships that we find in the MENA region are stable across time. An unstable cointegrating relation, even if statistically significant, would lose much of its appeal for policy purposes. We employ the recent technique of Hansen and Johansen (1999) to test for parameter constancy (stability) of the cointegrating relationships. We plot the corresponding likelihood-ratio statistics of the Hansen-Johansen test in Figure 1 for the four MENA countries. Scaled by the 5 percent significance level, computed statistics that exceed one imply rejection of the null of constancy. As can be seen from the figure, the cointegrating relationships appear stable in the four MENA countries since the calculated statistics remain far below the significance line. The only exception is perhaps for Saudi Arabia where the statistics show some tendency towards significance around 1990. That particular year corresponds to the beginning of the second Gulf War (the Iraqi invasion of Kuwait) which understandably resulted in a major shake up, especially for a Gulf country like Saudi Arabia with its close proximity and strong cultural and economic ties to Kuwait. However, as the figure also shows, the turbulence resulting from the war started abating in 1991 and became almost non-existent by the mid 1995. The Hansen-Johansen test further suggests that the Gulf War did not apparently have noticeable impact upon the other three MENA countries, at least in terms of the relationship linking population, human and physical capital with economic growth in the region.

4.3. Driving Force Tests Results

The presence of strong cointegrating relationships among real output, human capital, population, and physical capital do not, by themselves, provide information on which of these variables drive the long-run relationships in the four MENA countries. Important insights on this issue can be obtained from the Gonzalo and Granger (1995, GG) test of the common long-memory components of cointegrated systems.

The likelihood Ratio (LR) statistics of the GG test using the quarterly data are reported in Table 3. The results reported in Panel A focus on the relation of human capital to economic growth in the context of bivariate models. Since bivariate models may distort inferences due to possible biases from omitting other variables, Panel B in the table reports the results from multivariate models that allow all variables to exert their effects simultaneously. The results in both panels robustly suggest that human capital is a significant force driving long-run relationships in *all* four MENA countries. As Panel A shows, the null hypothesis that human capital is not a dominant force in the cointegrating vectors is rejected at the 5 percent level of significance in all four countries. In the context of multivariate models, the results continue to support a pivotal role of human capital in all MENA countries.[5] This finding is yet another testimony in support of the powerful contribution of human capital accumulation in promoting long-term growth process in the countries studied.

While human capital is a significant long-run growth factor across the four MENA countries, the role of physical capital and population varies. In particular, population is an essential engine of growth in Jordan, Tunisia, and Turkey, but not in Saudi Arabia. And physical capital is a key long-run growth ingredient for Jordan, Tunisia, and Saudi Arabia, but not in Turkey. It is important to note that a significant effect of physical capital on economic growth strengthens the verdict that human capital is a key growth ingredient in the region. As Barro (2001) explains, higher accumulation of human capital increases the absorption of technology, which in turns enhances the level of physical capital and promotes economic growth. Thus, a significant impact of physical capital supports a positive role of human capital in economic development. Ladron-de-Guevara *et al*. (1997) extend the Lucas model and demonstrate that physical and human capital complement each other in the growth process and Romer (1990) argues that human capital impacts economic growth through the physical capital channel. Of course, besides this indirect channel, human capital has its own independent and direct effect on economic growth [Gemmell (1996)]. Our results from testing cointegration and driving forces support Gemmell's contention since human capital maintains its significant role even after controlling for the effect physical capital in the model. If human capital were to influence economic growth only indirectly through its impact on physical capital, human capital should have proven statistically insignificant whenever physical capital appears in the model. As we learned from our earlier cointegration and driving-forces tests, this is not the case as human capital does maintain its significant impact upon economic growth even in the presence of physical capital in the model.

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[5] For Tunisia, the null is rejected only at the 15 percent level of significance.

4.4. Results from Decomposing Forecast-Error Variances

The cointegration approach is useful for checking if there exists a stationary, long-run, equilibrium relationship linking real output with fertility, human capital, and physical capital in the MENA countries. As Sims (1980) and Friedman and Kuttner (1992) argue, another important issue concerns the dynamic adjustments necessary to maintain these long-run relationships in the face of shocks to the cointegrated system. Evaluating the dynamic adjustments is an important metric for studying the interrelationships among the variables in the system and in determining the relative importance of some variables in forecasting *ex post* movements in others.

We partition the variance of the forecast error of real output in each country into percentages attributable to a one standard-deviation innovation (shocks) in each of the other three variables in the system (human capital, population, and physical capital) over twenty-quarter (5-year) horizons. Since the innovations across the various equations may be significantly correlated, the interpretation of the variance decompositions (VDCs), as capturing the effect of one variable while holding constant all other variables, could be misleading. Following the literature in this area [see Enders (1995)], we orthogonolize the innovations using the Cholosky decomposition method.[6]

Table 4 assembles the results of decomposing the forecast-error variance of real output in the four MENA countries. It is both encouraging and reassuring that the computed VDCs are broadly consistent with those obtained from the cointegration and driving-force tests. Particularly for Jordan, Saudi Arabia, and Turkey, human capital shocks dominate shocks in population and physical capital as a key source of the forecast-error variance of real output in the three countries. Taking Jordan as an example over an 8-quarter (2-year) horizon, 62 percent of the forecast-error variance (FEV) of real output can be attributed to a one standard-deviation shock in human capital, compared only to 3 percent and 5 percent of the FEV of real output due to similar shocks in population and physical capital, respectively. When the forecasting horizon extends beyond 2 years, the explanatory power of population shocks also increases, reaching 18 percent for a 5-year horizon. However, the forecasting powers of shocks in both human and physical capital do not change over time and in fact remains essentially the same.

