The Role of Components of Demographic Change in Economic Development: Whither the Trend?

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Abstract

In this paper, we investigate the role of the components of demographic change on economic development. Population growth has both positive and negative effects on income growth. Kelley and Schmidt (1995) states that high birth rates are costly in terms of growth but this effect can be offset by a positive impact of mortality reductions. We study how the weight of each effect has changed over time considering a panel of countries over the last four decades. We find that there is little gain to expect from further reductions in mortality in developing countries, and that the effect of birth rates has become positive in developed countries. In contrast to the earlier study, where growth enhancing effect of population density is felt consistently for all decades, we find that the effect is limited only to the sixties.

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1 Introduction

The 'rise of the population number' is probably the most influential socio-economic phenomenon since Malthus (1798) that has kept the 'population debate' alive. The debate centers around the exact sign and magnitude of the effect of growth rate of population on economic development. Disparities of conclusions still persist, though a clearer picture has started to emerge from the recent research, especially after 1990s. Notable contributions in this regard came from Kelley and Schmidt (1995, hereafter KS), and Crenshaw et al. (1997) among others, who showed that decomposing 'aggregate population' growth into the components of demographic change[1] is crucial to understand the exact nature of its impact, viz., the sign of impact on per capita income growth. Going by this line, KS (1995) explained why dozens of studies in the last two decades 'failed to unearth a statistically significant correlation' between the growth rates of population and per capita output. One of the most important contributions of KS (1995) and later Crenshaw et al. (1997) concerns about measuring the consequences of crude birth rate (CBR) and crude death rate (CDR) reductions in developed and developing countries. Our purpose in the present paper is to extend KS (1995) work and show how the weight of each effect (of CBR and CDR) has changed over time.

Considering the period (1960-1990), KS (1995) showed that high birth rates are costly in terms of growth but this effect can be offset by a positive impact of mortality reductions. The pattern that arises due to higher birth rates (in KS, 1995), is monotonic over time. A forecast based on the estimates of CBR in KS would mean that higher CBR in developing countries would further reduce economic growth. Crenshaw et al. (1997) also find similar results: '...an increase in the child population hinders economic progress... .' As the populaion number increases, one of its most important effects is perceived in higher population density over time. In the growth theoretic set up, higher density of population induces higher innovation due to population pressure and consequently hastens up economic progress. KS (1995) found a significant effect of population density on economic growth over decades. A comparative effect of CBR can be matched by higher (lower) CDR in the both the developed and developing countries. KS (1995) found that a decrease in CDR fosters economic growth in the developing countries and that the contribution of CDR reduction has declined monotonically over time.

To contribute to the growing literature on the effect of demographic components on economic growth, the main objective of our paper is to exhibit the changing weight of the effect of demographic change one economic development. Specifically, we show that the effect of CBR and CDR increase (decrease) has changed over time. Using an up-to-date sample period (till 2000) and GDP per capita income compatible with purchasing power parity (in 1995 international prices), we show that the weight of the effect has changed over the last four decades. In contrast to KS

[1]The components of change refer to decomposition of aggregate population according to its vintage group, e.g., crude birth rates and death rates for younger age (0-14), working age (15-65), and retired cohorts (65+).

(1995), we find that there is little gain to expect from further reductions in mortality in developing countries. Importantly, the effect of CBR has become positive for developed countries. In light of the current demographic transition and consideration of 'zero population growth' as optimum for higher economic prosperity in the developed countries as held by some research[2], the finding of positive CBR in these countries calls for a rethinking on the population policy. Also in contrast to KS (1995) we find that the growth-enhancing effect of population density is limited to the 1960s.

Before we draw on the detailed findings of the paper, it is useful to have a summary view on the population debate. The summary picture would provide essential information about the current state of population debate. To say clearly, the purpose is to find the exact direction of the trend, namely as of now what has been held and concurrently proved about the effect of demographic components on economic growth. Three basic models have been propounded in the literature to explore the economic-demographic relationship. These are: correlation approach, production function approach, and convergence patterns model. While early empirical models used to employ the simple but econometrically weak, correlation approach, recent research extensively use convergence-patterns models which is built on the production function framework. Section 2 is devoted mainly to critically review these three models and the implications of their empirical applications.

The rest of the sections are organized as follows. In section 3 we discuss the importance of the components of demographic change where we concentrate on evaluating the short and long run impact of demographic components on economic development. Section 4 outlines the model to be estimated and discusses the econometric methodology to be used. Features of the data and design of the variables are also noted in this section. Empirical results are presented in section 5. Section 6 concludes the major findings of the paper and discusses their implications in the current development context.

2 Theoretical Structure and Evidences from the Literature

2.1 The constructs

Though recent endeavour showed that 'components of demographic change' provide deeper and clearer insight in explaining the dynamic relation between growth of income and population, not very long ago, the contributory role of the latter was underemphasized. Technological change[3] tended to be used as the guiding force in models of economic growth. Demographic factors were thought to be irrelevent to the growth process, and hence the effect of past and future demographic trends on

[2]See Boucekkine et al. 2002 for an analysis in this respect

[3]Some other variables were also used for explaining aggregate output growth, viz., human capital, free market institutions, and budgetary disciplines.

growth remained largely unexplored (Boucekkine et al., 2002). The recent theoretical advances (e.g., Boucekkine et al., 2002), noted an exception to this trend, thanks to the advent of new growth theory (viz., Lucas, 1988; Romer,1991) that initiated research in this direction.

As per the current thinking, demographic factors are considered as much important as technological change for the analysis and modeling of economic growth. Some authors (e.g., Simon, 1981; Todaro, 1989) argue that demographic pressures would favorably influence the nature and pace of technological change and cause higher innovation ultimately fostering economic growth. This logic, however did not find unequivocal testimony in the empirical literature until the last decade when the role of demographic factors started to get rigorous treatment in economic growth models as in KS (1995) and Crenshaw et al (1997). Though the theoretical rigorousness has recently started to have momentum, the empirical foundation has not been equally paced. Since the empirical formulation relies heavily on theoretical constructs, it will be useful to describe in brief the three methods, viz., correlation approach, production function approach, convergence-pattern approach in a nutshell.

Traditionally, **correlation approach** used to be extensively applied in early empirical growth models to describe demographic-economic interactions. The model is described in Eq.1:

$$(Y/Ngr) = \Gamma_1(X_D) \tag{1}$$

(Y/Ngr) is per capita output growth, X_D indicates demographic variable(s) which may include ngr, the contemporaneous growth of population (N), age structure of the population, crude birth rates (CBR) and /or crude death rates (CDR), N and/or population density, life expectancy, and migration. Performing investigation for various countries[4] over periods of time, several models during and before 1980s drew on unconditional correlations between per capita output, (Y/N), and population growth, ngr. Empirical results widely vary: some providing evidence of 'no measured impact' of ngr on (Y/N), many studies showing negative impact, and even some providing evidence of positive association between the two.

The results from this approach are difficult to interpret as it renders at best the first hand information on the effects of demography[5]. Moreover, ngr is an aggregate phenomenon and does not reveal anything about the specific channels population affects output growth. For instance, since ngr equals fertility rate minus the death rate[6], and given that an individual acts upon the economy's resource differently over his life cycle, it is instructive to segregate ngr into various components viz., young generation, working age, and retired cohorts. Correlation approach does not lend to segregation of demographic variables into various components. This feature is aptly carried by convergence-patterns approach which we will discuss shortly.

[4]Mostly developing countries considering the spur of rapid population growth.

[5]KS, 2001 describe this as 'first pass assessments'.

[6]the net migration rate may be added, but this has been suppressed in the empirical model of this paper.

Another way to explore the economic-demographic relationship is to use **production functio**n framework (Eq.2)

$$Y = \Gamma_2(K, L, H, R, A) \tag{2}$$

Eq.2 involves lot of growth variables like physical capital (K), human capital (H), technology (A), and natural resources (R), to explain output (Y). Data on these variables are difficult to compile and consequently Eq.2 is transformed into growth terms for empirical convenience. Then, demographic processes are linked to the growth of the factor inputs in the production function. Even though Eq.2 possesses elegant analytical rendering, the empirical implementation of this model is limited in scope. Some of the reasons are: estimates of capital depreciation and resource depletion is difficult to compile, technology and scale are elusive to assess and involve lot of uncertainties (KS, 2001).