We observe again that the dominant role of human capital in explaining the forecast-error variance of real output is not unique with Jordan, but is also apparent in the case of Turkey and Saudi Arabia as well. Specifically, a one standard-deviation shock in human capital in Turkey explains, using a 2-year forecast horizon, almost 8 percent of FEV of her real output, compared to nearly 0 percent and 4 percent of FEV of real output, respectively, for similar shocks in population and physical capital. As the forecasting horizon expands to 5 years, the forecasting power of human capital also increases to reach almost 12 percent, while those of population and physical capital remain relatively small at 4 percent and 5 percent, respectively. And for Saudi Arabia

[6] As in Lutkepohl and Riemers (1992), we use the Gaussian VARs of the cointegrated systems to compute the VDCs.

as well, the share of real-output variance accounted for by shocks in human capital over a 5-year horizon (=9 percent) easily dominates the variance's shares due to shocks in population (=4 percent), or in physical capital (=5 percent).

Turning to the VDCs for Tunisia, the results indicate that population, rather than human or physical capitals, explains a larger proportion of the variance in real output. Over alternative forecasting horizons, a one standard-deviation shock in population is responsible for an average of about 19 percent of the FEV of real output in Tunisia. Nevertheless, shocks in human and physical capitals are not meager either, since they too explain sizable proportions of the FEV of real output (14 percent, and 13 percent, respectively over a 5-year horizon).

On the whole, then, the results from analyzing the VDCs corroborate earlier inferences and suggest that human capital is an important (perhaps a dominant) catalyst of long-term growth across all four MENA countries studied in this paper.

4.5. Estimates of the Convergence Speed

As we saw earlier, all four MENA countries exhibit significant long-run cointegrating relationships among real output, human capital, population, and physical capital. How long is the long run? In other words, what is the length of time required for the long-run impacts to materialize? To address that, we calculate the half-life (median lag) that underlies the significant long-run relationship between real output, on the one hand, and human capital, population, and physical capital, on the other. The half-life (HL) measures the number of years (or quarters) necessary to complete half of the long-run adjustment, and is calculated as:

$$HL = \log(0.50) / \log(\lambda) \qquad (20)$$

where for any country in the sample, λ is the estimated coefficient obtained from an AR1 process of the error term in the cointegrating equation (normalized on real output).

The results show that the convergence speed varies across countries, and is estimated at about five quarters each for Saudi Arabia and Turkey, and at about ten quarters each for Jordan and Tunisia. That is, the long-run joint impact of human capital accumulation, population and physical capital on real output is relatively rapid in Saudi Arabia and Turkey, requiring only about one year to reach half of the total impact. In contrast, the long-run response of real output in Jordan and Tunisia to changes in the three determinants is much slower, whereby half of the long-run effect will be felt only after the elapse of more than two years.

These results suggest that Saudi Arabia and Turkey benefit from the growth factors at a much faster rate than Jordan and Tunisia. Several reasons may account for this outcome, including that Saudi Arabia and Turkey may be both better endowed with other complementary resources and infrastructures necessary for the efficient use of human capital and other growth ingredients.

5. Short-Run Causal Dynamics

5.1. Model Specification

Our empirical analysis thus far has focused on different aspects of the long-run (equilibrium) relationships among real output, human capital, population and physical capital in the four MENA countries. In this section, we shift attention to the nature of causal (short-run) interrelationships among the four variables in each country. In particular, does a rapid accumulation of human capital spur economic growth in these countries? Alternatively, would the educational environment be improved as a result of better economic conditions as Becker's (1981) theory hypothesizes? Similarly, does population expansion cause changes in economic growth, or is population expansion itself driven by income changes? Do poor educational environments trigger rapid population, or does rising population and the accompanying higher demands on scarce educational resources hamper the process of human capital accumulation? These alternative causality dynamics have quite different policy implications. Therefore, it is important to examine the direction of the triangular causal relationships among real economic growth, the accumulation of human capital and population growth in the four MENA countries, a task we perform in this section.

To repeat, the primary task here is to examine the direction of causality among the variables of interest. Thus, it does not matter what the exact underlying theoretical or structural relationships among the variables are. Our central focus is on the predictive content of certain variables. Thus, the following discussion bypasses any theoretical priors underlying the hypothesized relationships. In Granger's (1987) words, "the choice of the causation to investigate and the choice of the practical information set will probably depend on some theory, but this would be a low level theory".

As already discussed previously, the four variables (real output, human capital, population, and physical capital) do exhibit robust cointegrating relationships across all four MENA countries. Under this scenario, the Granger (1986) Representation Theorem implies that there exists Granger-causality among the four variables in at least one direction. Granger's Theorem also implies that the data a dynamic error-correction model (ECM) can represent the data for each of these countries. An ECM expresses each variable in the model in first-differences as a function of lagged first-differences of all other variables, including its own, plus a once-lagged error-correction term (ECT) that is distilled from the underlying cointegrating relation.

Several previous studies on the link between population and economic development, and/or between human capital and economic growth mostly use simple correlations, but some employ Granger-causality analyses. However, the majority of these studies appear suspect since they ignore the underlying cointegrating relationships binding these variables in the long run. The central message from the Johansen-Juselius tests performed in this paper is that there exists a potent cointegrating relation in the MENA countries studied here linking real output with fertility, human capital and physical capital, and that such a long-run relation should not be ignored when analyzing sources of growth in these countries.

Before turning to the empirical results from the estimated ECMs, three comments are in order. First, an important step in estimating appropriate ECMs is to select proper lag profiles for the various variables. Too long lags yield statistically inefficient estimates, while too short lags might introduce biased results due to omitting important information. Balancing out these two extremes, we employ the Hendry General-to-Specific approach, which allows for a truncation of up to five lags to avoid possible biases, but deletes any insignificant lags to ensure parsimonious estimates.

Secondly, temporal stability of the estimated model is an important requirement for policy/prediction analysis. To induce a stable data regime, we incorporate a (0,1) dummy variable in all ECMs to capture the 1990 Iraqi invasion of Kuwait and the following Gulf war (=0 for each quarter until 1990:3, and =1 thereafter). Undoubtedly, this event is quite significant, especially for the entire MENA region. It also splits the estimation period to two distinct regimes, the first is over 1981:1-1990:3 for the declining oil-price regime, and the second is over the rising oil-price regime.

A final comment pertains to the method of estimation. Initially, we specified an ECM for each of the four variables separately, leading to four ECMs for each country. To enhance statistical efficiency, we then pooled the four ECMs together and estimated them as a system using Zellner's Seemingly Unrelated Regressions (SUR) approach. In contrast to OLS, estimates from SUR are consistent and asymptotically efficient on the assumption that the errors in cash equation are themselves uncorrelated.[7]

Combining the four ECMs to form a unified system for each country yields a vector-error-correction-model (VECM). VECMs are linear representations of the joint stochastic data generating process underlying the variables. Each of the variables in the model is considered endogenous and comprises a linear combination of past realizations of all variables in the system, including each variable's own lagged values, plus an unpredictable innovation vector. The VECM framework is often used as an alternative to structural models and has been found to be especially useful when economic theory does not clearly define the relationships among the variables. Such a model, as Fischer (1981, p. 402) notes, "is a convenient way of summarizing empirical regularities and perhaps suggesting predominant channels through which relations work". While this modeling technique has its share of critics [see, for example, Cooley and LeRoy (1985)], many researchers acknowledge the value of its inferences regarding the short-run causal interrelationships among the variables [e.g., Sims (1980), Lupoletti and Webb (1986), and Todd (1990)].

A general representation of the VECM model used here is given by:

$$Z_t = \beta(L)\, Z_t + \alpha\, \lambda\, ECM_{t-1} + \mu_t \qquad (21)$$

[7] If the errors are not significantly correlated across equations, OLS and SUR estimations become essentially similar.

where Z_t is a 4x1 vector of the endogenous variables included in the system, $\beta(L)$ is a 4x4 matrix of lagged polynomial coefficients, α is a 4x1 vector of constants, ECM_{t-1} is a 4x1 vector of lagged error-correction terms, λ is a 4x1 vector of coefficients on the error-correction terms, and μ_t is 4x1 vector of white noise disturbance terms. The VECMs are normalized so that only past values of the data are used as explanatory variables. As Hsiao (1981) suggests, contemporaneous relations among the variables are reflected in the contemporaneous innovations.

Using the above approach, we obtain the following VECMs for the four MENA countries over the quarterly data 1981:1-1996:4, starting with Jordan:[8]

$$\begin{bmatrix} DRY_t \\ DPC_t \\ DHC_t \\ DPO_t \end{bmatrix} = \begin{bmatrix} \beta_{11}^{1}(L)\beta_{12}^{1}(L)\beta_{13}^{1}(L)\beta_{14}^{1}(L) \\ \beta_{21}^{2}(L)\beta_{22}^{1}(L)\beta_{23}^{2}(L)\beta_{24}^{3}(L) \\ \beta_{31}^{2}(L)\beta_{32}^{1}(L)\beta_{33}^{3}(L)\beta_{34}^{1}(L) \\ \beta_{41}^{1}(L)\beta_{42}^{1}(L)\beta_{43}^{1}(L)\beta_{44}^{2}(L) \end{bmatrix} \begin{bmatrix} DRY_t \\ DPC_t \\ DHC_t \\ DPO_t \end{bmatrix} + \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \end{bmatrix} + \begin{bmatrix} \lambda_1 \\ \lambda_2 \\ \lambda_3 \\ \lambda_4 \end{bmatrix} ECT_{t-1} + \begin{bmatrix} \mu_{1t} \\ \mu_{2t} \\ \mu_{3t} \\ \mu_{4t} \end{bmatrix} (Jordan)$$

$$\begin{bmatrix} DRY_t \\ DPC_t \\ DHC_t \\ DPO_t \end{bmatrix} = \begin{bmatrix} \beta_{11}^{2}(L)\beta_{12}^{1}(L)\beta_{13}^{3}(L)\beta_{14}^{3}(L) \\ \beta_{21}^{1}(L)\beta_{22}^{3}(L)\beta_{23}^{1}(L)\beta_{24}^{0}(L) \\ \beta_{31}^{2}(L)\beta_{32}^{1}(L)\beta_{33}^{2}(L)\beta_{34}^{2}(L) \\ \beta_{41}^{3}(L)\beta_{42}^{1}(L)\beta_{43}^{1}(L)\beta_{44}^{1}(L) \end{bmatrix} \begin{bmatrix} DRY_t \\ DPC_t \\ DHC_t \\ DPO_t \end{bmatrix} + \begin{bmatrix} \alpha 1 \\ \alpha 2 \\ \alpha 3 \\ \alpha 4 \end{bmatrix} + \begin{bmatrix} \lambda 1 \\ \lambda 2 \\ \lambda 3 \\ \lambda 4 \end{bmatrix} ECT_{t-1} + \begin{bmatrix} \mu 1t \\ \mu 2t \\ \mu 3t \\ \mu 4t \end{bmatrix} (SaudiArabia)$$

$$\begin{bmatrix} DRY_t \\ DPC_t \\ DHC_t \\ DPO_t \end{bmatrix} = \begin{bmatrix} \beta_{11}^{1}(L)\beta_{12}^{1}(L)\beta_{13}^{5}(L)\beta_{14}^{1}(L) \\ \beta_{21}^{1}(L)\beta_{22}^{1}(L)\beta_{23}^{2}(L)\beta_{24}^{2}(L) \\ \beta_{31}^{3}(L)\beta_{32}^{1}(L)\beta_{33}^{3}(L)\beta_{34}^{1}(L) \\ \beta_{41}^{2}(L)\beta_{42}^{1}(L)\beta_{43}^{1}(L)\beta_{44}^{4}(L) \end{bmatrix} \begin{bmatrix} DRY_t \\ DPC_t \\ DHC_t \\ DPO_t \end{bmatrix} + \begin{bmatrix} \alpha 1 \\ \alpha 2 \\ \alpha 3 \\ \alpha 4 \end{bmatrix} + \begin{bmatrix} \lambda 1 \\ \lambda 2 \\ \lambda 3 \\ \lambda 4 \end{bmatrix} ECT_{t-1} + \begin{bmatrix} \mu 1t \\ \mu 2t \\ \mu 3t \\ \mu 4t \end{bmatrix} (Tunisia)$$