As we mentioned, the correlation approach does not provide any specific channel population affects output growth, whereas production function approach suffers from proper empirical implementation. The third approach, the **convergence-patterns or technology-gap** model takes account of the drawbacks of these two models and provide an exhaustive framework to explore the relationships between economic growth and demographic variables. Basically the convergence-patterns approach is based on the production function framework of Solow-Swan type. The economic growth of a country in this approach is allowed to vary with the *levels* of economic development. In this model initial endowments of the economy play important role along with the demographic factors.

The idea of the convergence-patterns model is to study the pace at which countries move from their current level of labour productivity to their long-run, or steady-state level. The rate of labour productivity is assumed to be proportional to the gap between the logs of the long-run steady state and current level of labour productivity [7]. Formally,

$$(Y/Ngr) = \delta[log((Y/N)^* - log((Y/N)] \tag{3}$$

Here $(Y/N)^*$ is the steady state (Y/N). The greater this gap, the greater are gaps of physical capital, human capital, and technical efficiency from their long-run levels. Depending on country specific characteristics, the long-run per capita output growth, (Y/Ngr) differs across countries.

As reviewed in Dasgupta (1995), due to the poor resources base and lower level of initial development, developing countries with persistent poverty are facing the problem of catching up with developed nations. This idea is aptly captured in the 'convergence-pattern' model as described above. As per this model it is known that the relationship between per capita income growth, $(Y/Ngr)_{t,t+n}$ and the initial level of per capita income should be negative (See Solow, 1956). Barro (1991) and others in this regard, point out a famous empirical regularity: if countries are similar with

[7] We are using here the per capita output and per-laborer output interchangeably. For the latter, it would have been written as Y/L, where L denotes labour. L= αN, where α is usually unity.

respect to structural parameters for preference and technology, then poor countries tend to grow faster than rich countries. Thus, there is an underlying force that promotes convergence in levels of per capita income across countries.

In line with the construct of the convergence-patterns approach, KS (1995) provided the following econometric model which has tended to be a bench mark for subsequent research. Allowing the demographic processes to vary by stage of economic development, KS (1995) describe the convergence-patterns model[8] as:

$$(Y/Ngr)_{t,t+n} = \Gamma_3((Y/N)_t, I_t, A_t, S_t, \{(X_D)_{t,t+n}, (X_D)_{t,t+n} * (Y/N)_t\}) \qquad (4)$$

$\Gamma_3(.)$ is assumed to be a linear function of the variables. $(Y/Ngr)_{t,t+n}$, represents per capita output growth, $(Y/N)_t$ is the initial level of per capita income, I variables provide additional details on the 'initial' state of the economy, for example, population density. 'Density' in the model (in the Boserup, 1965 tradition) is supposed to have positive impact on (Y/Ngr). The resulting sign is the combined influence of diminishing returns to land (which is negative) and positive effects on technical change, (A_t). From equation 1, the demographic variables (X_D), include the contemporaneous $CBR_{t,t+n}$ and $CDR_{t,t+n}$, as well as CBR lagged 15 years, CBR_{-15}. S_t variables represent factors influencing economic development as well as changes in the stocks, for example technological change.

Theoretically, the inverse relation between $(Y/Ngr)_{t,t+n}$ and $(Y/N)_t$ is the basis of convergence-pattern model. The interaction term, $(X_D)_{t,t+n} * (Y/N)_t$ implies that the effect of population growth and its components are allowed to vary by levels of economic development (Y/N). The competing hypotheses associated with this are consistent with a declining (increasing) negative (positive) effect of population growth as the country develops. A summary effect of CBR, CDR, and CBR_{-15} in the model described above is in order. While a rise in CBR is harmful for an economy as higher births prompt higher dependence on resources, a rise in CDR enhances economic growth as resource dependence is reduced. Nonetheless, this conclusion is subject to subtle evaluation as higher deaths of workers impede economic growth while higher death of dependants stimulate it. The short-run and long-run consequences of demogrpahic components will be described in the next section. A state-of-the-art analysis of the the empirical findings based on the correlation approach and convergence-patterns approach is presented below. Note that since emprical investigation using production function approach are very sparse, we concentrate on the other two approaches.

[8]Note that, while in theory all variables are measured in exact instant t, in implementation, the measurement (of say, $(Y/N)_{t,t+n}$) is over the period $(t, t+n)$. Studies employ five-, ten-, 25-year, or even longer periods (KS, 2001).

2.2 Facts from the literature - population and economic growth nexus

- ***Empirical results based on correlation approach***

Based on the correlation approach, Simon Kuznet's empirical finding depicted that there is in *general* a lack of correlation between population and economic growth in the early 1970s. Documented in more than a dozen studies, 'such a (lack of) statistical regularity flies in the face of strongly held beliefs by those who expect rapid population growth to deter the pace of economic progress' (Kelley and Schmidt, 2001). This is because, increasing population has been customarily regarded as mere consumers of resources and that its faster growth is associated with diminishing returns to capital. Based on this strong prior belief, some research (e.g., United Nations, 1973), as reviewed by KS (1994) using international cross-country data for the 1980s, found a negative association between population and economic growth. As per this line of research, a high rate of growth can not be supported by a corresponding increase in investment, thus lowering growth of per capita output.

Simon (1981) in his "*The Ultimate Resource*" challenged this pessimistic view showing that population growth was likely to exert a *positive* net impact on economic development in many Third World countries 'in the intermediate-run'. In fact, this 'revisionist' approach of Simon (1981) changed much of the dogmatic thinking of population growth's consequence on economic development in the subsequent years. He illustrated that the outcome of the population impacts on the economy are likely to depend both on the *time dimension* of the assessments, and whether *feedbacks* are included in the analysis. Feedback effects arise, in the model, due to the population pressure that would ultimately cause natural resource exhaustion. Going by his illustration, it means, over longer periods most natural resource prices actually declined. This happened despite the existence of rising demand from increasing population because of price-induced substitutions in production and consumption of natural resources, and an increase of supply due to technical advancement and innovation. Hence the 'time dimension' is important for these 'adjustments' or 'feedbacks' to be assessed, which arises due to population pressure. Density and size of population are other demographic variables he included in his analysis.

Based on both the time series and cross-sectional data, the investigators of National Research Council (NRC, 1986)[9] put a rather balanced and non-alarmist assessment: 'on *balance*, we reach the qualitative conclusion that slower population growth would be beneficial to economic development of most developing countries... (but) there is no cause of alarm over the high rates being experienced there'. What the NRC's finding implied is that population growth has both positive and negative effects, and "given the current evidence, though the actual size of the impact can not be determined, the direction of the impact...can be detected". Since the

[9] The investigation purported for the economic consequences of population growth in poor countries, recognized that instead of regarding population growth as exogenously given, it should be treated as a causal factor.

sample considered by the council involved developing countries, a cautionary note was always due as 'persistent' high births[10] in those countries negate the positive feedback from the labor force. But since 'persistency' of higher births is likely to be attenuated in the longer run, youth's dependency on resources will go down giving rise to substantial contribution from the labor force.

Some other studies in the late 1980's (Srinivasan, 1988; Kelley, 1988) found that while slower population growth would indeed advance the economic well-being of most developing countries, the size of the net impact would not likely be especially remarkable by comparison with many other determinants of economic growth. Precisely, Kelley (1988) states that: "economic growth ...would have been more rapid in an environment of slower population growth, although in a number of countries the impact was probably negligible and in some it may have been positive". Kapuria-Foreman (1995), in the more recent literature, found that there is in general non-significant correlation in cross country studies and a slightly positive causality from population to growth while considering time series analyses. In a sense, though it can be said that, research started in the 1980s 'revisioned' a comprehensive development in analyzing the impact of population growth mainly due to the consideration of 'time' dimension (i.e., modifying shorter-run direct effects of demography with feedbacks occurring in the longer run) and impact of separate components of demographic change (births, deaths, age, size, and density), however, until the 1990s, uncertainties remained concerning quantitative assessments of the impact.