$$\begin{bmatrix} DRY_t \\ DPC_t \\ DHC_t \\ DPO_t \end{bmatrix} = \begin{bmatrix} \beta_{11}^{1}(L)\beta_{12}^{1}(L)\beta_{13}^{5}(L)\beta_{14}^{1}(L) \\ \beta_{21}^{2}(L)\beta_{22}^{2}(L)\beta_{23}^{2}(L)\beta_{24}^{1}(L) \\ \beta_{31}^{4}(L)\beta_{32}^{2}(L)\beta_{33}^{1}(L)\beta_{34}^{1}(L) \\ \beta_{41}^{2}(L)\beta_{42}^{1}(L)\beta_{43}^{2}(L)\beta_{44}^{1}(L) \end{bmatrix} \begin{bmatrix} DRY_t \\ DPC_t \\ DHC_t \\ DPO_t \end{bmatrix} + \begin{bmatrix} \alpha 1 \\ \alpha 2 \\ \alpha 3 \\ \alpha 4 \end{bmatrix} + \begin{bmatrix} \lambda 1 \\ \lambda 2 \\ \lambda 3 \\ \lambda 4 \end{bmatrix} ECT_{t-1} + \begin{bmatrix} \mu 1t \\ \mu 2t \\ \mu 3t \\ \mu 4t \end{bmatrix} (Turkey)$$

where DRY_t = (1-L) log RY_t, and RY is real GDP (in 1995 prices); DPC_t = (1-L) PC_t and PC is physical capital measured by gross fixed capital formation; DHC_t = (1-L) HC_t, and HC is human capital measured by the education-adjusted labor; DPO_t = (1-L) PO_t, where PO stands for population; $\beta_{ij}^{k}(L)$ is the k^{th} lag coefficient on variable j in equation i; the α's are constant terms; the λ's are the coefficients on the error-

[8] Given the difficulty of interpreting coefficient estimates obtained from reduced-form models see Sims (1982) and Fackler (1985)], we do not report these coefficient estimates here, but they are available upon request.

correction terms (ECT); and the μ's are white-noise residual processes.[9] We should note that the above final VECMs were subjected to a series of diagnostic tests to check their statistical adequacy. In particular, each cell in all VECMs was over-fitted by at least 2 additional lags. Generally, the results from system estimations suggest that the models are properly specified. In the few cases where the additional lags are significance, we make adjustments in the final models to avoid possible misspecifications.

5.2. Interpretation of the Results

Using the above VECMs as the maintained hypotheses, we calculate likelihood ratio (LR) statistics within system (SUR) estimations to test the implied short-run Granger-causality interrelationships among the variables in each VECM. A significant LR statistic on distributed lags indicates the presence of short-run causality running from the explanatory variable to the dependent variable in the equation. On the other hand, a significant LR on the coefficient of the ECT indicates the presence of a potent long-run causality flowing from the right hand-side variables to the dependent variable. We report the causality results in Table 5. We first note that the VECM estimates indicate the presence of significant ECT terms in at least one relationship across all four MENA countries. This corroborates the earlier results we reported from the Johansen-Juselius tests and strengthens the evidence for potent cointegrating relationships among the variables. Therefore, overlooking the cointegratedness of the variables would have contaminated the empirical results with serious misspecification biases.

However, our focus in this section is on short-run causal interrelationships, which can be inferred from the joint significance of distributed lags of off-diagonal coefficient elements in the estimated VECM. According to Granger's Representation Theorem, pronounced cointegrating relationships among the variables imply the presence of Granger-causality in at least one direction, and indeed the results in Table 5 bear that out quite clearly. The calculated LR statistics for these distributed lags suggest several interesting inferences across the four MENA countries. To better organize the discussion that follows, we begin with the interpretation of the results for Tunisia.

5.2.1 Tunisia

As to the population/economic growth nexus, the results in Table 5 reject the Malthusian traditional view and support instead the contention that population expansion is itself driven by income changes, as the Transition theory and the Post-Malthusian Regime hypothesis contend. Specifically, the null hypothesis that population expansion does not Granger-cause economic growth is not rejected (see test 3 for Tunisia). However, the reverse hypothesis that economic growth does not Granger-cause population expansion is soundly rejected at better than the 5 percent level (see 13). Thus, in the case of Tunisia, family planning to control fertility is not a

[9] Although we use the same symbol chart for the variables in the four countries, the estimated parameters clearly vary across the four models.

proper public policy since it will unlikely achieve the commonly proclaimed objective of poverty reduction.[10] Rather, governmental efforts in Tunisia should instead concentrate on fostering economic development in the country as the main mechanism for controlling her population growth. In Tunisia, therefore, it appears that large population is a consequence of being economically poor, as Becker (1981) postulates. As economic conditions improve, families prefer quality over quantity of children. Furthermore, the increase in the cost of raising healthy and well-educated (quality) children will also induce smaller family sizes, and consequently fertility declines.

The question, then, is how to promote economic development in Tunisia in order to control population expansion? The results in Table 5 unambiguously suggest that the country needs improvements both in physical capital as well as in human capital in order to spur economic growth (see tests 1 and 2 in Table 5).[11] To be economically prosperous, the population must get access to equity capital, production infrastructure, as well as better schools and improved educational environment. According to the results, inadequate investment in physical *and* human capital in Tunisia hampers economic growth, perpetuates poverty, and leads to population explosion.The above policy prescription for Tunisia receives additional support from other results in Table 5. Looking at the link between human capital and population growth, there appears to be a strong causal effect flowing from human capital to population (see test 15). Therefore, not only does human capital promote economic growth (and thus indirectly impacts population), but human capital also directly and significantly influences population size. As the educational levels of parents increase, the results seem to suggest that the quality (rather than the quantity) of children does become a predominant concern of families. It is, therefore, reasonable to conclude that, for Tunisia, investment in human capital may hold the key for promoting economic growth as well as for controlling her population size.