- ***Empirical results based on convergence-patterns approach***

Extending Brander and Dowrick (1994) and Barlow (1994) models[11] KS (1995) used the convergence-patterns approach (Eq.4) to explore the relation between economic growth and demographic factors. Counting on the anomalies in the 1980s KS(1995) posed the intriguing question: "Has the impact of population growth changed?" Putting it more specifically, "Has the direction of the impact of population growth changed over the decades?" Building on Barro's (1991) core variables[12], KS (1995) have modeled aggregate population growth taking into account its different demographic components and answered the above question by untangling the short- and long-run effects of the components of demographic change. They distinguish between several alternative demographic influences on the economy's potential output in the long-run (e.g., the impact of population size and density), and timing of demographic impacts (e.g., the timing of birth rate and death rate reductions) which affect both the short and long-run.

The central results in KS (1995) have been summarised in Section 1, however, just to recollect the main findings of KS (1995), we summarise them as follows: (i)

[10]We explain this feature and its consequence more clearly in the next section.

[11]These models showed that past births contribute to current labor force and hence promote economic growth, whereas current births impede economic growth due to adverse effects on resource base and thus on investment.

[12]The variables are age structure, life-expectancy, level of per capita income, level of education, crude birth and death rates, etc.

'A decrease in the crude death rate induces economic growth in developing countries'. (ii) Although death rate reductions contributed positively in each decade, this contribution declined monotonically over time. (iii) Concerning the impact of birth rates, KS (1995) conclude that the short-term costs of high birth rates increased in the developing countries in the 1980s. For developed countries a different picture emerge: negative effects of birth rate are found, the magnitude of which is large in the 1960s and 1970s, but fairly small in 1980s. Nonetheless, the effect of past births are depicted to be small. Interestingly, the population pressure depicted by 'density' variable is found to significantly affect output growth for all the decades (1960-1990). The growth-enhancing effect of density in all these periods mean that increasing population prompt higher innovation and hence higher economic growth. The result is found to be consistent for all the countries over three decades (1960-1990).

Since different components of demographic change exert varying effects on growth of income depending on the time profile, i.e., on the short-run and long-run consequences, a summary analysis of their impact in the following section can explain the consequences of demographic change from development perspective.

3 Components of Demographic Change and Economic Growth: Short-run and Long-run Impacts

3.1 Overview

Notwithstanding the standard explanation of aggregate output fluctuation, research in the last decades (as summarised in the preceding sections) weigh heavily in favor of demographic factors in order to provide an alternative explanation to economic growth fluctuation. Population theorists argue that demographic components, like age structure and life expectancy rate remain much more stable over time while technological changes, human capital, and budgetary disciplines involve lot of uncertainties and complex methodological issues. Unlike the former, the short-run and long-run impacts, which demographic components exert on the aggregate economy, are more easy to be tapped and channelled into the economy due to the same reason of less uncertainty and more stability. Taking the recent flavor of demographic route, it is getting increasingly acclaimed that population growth is the driving force of growth in the economy.

Extant literature in economic growth is abound with numerous findings in this regard. For instance, Boucekkine et al. (2002) argue that the effect of population growth on per capita output growth should be interpreted in the light of the vintage structure of the aggregate human capital. Based on demographic shifts, the authors provide explanation to the transition from a stagnant to a modern-growth economy by noting that an exogenous increase in longevity leads to higher schooling time and can induce an economy from a no-growth path to a balanced growth path. Essentially this means that the short-run and long-run consequences of population growth depends on the growth of its vintage components (refer to equation 2). That is, contrary to the orthodox perception of 'people being only the *consumers* of resources' (Crenshaw et al., 1997), the rise of the population number should not, *per se*, be thought of retarding economic growth. The number may in fact spur economic growth depending on the caveat of which 'segment' of the population is on the rise. A brief analysis of the dynamic consequences of population growth follows next.

3.2 Short and long run impacts

We mentioned above that the dynamic impact of population growth on the growth of per capita output depends on the *vintage structure* of population viz., the young generation, the labor force, and the retired cohorts. The magnitude of short-run and long-run effects depends on the magnitude and pace of growth of these generations. To start with, the growth in the number of children may impede economic growth as scarce economic resources are invested in goods and services that yield 'few immediate economic multipliers' (Crenshaw et al., 1997). But growth in the economically active population, i.e., labor force, is rather beneficial as it can propel economic growth due to their resource creating abilities. Thus population policy aiming at birth rate and mortality reductions will infuse short-run and long-run consequences in the economy.

To be more clear on the timing of impact consider that higher births generally add to the population mass of a country and that the short-run effect of a birth is likely to be negative[13]. This may incline a national government to adopt birth rate reductions policies. This has an immediate positive short-run impact on growth since it economizes on child-rearing expenses. In about say fifteen years, the role may be reversed as 'there will be fewer persons entering their productive work force years' (KS, 2001). However, the dynamics due to birth rate reductions can be explained in terms of the 'autocorrelated' nature of past and current births.

A strong economic logic and empirical evidence follows this fact. Take for instance, the case of developing countries. Current high population growth of these countries is autocorrelated, implying that they experienced hight past population growth rates. This observation has two-way effects: On the one hand, the stock of accumulated 'resource users' shoots up over time exhibiting negative impact on the economy, while on the other hand, as the new births in the past turn out to be 'resource creators' in the life cycle, accumulation of them in the economy infuses positive externalities. In terms of time impact, population growth can have short-run negative effect on economic growth due to youth dependency, and long-term positive impact resulting from labor force growth and a subsequent boost in aggregate demand (Bloom and Freeman, 1998; Barlow, 1994).

Following neoclassical economic thinking, where a labor force growth is assumed to be essential for economic growth, the positive correlation of labor force

[13]Because the children or young generation are net 'resource users'.

growth and economic growth can be explained taking account of the scale and demand effects. Following Crenshaw et al. (1997), a growing labor force encourages scale effects in terms of larger domestic markets, a more complex division of labor, a greater volume of diffused technology, and lower per capita costs of public infrastructure (e.g., roads and transports). Similarly, the demand effects can be explained using 'Kuznets cycles' of U.S. economic history; increasing population has been associated with increasing production - the possible reason being increased demand for consumer goods in the wake of family formation (Easterlin, 1968).

Mortality reductions, especially infant/child mortality, can have similar time impacts as birth rate reduction. If mortality decline is concentrated among infants and young children, this may create a baby boom in the initial years. Subsequently, due to increased use of contraception, the consequent declining fertility generates a large cohort of young people. When this cohort enters the labor force, it produces a period of 40 to 50 years in which the existence of relatively high worker-dependent ratio creates a potential boost to per capita income (Bloom and Canning, 2001). Eventually, as the cohort ages, the effect disappears, though it can still have notable significance while it lasts.

Population growth has also been explained in some recent studies (e.g., Nielsen and Alderson, 1995) as generating income inequality in the long run. According to them, rapid labor force growth deteriorates wage rates and generates inequalities. As Crenshaw et al. (1997) put, to justify the logic of positive association between labor force growth and economic development, it is necessary to have individual and family adversity, sharp levels of income inequality, and declining wages in the face of stiff labor competition. Following Lewis's (1954, 1958) two-sector model, the authors explain that during early and intermediate stages of development, rapid labor force growth boosts the profit margins of the capitalists in the modern sector by reducing the average wage levels. These profits, in turn, get invested in the modern sector, and productivity and hence the job opportunities improve in the long run.

Excessive population growth can also have a long term impact on economic growth with respect to higher population density and size. In economic geography literature, explanations have been put forward how density of population positively affects production and consequently affect growth. In empirical growth literature, models which explore density and size, in addition to population growth posit that, population density and all components of demographic change exert significant effect on output growth. They found that population density had a significant positive effect in 1960s and 1970s and the net effect of all three components of demographic change is negative, on average for all countries. However, a complete explanation of statistically robust correlations between population growth and per capita output growth, as summarised above, needed a complex and extensive statistical modeling because of the anomaly in the 1980s due to world recessions, war, and droughts and because of a possible association of negative consequences of population growth with diminishing returns to capital and the environment (KS, 1995).