5.2.2 Jordan

Results for Jordan are similar to those for Tunisia regarding the developmental role of human capital. As test 2 in Table 5 indicates, the accumulation of human capital in Jordan is a significant causal force behind her economic development. Thus, what was inferred regarding the need to improve the educational environment to promote growth in Tunisia holds as well for Jordan. However, a critical difference in the results for these two MENA countries lies in the relationship between population and economic growth, and also between population and human capital. For Jordan, the results (see tests 3 and 13 in Table 5) strongly support a unidirectional causality from population to income changes. The results, though, do not provide a clear answer as

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[10] Clearly, this empirical finding disproves recent claims in the Tunisian popular press that the government-sponsored family planning has improved economic conditions in the country. See, for example, *The Press*, April 3, 2000, p. 3.

[11] Note that, besides the potent causal effect of human capital on economic growth, there are also feedbacks from the latter to the former. Interestingly, such mutual causality between human capital and economic development appears to be pronounced in Jordan and Saudi Arabia as well, but not in Turkey.

whether the net effect of population on income is positive or negative since these results are based on reduced-form models without well-established structural bases [Sims (1982), and Fackler (1985)]. Interestingly, population has no discernible influence on the accumulation of human capital (see test 11), nor is there any significant feedbacks from human capital to population expansion (see test 15). That is, population expansion and the accumulation of human capital seem causally independent in Jordan, at least in the short-run. Thus, rapid population in Jordan does not seem to hamper the process of human capital accumulation. Jordan, perhaps among a small group of MENA countries, is relatively endowed with reasonable educational resources and infrastructures (e.g., availability of many public and private schools and institutions of learning at various levels).

It is, therefore, not surprising that the empirical results suggest that large population in Jordan does not inhibit the process of human capital accumulation. However, the absence of any feedback from human capital to population in Jordan rejects the contention, commonly made for underdeveloped countries, that fertility tend to rise in families with poor educational backgrounds.

5.2.3 Saudi Arabia

Exactly the opposite inference regarding the human capital/population nexus is revealed for Saudi Arabia. As the results in Table 5 suggest, the two variables appear mutually causal. That is, the null hypothesis that human capital does not Granger-cause significant short-run changes in population size is soundly rejected (see test 15). Similarly, the reverse hypothesis that population does not Granger-cause significant impact upon the process of human capital is also soundly rejected (see test 11). Thus, in Saudi Arabia, it appears that a rapid population growth presents undue pressures on available educational resources and could hinder the ability of the country to enlarge her stock of human capital. The results further reveal that low levels of human capital (poorly educated families) also tend to increase the fertility rate, leading to population explosion.

Clearly, these results taken together imply the presence of a "vicious cycle" in Saudi Arabia, whereby high population slows down the process of human capital accumulation, and low levels of human capital in turn feeds back and fuels higher population. One possible way out of this cycle is to channel more resources to schools and institutions of learning to enhance the educational systems in the country, and improve the accumulation of human capital, particularly among poor families. Such an improvement in human capital (both in number and in quality) should prove beneficial, as the results suggest, since it triggers a slowing down in population growth that has registered the highest rate (4.3 percent annual average) among the four MENA countries.

While population expansion does significantly influence human capital in Saudi Arabia, population has apparently no relation with economic growth in either direction (see tests 3 and 13 in Table 5). These results reject both the Malthusian and the Transition view for Saudi Arabia and suggest that population and economic growth rates are causally independent. Thus, a slower pace of economic development cannot be blamed on population expansion in Saudi Arabia. Indeed, the results seem to suggest that human capital, rather than population size, is critical for fostering economic development in the country (see test 2). As in Tunisia and Jordan, the results for Saudi Arabia too confirm the central finding that the accumulation of human capital matters for promoting economic growth, and indeed matters a great deal for all three MENA countries.

5.2.4 Turkey

We come now to discussing the results in Table 5 for Turkey. Similar to Saudi Arabia, population and human capital are mutually causal in Turkey (see tests 11 and 15). Unlike Saudi Arabia, the results for Turkey show that population and economic growth are also mutually causal (see tests 3 and 13). It is, therefore, possible that Turkey faces two "vicious cycles", in that a slower accumulation of human capital tends to inflate the size of its population, which in turn may further weaken the country's stock of human capital. Moreover, population explosion could hinder economic development (if in fact the sign of the causality linkage is negative), and poor economic conditions could intensify the cycle by fueling population expansion.

The implied policy prescriptions for Turkey are the same to those derived for Saudi Arabia, and perhaps even clearer. The above empirical results strongly call for improvements in the educational system in Turkey and for a faster accumulation of human capital. Doing so should be effective in breaking both human capital/ population vicious cycle and, as a consequence, also the potentially vicious cycle of the population/economic growth. That is, promoting human capital should help reduce population growth and also spur economic growth, with beneficial feedbacks. These policy implications for Turkey are additionally supported by the results on the human capital/economic development nexus. As tests 2 and 9 in Table 5 suggest, there appears to be a unidirectional short-run causal effect flowing from economic development to human capital.[12] Thus, as economic conditions and living standards improve in the country, the concomitant enlargement in available financial and educational resources should promote a faster accumulation of human capital. This process will then set in motion a "*virtuous"* cycle whereby the rapid accumulation of human capital triggers other fruitful rounds of population and income changes.

Taken together, the central message that consistently emerges from the empirical analysis of this paper is that the accumulation of human capital is a powerful engine of growth across all four MENA countries. This, of course, is consistent with the body of evidence indicating that economies that invest more on education grow faster.[13]

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[12] Turkey is the only MENA country in the sample wher capital has no *direct* discernible influence on her economic growth. Of course, human capital in Turkey may still impact economic development indirectly through its effect on population, and then the effect of the latter on economic growth.

[13] A few recent studies, most notably Benhabib and Spiegel (1994) and Pritchett (1997), argue that educational attainment does not provide significant economic benefits. Nevertheless, both studies appear seriously faulty due to several specification and data related problems [see, for example, Krueger and Lindahl (1998), and Temple (1999)].