To summarise the discussions so far, the research investigating the impact of population growth on economic development, have substantially changed over the years. From theoretical perspective, the formulation of population in terms of vintage structure and studying its impact on the economy in an endogenous growth framework (Boucekkine et al. 2002) is a major leap. A remarkable contribution followed from KS (1995) in the empirical front; in line with Brander and Dowrick's (1994) tradition, KS decomposed the aggregate population into components of change and laid the foundation for untangling the long-run and short-run effects of population growth on economic development using an exhaustive econometric methodology. As pointed out before, extending KS (1995) work, in this paper, we study how the weight of each demographic effect has changed over time. In the following section we describe the features of the data and methodological framework used in this paper.

4 Methodology and Data

4.1 Methodology

The methodological framework described in this section heavily draws on KS (1995). Since our purpose in this paper is to show the changing weight of the demographic factors by extending KS (1995) data set till the current period, hence, the empirical specifications as well as the econometric methodologies used by KS (1995) have been retained in our investigation so that appropriate comparison[14] can be made. KS (1995) specified the following equation:

$$(Y/Ngr)_{i(t,t+n)} = \alpha_i + \eta_t + \beta \ln (Y/N)_{it} + \theta I_{it} + \delta S_{it} + \varsigma (X_D)_{it} + \xi \left\{ X_D * Y/N \right\}_{it} + \varepsilon_{it} \quad (5)$$

$$\text{where } \varepsilon_{it} \sim IN(0, \sigma^2)$$

Three empirical specifications (of equation 4 and hence equation 5), are used, each one succeeding the other inductively following the addition of different demographic variables in the model. Specifically, we start with the simple model where per capita output growth[15] is explained by the log of initial level of per capita income, the aggregate population growth, the density of the population, and the interaction term, i.e., $Ngr * (Y/Ngr)$. Note that the variable, 'density', has been entered in each (of the three) equation as it represents the information about the initial state of the economy and most importantly it captures the technological change concept which is induced by faster population growth. In the next model, a decomposition of Ngr, viz., CBR, and CDR, and their interaction terms are considered. The third model is the most general one, where another demographic component, $CBR - 15$ is added to model 2 to take account of the net effect of past births on the growth of

[14]The methodologies used in this paper can be substantially changed incorporating more time series features in the framework and studying the memory property of the demographic components. However, this exercise is reserved for future investigation.

[15]note that we do not refer here to the instantaneous growth, rather growth over period.

per capita output. The empirical models derived from equation 5 have the following specifications:

$$Model1 : (Y/Ngr)_{i(t,t+n)} = \alpha_i + \eta_t + \beta \ln{(Y/N)}_{it} + \delta_1 Ngr_{it} + \delta_2 (Ngr * Y/N)_{it} + \theta(Density)_{it} + \varepsilon_{it} \quad (6)$$

$$Model2 : (Y/Ngr)_{i(t,t+n)} = \alpha_i + \eta_t + \beta \ln{(Y/N)}_{it} + \delta_1 (CBR)_{it} + \delta_2 (CBR * Y/N)_{it} + \delta_3 (CDR)_{it} + \delta_4 (CDR * Y/N)_{it} + \theta(Density)_{it} + \varepsilon_{it} \quad (7)$$

$$Model3 : (Y/Ngr)_{i(t,t+n)} = \alpha_i + \eta_t + \beta \ln{(Y/N)}_{it} + \delta_1 (CBR)_{it} + \delta_2 (CBR * Y/N)_{it} + \delta_3 (CBR_{-15})_{it} + \delta_4 (CBR_{-15} * Y/N)_{it} + \delta_5 (CDR)_{it} + \delta_6 (CDR * Y/N)_{it} + \theta(Density)_{it} + \varepsilon_{it}. \quad (8)$$

KS (1995) argued that the variables, CBR, CDR, and CBR-15, included in the demographic models (as described above), are robust in explaining the effect of demographic component on economic growth, though several other 'extra' variables like primary and secondary enrollment rates, government expenditure shares, and a proxy for distortions in investment prices, can be included in the model in line with Barro(1991). However, as KS(1995) noted, inclusion of these 'extra' variables unnecessarily complicated their model and most importantly, their inclusion barely changed the demographic coefficients. In the present exercise, as in KS (1995) we have used the same set of demographic variables. An importnat question arises about the functional form of Y/N. Basically three types functional forms, viz., linear, log, and cubic forms have been used by different authors in various studies. Among them the log form of Y/N is chosen following KS (1995), as adjusted R^2 for log form was among the highest with no notable differences in demographic effects (KS, 1995).

We discuss now the method of estimation of the empirical specification of the convergence-patterns model (equations 5-8). α_i and η_t in these equations denote country specific and time specific intercepts. Depending on the assumptions made about α_i and η_t different kinds of models could be generated viz., Pooled estimation, Fixed Effect Model (FEM) and Random Effect Model (REM). In the empirical growth theory, there are numerous applications and discussions about the relative significance of these methods. Specific discussions in this regard centered on whether α_i is properly viewed as a random variable (known as random effect model) or as parameter to be estimated (known as fixed effect model). Nevertheless, the application of these two methods (viz., FEM and REM) is sometimes limited by the choice of the economic model and intuition guiding the theory of specific interest to the researchers.

REM assumes α_i and η_t as random which are separate components of the error terms. Though theoretically REM edges over FEM on efficiency ground, its estimates may be biased if α_i and η_t are correlated with independent variables, i.e., X_D type of variables, and $ln(Y/N)$ in our case. For instance, if natural resources are a part of the individual intercept α_i and are correlated with $ln(Y/N)$, then use of REM will result in biased coefficient estimates. Moreover, FEM are appropriate if individuals in the sample (i) can not be viewed as random draw of some underlying distribution. It is the case here where i denotes countries. KS (1995) note that FEM 'edges out REM in situations in which the sample represents a sizable proportion of the population', which is a feature of our specific case. Using Hausman specification test, the authors showed that FEM consistently dominates REM and Pooled estimation methods employed in his study. Following KS, the fixed effects method has been used for our purpose. Note that the most important assumption on which panel estimation methods (FEM or REM) are based is the cross-section independence of observations. There is a growing literature in this field recently which considers 'dependence' structure and not the standard 'structure of independence' of observations in the model. Empirical applications of this new consideration is rather sparse because it involves lot of methodological complexities. Nonetheles, the 'independence' assumption is very standard in panel data literature and therefore, FEM has been estimated for our empirical model based on this assumption.

Using FEM means inclusion of as many country intercepts and the determined time periods intercepts in the estimation. The country dummies control for the influences of per capita income growth, viz., cultural attitude or natural resource base, which vary across countries but reasonably remain constant over time within countries (KS, 1995). The time dummies control for period-specific and /or global influences, for instance, the oil price shock in the 70s and recessionary periods (in the 80s). Moreover, under the assumption of single intercept, we perform a 'pooled regression' (see Table 3). At the same time, to capture the separate effect of each decade, cross section regressions for four decennial periods have been performed. The results of FEM (based on all models), Pooled, and Cross-section estimations (based on Model 3) are reported in Tables 1 and 2.

4.2 Data

The estimation is based on the regression of 86 countries (63: developing and 23: developed countries). Our dependent variable is per capita growth rate of GDP (at constant purchasing power parity (PPP) at 1995 base). It is now widely recognised that Real GDP per capita is the best indicator of a nation's affluence. We have used real GDP given its standardization in 1995 international dollars that adjusts for the actual buying power of national currencies, and excludes the factor income from abroad (See, Summers and Heston,1994, and Penn World Table 5.1).

Data on population growth, the crude birth rate (CBR) and the crude death rate (CDR) have been collected from the US Census Bureau, while density, and other relevant data have been collected from the World Bank Development Indicators. CBR, and CDR are measured per 100 population, and density is measured per 1000 population. The available length of data is for 40 years, beginning from 1960 and ending at 2000. Note that data on these variables have been aggregated over decennial periods keeping in mind the possibility of persistence and simultaneity between the dependent and explanatory variables. Aggregating over longer growth periods (say 10 year aggregation in our case), the differential Y/Ngr growth rates can alter Y/N enough to influence substantially the pace of demographic change. KS (1995) note that decennial periods embody more 'real' demographic information because lower-degree aggregation, say 5 years, rely on the assumptions inherent in extrapolations between decennial censuses. Thus in the estimation we have four decennial periods: 1960-70, 1970-80, 1980-90, and 1990-2000.

It may be mentioned here that per capita output growth, the dependent variable of our model, is not an 'instantaneous' growth rate. In the empirical literature, growth models often use 'growth over periods' and not 'instantaneous growth'. Hence confusion might arise about the calculation of the per capita output growth rate in our model which is calculated as: $\sqrt[n]{(Y/Ngr)_{t+n}/(Y/Ngr)_t} - 1$. n, in our case, is 10 years. To take into account the dynamic effect of the birth rate, we have lagged crude birth rate by 15 years, as netting out the effect of lagged birth rate, $(CBR{-}15)$, establishes the significance of labor force in the estimation and thereby can reduce the magnitude of 'negative effect' of CBR in the estimation. Since demographic data were unavailable before 1950, therefore, lagged values for CBR-15 for 1960s apply to 1950-55. Similarly for 1970s, it applies to 1955-1965; for 1980s, to 1965-1975; and for 1990, it is 1975-1985.

5 Empirical results

5.1 Results of Panel and Cross-section estimation

The empirical results presented in this section are based on the methodological framework outlined in Section 4. We consider a panel of 86 countries spanning over four decades (1960-2000). The results can be studied from two perspectives: first, the fixed effect panel estimation results summarise the efect of each demographic component over four decades. A pooled regression under common country intercepts for all countries (both developed and developing) has been performed for model 3 (Equation 8).

Second, to perceive the separate effect of these components in each decade cross-section regressions of per capita income growth on demographic components have been performed using model 3. Based on the estimates from these regressions, partial derivatives of the per capita income with respect to each demographic components have been calculated so that their exact effect on per capita income growth can be assessed. A confidence band ($\pm 2\sigma$) has been constructed for the partial effect of demographic components so that significance of each effect can be judged statistically. To provide credence to our findings, we have also performed parameter stability test for all countries as well as separately for developing and developed countries. As expected, the stability test results confirms the consistency and invariance of our results across time. A detailed analysis of our results and comparison with KS (1995) findings follows next.

I. Effects of $ln(Y/N)$ and Density

To begin with, we first examine the convergence-patterns hypothesis from our estimation. The empirical relation between Y/Ngr and Y/N was described in the preceding section (section 2). It was noted that Y/Ngr varies inversely with Y/N, the initial level of per capita income. The negative sign of the coefficient of Y/N explains the the logic of the convergence patterns model. The relation has been explored in three models (see Table 1), from the most restrictive to the most general (Model 3). Restrictive (Model 1) in the sense that the demographic components have been excluded in the model so that one can perceive only the effect of aggregate population growth and the state variable, the density of population in the model. In Model 2 and Model 3, demographic variables have been inductively included (See Table 1). Note that adding more demographic variables (in Model 2 first and then Model 3 for the most general one) increased the explanatory power of the model. As expected, R^2 is the highest with the most general model (Model 3 in Table 1). The estimates of the panel estimation using FEM (Table 1), exhibit the expected sign for the convergence pattern model, i.e., significant negative estimates of $ln(Y/N)$ are observed in all the three models. Precisely, this vindicates the invariance of 'convergence' hypothesis to the decomposition of aggregate population into various components, viz., CBR, CDR, CBR_{-15}.

Now consider the effect of population density from our estimation. Contrary to KS (1995) finding, where 'density' exerted significant positive effect on per capita output growth in all cross-sectional periods and across all models, we find a varied pattern in our estimation (See Tables 1 and 2). A siginicantly positive effect of density is found in our model considering only Model 2 (without CBR_{-15}), pooled estimation, and in the 1960 among cross section estimation (see Table 2). Though our own estimation of KS model for three decennial periods (Table 6 in the appendix) is very much in consonance with KS (1995), our new estimation with extended data provide interesting evidence in that population density had positive influence on per capita income growth in all the countries only in the 1960s. Over the next two decades, the effect remained insignificant, and most interestingly, it turned out to be negative[16] in the last decade (in the 1990-2000). Despite KS (1995) finding of significant effect of density over all periods, the finding of no consistent effect in our estimation over the decades indicates that population density has not contributed significantly for innovation inducement and economic growth over the past four decades.

[16]Despite showing insignificant negative sign, it can at least give indication of the changing pattern of density effect on Y/Ngr.

II. Effects of Demographic Components

The effects of the demographic components on Y/Ngr can be studied by looking at both their individual impacts on output growth and the corresponding effect of the interaction terms. To incorporate the effect of the interaction terms, notice that Y/N has been multiplied with each demographic component (see Model 2 and Model 3, also Tables 1 and 2) so that the magnitude of the partial effect of each demographic term on per capita output growth, Y/Ngr, can be assessed. Consider Model 1 (in Table 1). Though ngr and its interaction term (in this model) do not significantly affect Y/Ngr (individually), their joint impacts are found to be negatively significant (at the 0.05 level[17]). Conclusion about negative effect of population on Y/Ngr, following Model 1, at best provides preliminary gross assessments, as nothing is revealed about its exact profile of impact on Y/Ngr. For the purpose, ngr has been segregated into different components according to their resource using and creating abilities. In Models 2 and 3 (Table 1), the results from this regression are reported.

First, consider the effect of CBR on Y/Ngr. The coefficients of CBR and its interaction term, $CBR * Y/N$, in Model 2 (Table 1), are insignificant. In KS (1995), page 551, the coefficient of CBR has always been significant which is a contrast to our results. However, we find joint significance of CBR and its interaction term to be negative which is the same as KS (1995)[18]. Intuitively, this means higher births retard economic growth possibly though higher dependence of younger population on economic resources which ultimately reduces savings and hence economic growth via negative multiplier effect.

To know the specific effects of an increase (decrease) in CBR in case of developed and developing countries, let's study col.2 of Table 4 where partial effects of different demographic components on per capita output are reported. The partial effects are evaluated at (Y/N) medians of developed and developing countries (see Table 3). The partial effects are plotted in Figures 1 and 1a. Figure 1a presents a comparison of our finding with KS (1995). Evidently, the comparison is made till 1990 since KS (1995) sample included the period 1960-1990. In Figure 1a, CBR-own indicates our estimation and CBR-KS indicates KS (1995) result. Looking at Figure 1a, it can be observed that the partial effect of CBR in developing countries, in contrast to KS (1995), is not monotonically declining over time. Our estimate show a step-like pattern. Monotonic decline of the partial effect of CBR for developing countries in KS (1995) means that higher births in succeeding decades in these countries consistently and continuously impinge more harm on economic growth. Step-like pattern of the partial effect, as found in our case instead implies this is not the case. There could be the effect of some population policy which can cause

[17]the joint significance test result is not reported in the table but are indicated as square bracket over the respective demographic variable and its corresponding interaction term. The results can be obtained from the author upon request.

[18]We have reproduced the KS (1995) table with our data set using three decennial periods. Table 6 in the appendix summarised KS (1995) findings.

the effect of CBR to be felt severely in some decades, but not consistenly for all the decades together. I

In our case, the negative effect of birth rise reached the lowest in the 1980s. An upward trend (though negative) of the effect in 1990-2000 implies that in future the effect of CBR can have positive effect on per capita income growth for developing countries. A forecast based on our estimates would imply so. The reason for the step-like pattern could be as follows. Due to high investment in education and human capital in the developing countries the recent years, the negative effects of CBR may recede over time. Moreover, the adoption of population control policy in developing countries that began as early as 1960 and 1970s, did not register immediate impact on economic growth. The possibility of revival in the 1990s contemplates the fact that population control policy adopted earlier would bear some positive impact on economic growth which might take another decade or so to completely settle in. This empirical fact is much closer to the logic that depending on the nature of the structural parameters of the economy (e.g., in our case it could be the social environment and educational attainment of the population), a shock (in terms of policy adoption for population control) intended to put the economy in a different path - might take a long time for the effect to be felt. Indeed, this is the case with population control policy too: the economy might have to wait a long time for the full effect to be internalised (see Dasgupta, 1995 for a discussion on these issues).