6. Summary and Conclusions

This paper examines long-term interactions and short-term dynamics among fertility, human capital, and economic growth in the case of four MENA countries. The main purpose is to present a set of facts that may be of interest to policy-makers and researchers working on growth and development issues particularly in the MENA region. We first discuss the conventional wisdom that fertility and the accumulation of human capital are potential sources of economic growth. We then discuss several theoretical reasons suggestive of a reverse-causality paradigm in which both fertility and human capital are themselves driven by income changes. Bi-directional causality may also characterize the relation between fertility and human capital.

Besides the neglect of a possible reverse causality in the growth process, past research also fails to incorporate the cointegrating (long-run) relations linking together economic growth with its two key determinants. Theory suggests that the linkage of economic growth to fertility and human capital is inherently slow (long-term) in nature. Without an explicit account of the underlying long-term relation, results from past studies may be suspect due to serious model misspecifications.

The empirical analysis of the paper is based on data from four MENA countries (Jordan, Tunisia, Turkey, and Saudi Arabia) spanning an 18-year period from 1980-1997. We measure human capital by the enhancement of labor quality resulting from education attainment at different levels, and derive our inferences from a battery of empirical procedures, including tests of unit roots, cointegration, main driving forces, variance decompositions, convergence speed, and estimates from vector-error-correction models (VECMs).

Our results support the proposed theoretical priors and consistently suggest that there exists a stable and robust long-term (equilibrium) relationship linking economic growth with fertility, human capital, and physical capital in all four MENA countries. Perhaps more importantly, coherent evidence also emerges from a whole range of tests and models supportive of a pivotal role of human capital accumulation in the economic growth process across all four MENA countries. In particular, the results indicate that human capital is indeed a key growth ingredient in the region both over the long-term (as a driving force of the cointegrating system) as well as over the short-term (with its significant causal impact on growth in the estimated VECMs). The dominant role of human capital in promoting growth receives further support from the associated variance decompositions of real output in the four MENA countries examined.

In contrast to the unambiguously robust long-term and short-term contributions of human capital to growth in the MENA region, evidence on the role of fertility in development is not as clear, or as consistent, in the region. For example, the results from the VECMs suggest that fertility and economic development are not causally related at all in Saudi Arabia and, in Tunisia, fertility seems more a consequence (rather than a cause) of economic changes. Thus, policy-makers in Saudi Arabia could perhaps ignore future population projections when planning for economic development; while family programs to control fertility appear improper in Tunisia and Turkey. The case proves different for Jordan where population is a causal force behind her growth process.

This lack of uniform causality results between fertility and economic growth across the four countries may suggest, congruous with Wheeler's (1984) theoretical posture, that the nature of the population/economic growth nexus is sensitive to the country's stage of economic development, as well as to the institutional details. The message though is clear: what appears to be a proper demographic policy for one country may prove unnecessary, or perhaps even harmful, for another. Indeed, indiscriminate policies of family planning and birth controls do not receive support from the results in this paper. Curiously, while the threat to growth is commonly believed to come from population explosion in certain areas, several countries have recently voiced concern for slower growth because of the tendency of their population to implode due to falling birth rates and the persistent aging of their people [Ehrlich and Lui (1997), and Miller and VanHoose (2001)].[14]

All in all, results in this paper lend consistent support to the accumulation of human capital as a growth precursor in the four MENA countries examined here. As Psacharopoulos and Woodhall (1985) argue, the overall economic benefits from education may be greater in poor countries whose stocks of human capital are relatively small. Our results concur and suggest that, while having more people may not necessarily impede economic development, overlooking people's education most likely would.

Of course, economic growth is a complex and multi-facet process that critically depends on the quantity and quality (productivity) of available inputs. Growth also responds to many other elements, including cultural heritage and political freedom. Notwithstanding, our results clearly suggest that accelerating growth in the MENA countries does require the allocation of more of their national resources to enhance the education levels of their citizens. As the experience of Korea and other East Asian countries shows [see Thomas (2000)], higher educational levels must also be combined with a wider and more equitable distribution of education that encompasses the majority of the population. Indeed, declining education inequality is a key contributing factor to achieving high and sustained growth dividends from the accumulation of human capital.[15]

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[14] These results further suggest that it is improper to assume *a priori* that population 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.

[15] Several studies in the endogenous growth literature cited in this paper also suggest that personal financial rewards from human capital tend to be higher in developed countries. This may explain the brain drain from developing to developed countries and, perhaps more importantly in light of the results in this paper, it may also explain why it is often difficult for poor countries to achieve faster growth rates.