Within developed countries, effect of CBR gives rise to some interesting features. Beginning from high negative partial effect of higher births in the 1970s, the current decade (1990-2000) shows positive impact of CBR on developed countries income growth. In view of KS (1995) finding, the negative impacts of higher births seemed to recede over time, being 'fairly small' in 1980-90, though it still remained negative during the same decade (Figure 2a). From our cross-section estimation, we find that the effect of birth rates have become positive for the developed countries during the last decade (1990-2000). In view of the recent demographic changes in the developed world, this contributory effect of CBR is very important.

A possible reason for this trend can be laid as follows. Developed countries experienced a huge drop in mortality and consequently followed a continuous and steady decline in fertility. In most part of the European continent, as Boucekkine et al. (2001) note, "fertility has now reached or even fallen below the replacement level". Therefore, though "the future scenario of zero population growth is considered seriously", the finding of positive effect of higher births for developed countries in our study, calls for a re-examination of the hypothesi. It is nevertheless true that, due to drastic fall in fertility level in the developed countries, along with an increase in the schooling time, the 'replacement level' of population must be substituted for higher births. There is large literature that confounds this logic. At the simplest level, it can be said that higher CBR in the countries experiencing higher fertility is as dangerous as lower births in low fertility countries. The consequence being the same, only the time profile of effects differs.

Compensating for the negative overall effect of higher births, a decrease in CDR is expected to accelerate economic growth. Coefficient of CDR in Model 2

(Table 1) is not significant though the significant interaction term, $CDR*(Y/N)$, as well as their joint significance, summarises the partial negative effect of CDR on economic growth. The conclusion is strengthened when we consider the general model (model 3, where the effect of lagged birth rate (CBR_{-15}) is incorporated). As can be seen, both CDR and $CDR*(Y/N)$ exert significant impact on Y/Ngr. The finding of negative effect of CDR implies that reduction in CDR will enhance economic growth. But which country block (i.e., developing or developed) stand to gain more from a further reduction of CDR? A close look at Table 4 and figures 3-4 provide some insights. Column 3 of Table 4 presents the partial effect of CDR on per capita income growth for both developed and developing countries. Figures 3 and 4 plot the effects of CDR in both sets of countries. Additionally, to provide a comparison with KS (1995), Figures 3a and 4a represent the comparison for developing and developed countries respectively.

To evaluate the partial effect of CDR, first begin with the case of developing countries. A drop in median value of CDR from 0.985 (in 1980-90) to 0.765 (in 1990-2000) (see Table 3) in these countries was expected to increase output growth per capita during the decades. As mentioned, this can be known from the partial effect of CDR reduction on per capita output. Considering the estimates from Table 4, the partial effect of reducing CDR for developing countries during 1980-2000, in fact improved per capita output. Even, if we compare our estimates for the period 1980-90 with that of KS (1995), a clear distinction emerges: the size of the effect of CDR on output growth in case of KS (1995) is smaller than our estimates(Table 4, col.3). Figures 3 and 3a provide a plot of these results). It is true that death reductions in developing countries is mostly concentrated in younger and working age people who by and large contribute to the output growth process.

Going by KS(1995) estimates, a still positive partial effect can be expected from death reductions in developing countries. Considering our estimates, this optimism somehow fades in. As can be seen from Figures 3, and 3a, CDR reduction will benefit little to the developing countries at least in the short-run given the current magnitude which is still negative. In case of developed countries, the positive effect of CDR reduction diminish over time following KS (1995), even becoming negative during 1980-1990. The effect of CDR reduction for 1990-2000 cane be seen from our estimation (Table 4, col.3). We find even large negative effect of CDR during this decade. This result gives another intuition to our earlier explanation why CBR has contributed positively to the growth in the developed countries.

So far we discussed the effect of CBR and CDR reductions on the growth of output taking the case of both developed and developing nations. Another demographic factor which is also important is the lagged effect of CBR, namely CBR_{-15} in our model. Generally, CBR_{-15} is likely to scale down the negative partial effect of CBR in the model (see Model 3) so that the net effect of CBR can be correctly specified. Going by our results, we find significant negative effect of CBR_{-15} on output growth per capita (Model 3, Table 1). In fact, our pooled estimation also vindicates this finding (Table 1, col. 5). In KS (1995), initially starting from a negative effect in the 1960s, it latter became large and positive for the developing countries in the ensuing decades. Surprisingly, large negative effect of CBR_{-15} is found in our study for developing countries for all the decades, whereas for developed countries, the lagged birth rate contributed to per capita output growth in the 1980s, finally setting down to large negative value in 1990 (Figures 5a, 6a). It can be said that the expected (positive) effect of CBR_{-15} as per our estimation does not show much promise as a catalyst for growth since its growth-enhancing effect could have very much been confused by the 'persistent high births' in most of the developing countries. The caveat here is that as the number of births keep on rising every year, this 'persistent effect' becomes so large that it outweighs the effect of lagged birth rate (CBR_{-15} for those countries. Therefore, the growth-enhancing effect of CBR_{-15} may not be so prominent in developing countries in comparison to the developed counterpart.

At the end we have performed a parameter constancy test for developed and developing countries for the period 1960-2000. Table 5 reports the results of the test. As can be observed, we reject the null hypothesis of non-constant parameters during 1960-2000 for developed and developing countries.

6 Concluding remarks

Motivated by Kelley and Schmidt (1995, 2001) and Crenshaw et al. (1997) empirical findings concerning the 'effect of demographic components on economic development', we studied in this paper, how the weight of each component effect has changed over time. Extending Kelley and Schmidt (1995) data till 2000, (more precisely, including another decennial period in the model), we showed that the weight of the effect of demographic components have changed over the last four decades. Most important conclusions of this paper are: (*i*) there is little gain to expect from further reductions in mortality in the developing countries. Mortality reductions in these countries are heavily concentrated among children, which is costly in terms of economies output. With higher and persistent birth rates the effort to materialise the positive effect of mortality reductions in the developing countries can do no more good. In effect, the national governments in these countries should control for the momentum of persistent high birth rate effects.

(*ii*) Despite the fact that higher birth rates retard economic progress in developing countries, interestingly the same may not be true for developed nations. We found that the effect of CBR has become positive in the developed countries in the recent decade. This finding can be put into perspective given that the future of zero population growth as optimum for higher economic growth is considered nowadays by some researchers (Boucekkine et al. 2002). Given the recent trend of demographic transitions and declining fertility level in these countries, economic growth may in fact get slowly paced. A positive effect of CBR as found in our paper in fact provides an interesting and healthy sign for economic growth. (*iii*) The effect of CDR in the developed countries is very large in all the decades - larger during the current decade (1990-2000). As we know, death rate reductions contribute positively to economic growth in each decade. During the last decade, the effect seems to be quite large. Important to note that unlike developing countries, death rate reductions in the developed countries are concentrated not only among younger generations but most importantly among the working age people. Hence, as the greater the number of working age people, the faster is the economic progress.

(*iv*) Another contribution of the paper is the finding of vanishing positive effect of population density. Though under common country intercepts (pooled estimation), a significantly positive effect of density was observed, in the span of four decades, the growth-enhancing role of density found in our paper has only been limited to the sixties.

The finding of large negative partial effect of CBR in developing country for the past decade can be put both in historical and theoretical perspectives: given poor resource base, higher birth rate (accumulated over time from successive higher birth rates in the past) will put the developing countries economic prosperity into dismay. The effect of population policies aimed at controlling birth rate reductions in developing nations, will take time to make the positive effects being felt. Since these countries historically suffer from past high population growth, the rate of accumulation of lagged birth rate (CBR-15) might have been slower in the 1970s and 1980s and the net effect of CBR could have less than an offsetting amount. The period 1990s experienced a slackening effect of lagged birth rate both in case of developing and developed countries especially in the last decade. This is in contrast to KS (1995) finding: in case of developing countries, the favorable effect of past births starting from 1970s continued to be positive till 1990s, while the effect turned out to be negative during 1970-90s for developed nations. Overall it seems that the impact of lagged birth rate in the last decade is highly increased both in developed and developing country economies. Our estimates show that the favorable effect of lagged birth rate is felt only in 1980s in case of developed countries, while the effect tended to be negative for developing nations over time. The short-term costs of high birth rates has been increasingly felt by developing countries over past four decades. Mortality reductions in those countries (concentrated mainly on infants) showed a sign of improvement though still remained negative till date.

Finally a note on the model and assumption is in order. Notice that throughout the paper we assumed stationarity of the demographic variables. Consequently, a stationary panel method was used for estimation. However, recent research (Gil Alana, 2003) shows that population can possess a kind of memory property or long-range dependence. With stationary assumption all inherent dynamics of the process is assumed out. However, allowing for memory structure to prevail in population variable shows high degree of memory which of course affects other variables like per capita output growth. Hence the time series effect of demographic variables must be taken into account which is disregarded in stationary panels.

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Table 1: KS Extended Model: Dependent Variable, (Y/Ngr)

	Panel Estimation: Fixed effect model			
	Model 1	Model 2	Model 3	Pooled
Ln(Y/N)	-2.389(-3.66)	-2.567(-2.15)	-3.55(-2.58)	-0.115(-0.184)
Ngr	$\lceil -0.409(-1.00) \rceil$			
Ngr*(Y/N)	$\lfloor -0.025(-0.728) \rfloor$			
CBR		$\lceil -0.544(-0.853) \rceil$	$\lceil -0.334(-0.504) \rceil$	-0.272(-0.785)
CBR*(Y/N)		$\lfloor -0.100(-1.44) \rfloor$	$\lfloor -0.120(-1.75) \rfloor$	-0.042(-0.732)
CBR_{-15}			$\lceil -1.05(-3.08) \rceil$	-0.901(-3.24)
$CBR_{-15} * (Y/N)$			$\lfloor 0.049(0.817) \rfloor$	-0.019(-0.502)
CDR		$\lceil -0.884(-1.38) \rceil$	$\lceil -1.22(-2.12) \rceil$	-0.571(-1.14)
CDR*(Y/N)		$\lfloor 0.186(2.50) \rfloor$	$\lfloor 0.163(2.16) \rfloor$	-0.094(-1.52)
Density	0.719(1.36)	0.740(1.69)	0.281(0.567)	0.614(8.23)
Constant	8.61(6.63)	11.06(4.16)	14.63(4.44)	7.47(5.49)
R^2	0.60	0.62	0.63	0.20
Std. Error (σ)	2.057	2.052	2.01	2.05
No. of Observations	343	343	343	343

Note: t-statistics are in parentheses (at 0.05 level)
Square brackets over two variables indicate joint significance at 0.05 level

Table 2: Cross-Section Estimation (Model 3): Dependent Variable, (Y/Ngr)

	1960-70	1970-80	1980-90	1990-2000
Ln(Y/N)	-0.133(-0.136)	1.219(1.064)	-2.653(-2.90)	-1.615(-1.313)
CBR	-0.346(-0.393)	0.902(1.182)	-1.549(-2.623)	-1.658(-1.712)
CBR*(Y/N)	0.031(0.108)	-0.279(-1.75)	-0.025(-0.229)	0.142(0.923)
CBR_{-15}	-0.468(-0.679)	-0.525(-0.792)	-0.545(-0.997)	-0.840(-1.031)
$CBR_{-15} * (Y/N)$	-0.040(-0.197)	0.033(0.291)	0.052(0.574)	-0.031(-0.231)
CDR	-1.066(-1.272)	-2.864(-3.13)	-1.259(-1.548)	0.305(0.315)
CDR*(Y/N)	-0.176(-0.704)	0.043(0.267)	0.065(0.607)	-0.200(-1.69)
Density	1.01(2.37)	0.634(1.474)	0.527(1.522)	-0.027(-0.100)
Constant	8.033(4.217)	5.492(2.26)	11.340(5.405)	10.395(3.643)
R^2	0.37	0.38	0.48	0.27
Adj.R^2	0.31	0.31	0.43	0.19
Std. Error (σ)	1.65	1.82	1.57	2.05
No. of Observations	86	86	86	86

Note: Bracketed values are t-statistics at 5 per cent level

Table 3: Variable Medians

Years	Y/Ngr	Y/N	$Density$	Ngr	CBR	CDR	CBR_{-15}
Developing Countries							
1960-70	2.074	1.628	0.026	2.654	4.559	1.880	3.852
1970-80	1.491	2.018	0.033	2.627	4.345	1.479	3.869
1980-90	-0.028	2.634	0.041	2.541	4.032	0.985	3.762
1990-2000	0.872	2.851	0.057	2.301	3.285	0.765	4.244
Developed Countries							
1960-70	3.455	7.801	0.088	0.811	1.829	0.960	1.881
1970-80	2.532	12.085	0.091	0.847	1.523	0.976	1.774
1980-90	1.864	15.782	0.092	0.444	1.268	0.948	1.659
1990-2000	1.524	19.813	0.096	0.430	1.269	0.932	1.415

Table 4: Partial Derivatives Evaluated at (Y/N) Medians

Years	CBR	CDR	CBR_{-15}
Developing Countries			
1960-70	-0.295	-1.352	-0.533
1970-80	0.338	-2.78	-0.458
1980-90	-1.614	-1.09	-0.408
1990-2000	-1.253	-0.265	-0.928
Developed Countries			
1960-70	-0.104	-2.439	-0.780
1970-80	-2.470	-2.344	-0.126
1980-90	-1.944	-0.233	0.276
1990-2000	1.155	-3.658	-1.454

Table 5: Parameter Constancy Test

	χ^2	Prob.$\succ \chi^2$
All Countries	15.18	0.018
Developing Countries	25.26	0.003
Developed Countries	15.60	0.016