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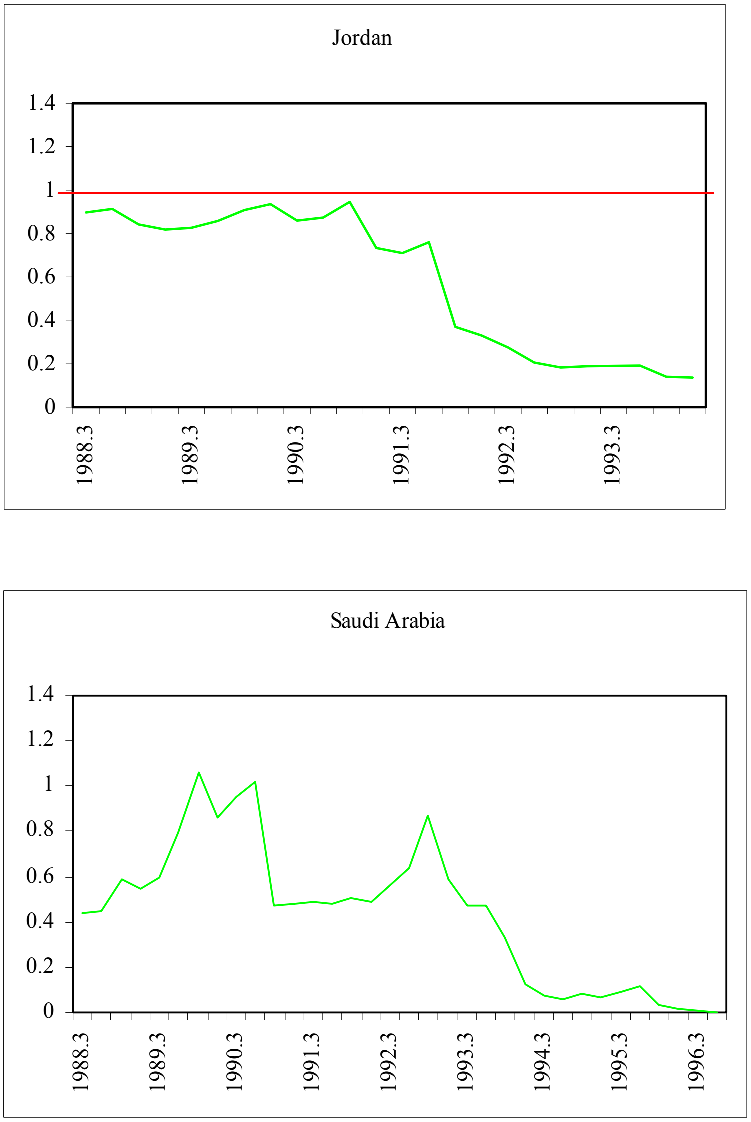
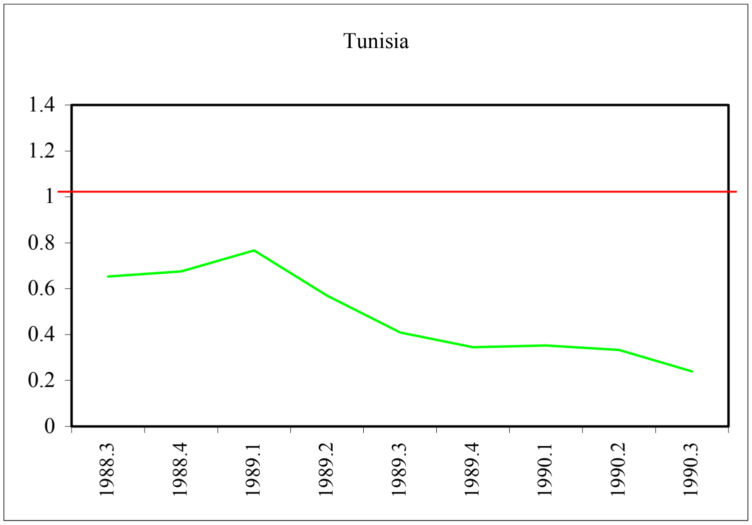
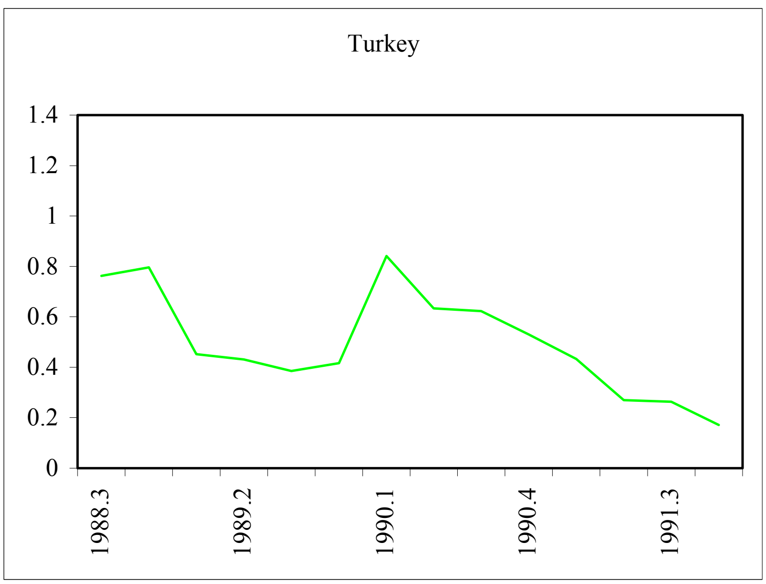
Figure 1: Likelihood Ratio (LR) Tests of Cointegration Constancy







Notes: The LR statistics assess the parameter constancy of the cointegration vector using the Hansen and Johansen's (1999) approach. The statistics are asymptotically χ^2- distributed and scaled by the 5% significance level, where values greater than 1 imply rejection of the null hypothesis of a constant cointegrating vector.

Table 1: Unit Root (Nonstationarity) Test Results (Quarterly Data: 1980-1997)

	Jordan		Saudi Arabia		Tunisia		Turkey	
	PP	WS	PP	WS	PP	WS	PP	WS
Variables in Log Levels								
Real Output, RY	-2.48	-1.41	-4.96	-0.79	-9.94	0.04	-0.48	1.43
Physical Capital, PC	-6.73	-0.42	-4.77	-0.48	-5.15	-0.65	0.93	1.21
Human Capital, HC	0.01	0.41	-0.88	0.60	-0.25	0.46	-0.19	1.20
Fertility (Pop), PO	-0.36	0.72	-1.00	0.85	-0.48	-0.57	-0.71	0.46
Variables in First-Differences								
DRY	-27.53**	-2.76**	-12.23*	-1.44	-47.36**	-3.17**	-31.32**	-3.72**
DPC	-26.55**	-2.62**	-22.63**	-2.22	-45.68**	-2.51**	-28.20**	-2.98**
DHC	-23.12**	-2.43*	-20.53**	-1.35	-25.35**	-2.58**	-31.66**	-2.77**
DPO	-23.32**	-2.75**	-24.86**	-2.56**	-17.88**	-1.84	-20.63**	-2.43*

Notes: PP is the Phillips-Perron test and WS is the Weighted-Symmetric test. The Akaike Information Criterion (AIC) selects the proper lag lengths in the tests, which are found to be four quarterly lags for most tests, except for a few cases in which shorter lags (2 or 3) prove adequate. An * indicates rejection of the null hypothesis of non-stationarity at the 10% level of significance, while ** indicates rejection at the 5% level.