Figure 1

Confidence band for partial derivative for CBR:
Developing Countries

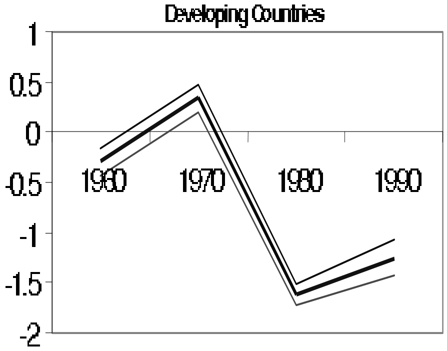


Figure 2
Confidence band for partial derivative of CBR:
Developed Countries

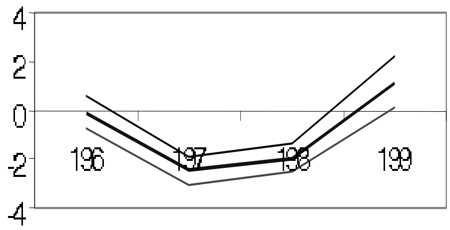


Figure 3
Confidence band for partial derivative of CDR:
Developing Countries

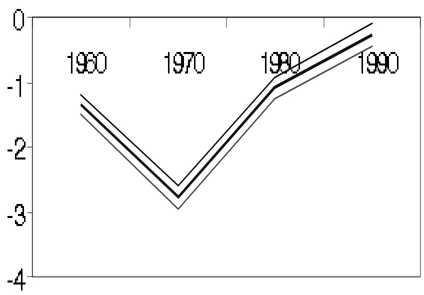


Figure 4

Confidence band for partial derivative of CDR:
Developed Countries

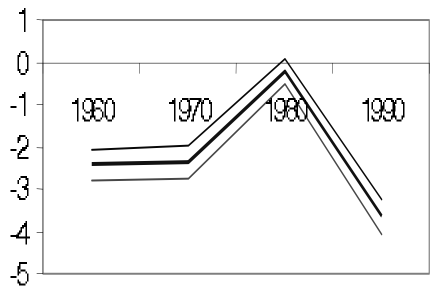


Figure 5

Confidence band for partial derivative of CBR-15:
Developing Countries

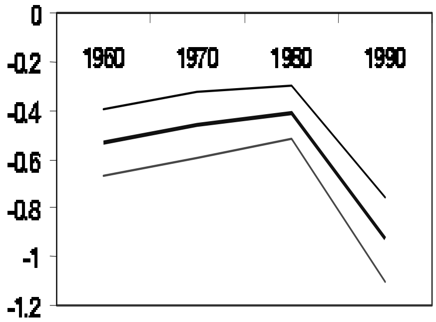


Figure 6

Confidence band for partial derivative of CBR-15:
Developed Countries

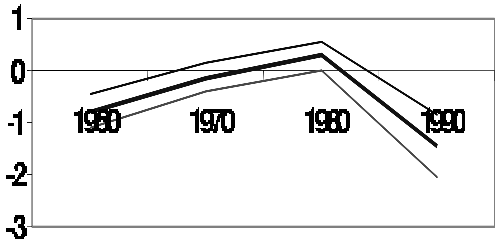


Figure 1a

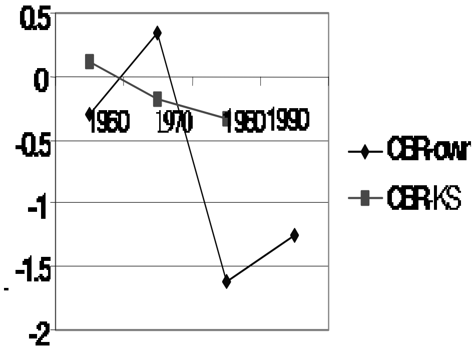


Figure 2a

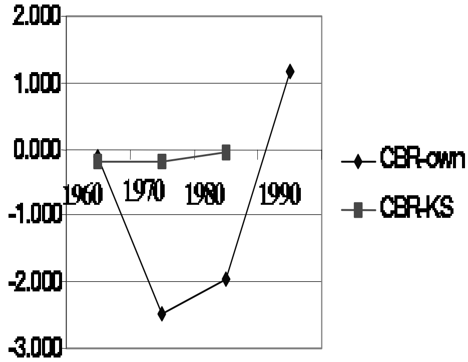


Figure 3a

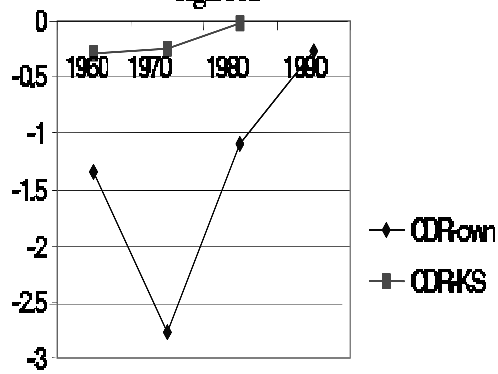


Figure 4a

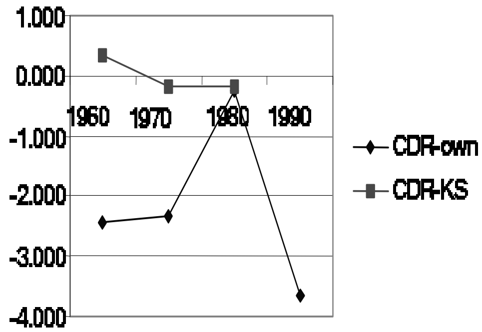


Figure 5a

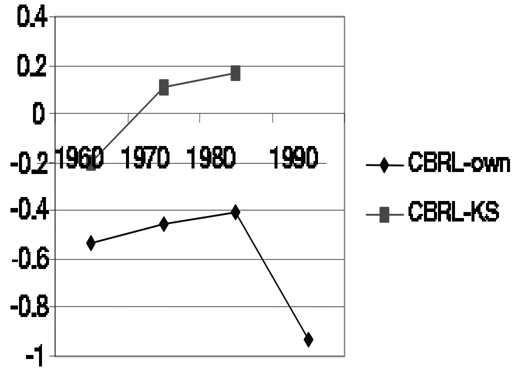
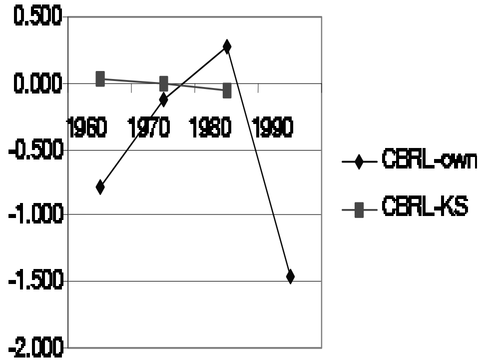


Figure 6a



Appendix

***A*. Calculation of Partial Derivatives**

The partial derivatives reported in Table 4 are calculated in the following way. Recall Model 3 (equation 6) of Section 3:

$$(Y/Ngr)_t = \alpha_i + \eta_t + \beta \ln{(Y/N)}_{it} + \delta_1(CBR)_{it} + \delta_2(CBR * Y/N)_{it} + \delta_3(CBR{-}15)_{it} + \delta_4(CBR{-}15 * Y/N)_{it} + \delta_5(CDR)_{it} + \delta_6(CDR * Y/N)_{it} + \theta(Density)_{it} + \varepsilon_{it} \quad (9)$$

Table 2 reports the cross section estimates of this regression (for four decennial periods). Given those parameter estimates, our purpose is to find the partial derivatives of $(Y/Ngr)_t$ with respect to the variable vector $\underline{\mathbf{X}} = (CBR, CDR, CBRL)$. For instance, in case of CBR, the partial derivative is simply calculated as:

$$\frac{\partial(Y/Ngr)_{i(t,t+n)}}{\partial CBR_{it}} = \hat{\delta_1} + \hat{\delta_2} * Median(Y/N)_{it} \quad (10)$$

In the same way, the partial derivatives for CDR and CBRL could be found using the format above. Since we are interested in comparing the partial derivatives of developing and developed countries, we have used the median of Y/N separately for those two sets of countries.

***B*. Confidence band for estimates of partial derivatives**

Denote the estimate of the partial derivative of say, CBR (at period t and for the set of countries belonging to developing nations) as P_{st}, where s = (1, 2) and t = (1960-70, 1970-80, 1980-90, 1990-2000).

Confidence band of P_{st} at 95 percent significance level (given its mean, $\bar{P_{st}}$, and standard deviation, σ_P) is

$$CI = \bar{P_{st}} \pm 1.96 * \frac{\sigma_P}{\sqrt{N}} \quad (11)$$

$N = 23$ for developed and 63 for developing countries. $\bar{P_{st}}$ is assumed to be the same as the estimated $\hat{P_{st}}$ as

$$\bar{P_{st}} \equiv E[\hat{\delta_1} + \hat{\delta_2} * Median(Y/N)] = \hat{P_{st}} \quad (12)$$

Similarly,

$$l\sigma \equiv \sqrt{Var(P_{st})} \;=\; \sqrt{Var(\hat{\delta_1}) + Var(\hat{\delta_2}) * (Median(Y/N))^2 + 2Median(Y/N)Cov(\hat{\delta_1}, \hat{\delta_2})}$$

C: KS Basic Table (Three Decennial Periods Estimation)

Table 6: KS Basic Model: Dependent Variable, (Y/Ngr)

	Panel Estimation: Fixed effect model			Cross-Sectional Estimation:
	Model 1	Model 2	Model 3	Pooled
Ln(Y/N)	-3.67(-4.48)	-6.018(-4.13)	-5.977(-4.11)	-0.156(-0.301)
Ngr	-0.444(-0.991)			
Ngr*(Y/N)	-0.0406(-0.824)			
CBR		-1.741(-2.99)	-1.672(-2.65)	-0.690(-1.54)
CBR*(Y/N)		-0.032(-0.418)	-0.005(-0.066)	0.005(0.085)
CBR-15			-0.274(-0.491)	-0.226(0.503)
CBR-15*(Y/N)			-0.066(-1.03)	-0.097(-2.01)
CDR		-0.940(-0.913)	-1.137(-1.13)	-0.689(-1.56)
CDR*(Y/N)		0.340(3.00)	0.404(3.57)	-0.014(-0.210)
Density	2.096(3.69)	2.523(3.90)	3.157(3.95)	0.980(6.21)
Constant	9.719	18.05	19.22	7.049
R-square	0.68	0.7	0.71	0.23

Note: Bracketed values are t-statistics