Table 2:The Johansen-Juselius Cointegration Test Results

A. Quarterly Data										
Ho: Cointegrating Rank:	Jordan		Saudi Arabia		Tunisia		Turkey		C.V. 95%	
	Trace	λ-max	Trace	λ-max	Trace	λ-max	Trace	λ-max	Trace	λ-max
None	57.88**	31.35**	94.71**	55.52**	91.43**	68.75**	63.62**	34.28**	53.48	28.27
At most One Vector	26.54	12.27	39.20**	17.46	22.67	13.05	29.34	19.70	34.87	22.04
At Most Two Vectors	14.27	9.44	21.73**	14.13	9.62	6.88	9.65	5.53	20.18	15.87
Three Vectors	4.84	4.84	7.60	7.60	2.75	2.75	4.12	4.12	9.16	9.16
B. Annual Data										
Ho: Cointegrating Rank	Jordan		Saudi Arabia		Tunisia		Turkey		C.V. 95%	
	Trace	λ-max	Trace	λ-max	Trace	λ-max	Trace	λ-max	Trace	λ-max
None	70.99**	38.02**	68.94**	33.63**	63.76**	38.84**	79.31**	46.93**	53.48	28.27
At Most One Vector	41.24**	20.08	35.31**	16.13	24.92	12.93	32.38	15.51	34.87	22.04
At Most Two Vectors	21.15**	15.91	19.18	11.90	11.99	7.63	16.87	11.56	20.18	15.87
Three Vectors	5.24	5.24	7.27	7.27	4.35	4.35	5.31	5.31	9.16	9.16

Notes: An ** indicates rejection of the null hypothesis at the 95% level of significance.

Table 3:The Gonzalo-Granger Test of Driving Forces of the Cointegrating System

	Jordan	Saudi Arabia	Tunisia	Turkey
A. Bivariate Vectors (Real output and Human Capital):				
Real Output	5.38**	0.76	2.14	0.28
Human Capital	4.89**	7.47**	12.53**	7.26**
B. Multivariate Vectors (Real output, Human Capital, Physical Capital & Fertility):				
Real Output	11.27**	8.79**	12.50**	4.56
Human Capital	17.24**	18.73**	5.69[a]	6.57*
Physical Capital	13.37**	15.42**	10.83**	2.72
Fertility (Pop)	9.24**	3.90	12.33**	7.63**

Notes: The driving force tests are likelihood ratio statistics distributed as χ^2 with degrees of freedom equal to the number of common factors (=4-r, where r is the cointegration rank). The null hypothesis is that the corresponding variable is not a main driving force of the cointegrating vector in the country under examination. An ** indicates rejection of the null hypothesis at the 5% level of significance, an * indicates rejection at the 10% level, while an "a" indicates rejection at the 15% level.

Table 4: Decompositions of the Real output Forecast-Error Variance

Forecast	Due to Innovations in:											
Horizons in	Jordan			Saudi Arabia			Tunisia			Turkey		
Quarters	PC	HC	PO	PC	HC	PO	PC	HC	PO	PC	HC	PO
4	3.4	20.19	1.05	3.76	0.24	0.03	8.16	3.07	22.07	1.26	1.72	0.24
8	5.33	61.94	3.13	6.41	4.42	1.07	11.13	11.73	19.52	3.80	7.69	0.22
12	4.10	67.47	13.33	4.74	7.94	2.92	11.11	11.90	20.42	4.48	11.34	3.16
16	3.91	65.67	17.83	4.53	8.90	3.62	12.80	13.53	19.45	5.34	12.46	4.05
20	3.97	64.98	18.10	4.54	9.29	3.73	12.91	13.76	19.34	5.33	11.86	4.04

Notes: PC is physical capital, HC is human capital, PO is population. All figures of the VDCs are in percent and prove statistically significant at better than the 5% level (except for the population innovation in the case of Saudi Arabia for forecast horizon 4). The implied standard errors of the VDCs are computed from Monte Carlo simulations of 500 random draws.

Table 5: Likelihood-Ratio Test Statistics of Implied Granger-Causality Hypotheses (Derived from Off-Diagonal Elements of the Maintained VECMs)

Null Hypotheses for:	**Jordan**	**Saudi Arabia**	**Tunisia**	**Turkey**
DRY Equation:				
1. Growth in Physical Capital (DPC) Does Not Granger-Cause DRY	2.47	4.82**	7.96**	0.82
2. Growth in Human Capital (DHC) Does Not Granger-Cause DRY	8.06**	7.53*	9.67*	8.06
3. Population Growth (DPO) Does Not Granger-Cause DRY	6.38**	5.20	2.34	14.64**
4. Long-Run Granger-Causality (ECT)	9.07**	7.15**	0.70	12.76**
DPC Equation:				
5. DRY Does not Granger-Cause DPC	13.36**	15.56**	0.42	17.43**
6. DHC Does not Granger-Cause DPC	22.31**	9.81	0.60	18.68**
7. DPO Does not Granger-Cause DPC	20.87**	0.01	0.02	0.59
8. Long-Run Granger-Causality (ECT)	0.08	2.19	0.09	14.56**
DHC Equation:				
9. DRY Does not Granger-Cause DPC	10.61**	22.76**	20.89**	30.31**
10. DHC Does not Granger-Cause DPC	1.62	0.33	1.36	17.26**
11. DPO Does not Granger-Cause DPC	2.16	8.30**	3.01*	30.47**
12. Long-Run Granger-Causality (ECT)	0.14	0.30	2.08	8.78**
DPO Equation:				
13. DRY Does not Granger-Cause DPC	0.01	4.14	11.88**	8.22**
14. DHC Does not Granger-Cause DPC	0.16	0.36	12.73**	1.49
15. DPO Does not Granger-Cause DPC	2.65	6.15**	6.05**	23.86**
16. Long-Run Granger-Causality (ECT)	3.36*	3.18**	17.03**	1.12

Notes: The lag lengths of the various variables are selected by the Hendry's General-to-Specific approach. An * indicates rejection of the no-causality hypothesis at the 10% level of significance, while ** indicates rejection at the 5% level. All equations include a dummy variable for the second Gulf War (=0 for 1981:1 through 1990:3, and =1 thereafter).