

**DEMOGRAPHIC DIVIDEND AND ECONOMIC GROWTH: CROSS-COUNTRY  
EVIDENCE FROM A BALANCED PANEL**

**Dr. Abhay Singh Chauhan**

**Assistant Professor, Narsee Monjee Institute of Management Studies, Mumbai,  
Maharashtra (India).**

**Prof. S.K. Singh,**

**Head, School of Commerce & Business Studies, Dr. Radhakrishnan Bhavan, Jiwaji  
University, City Centre, Gwalior- 474002 (MP)**

**Dr. Amit Pratap Singh**

**Director, Sun Institute of Pharmaceutical Education & Research (SIPER)  
Lahar, Distt. - Bhind, Madhya Pradesh - 477445**

**Dr. Satyendra Kumar Singh**

**Principal, Divine International Group of Institutions, Gwalior**

**Abstract**

The paper uses the data on World Development Indicators and explores the relationship between the demographic composition and economic growth in a balanced cross-country panel of 266 countries during the 2000-2024 (6,650 country-year observations) period. The relationship between annual GDP per capita growth and the share of working age population (1564), the ratio of the age dependency, fertility and gross fixed capital formation is based on the two-way fixed-effects model administered with country and year dummies, and country-level clustered standard errors. Statistical performances indicate that the global mean working-age share is showing a slow increasing pattern amidst a strong fluctuation in per-capita growth. Fixed capital formation becomes a good, economically significant predictor of growth in base specifications. Modern demographic statistics are in large part, imprecisely modelled, which is near mechanical collinearity between working age share and dependency devices and weak within country age structure variation compared to annual growth shocks. The strong form tests of isolation of demographic proxies and effects lagged indicate that demographic variables can affect growth with lags other than contemporaneously, and the finding of heterogeneity indicate that relationships vary by income group and region. The interpretation of the results in light of the limited covariate set reflects the within-country conditional correlations and not causal effects. Results support the argument that a good age structure is not a sufficient condition to grow rapidly, but rather one needs complementary conditions to ensure the potential of labor supply is converted into productive work, capital accumulation, and long-lasting investment.

**Keywords:** Demographic dividend; age structure; GDP per capita growth; dependency ratio; fertility transition; fix effects; investment; cross country panel.

## 1. Introduction

The demographic trend is transforming the global growth. There are two trends that are prevailing, fertility decline in most areas of the world and high rates of population ageing in other areas. These changes change the ratio between workers and dependants, the support ratio of the economy changes, necessarily reducing the size of resources available to savings, investment, and productivity-enhancing action. The recent World Population Prospects 2024 reports published by the United Nations indicate that population ageing is rapidly increasing in most countries alongside the declining population growth, and considerable cross-country variation in pace and degree (Nations, n.d.). This tends to lead to a key question on the part of policy makers and researchers: under what circumstances (and at what age) a positive age structure can be converted to faster income growth.

The hypothesis of the demographic dividend has a systematic response. With a fall in fertility, the number of children born in a given age decreases in relation to the previous generations with the number born in an age group eventually increasing the proportion of the working-age population. A greater working-age population theoretically has the potential to boost output per capita because it can lead to an increase in supply of labor, a higher savings rate, and relieved fiscal pressure due to the dependency of youth. A contrasting view focuses on the idea that the dividend is not a bipolar: it requires economies to use and absorb larger cohorts with the help of human-capital formation, labor-market opportunities (including female-employment) and capital-deepening. Synoptic policy reviews highlight this conditional nature and promote the market carries out demographic change, both an opportunity in which employment and skills are growing at a faster rate and a threat in which institutions and markets could not transform a mass of working-age population into the productive workforce (“Glob. Monit. Rep. 2015/2016 Dev. Goals an Era Demogr. Chang.,” 2016).

Recent macroeconomic data also explains the same reason as to why, it is convenient to delve into dividends and drags on the same platform. Although fertility transitions remain a way through the flux of many developing economies, increasing old-age shares are already experienced in many developed and upper-middle-income economies. The US has empirical work examples where the potential variation in ageing is assumed to be plausible, and negative effects of ageing on GDP per capita growth are found to be economically significant, which work through employment and labour-productivity channels (Maestas et al., 2023). Simultaneously, OECD economies work is associated with the dynamic panel application of demographic composition to long-term changes in macroeconomic outcomes, stating that demographic structure could have long-lasting impacts in various ways (Aksoy et al., 2019). Combined, these strands suggest age structure is a first-order macroeconomic state variable, with its growth implication to be dependent on situations, timing and concomitant circumstances.

The paper is useful in presenting a clear reproducible cross-national panel examination of the demographic dividend-growth connection using the a balance dataset on 2000-2024. Data in the analysis are annual GDP per capita growth, the working-age share (1564 years old), dependency ratio (ages 15-64 years old) and fertility and gross fixed capital formation as a

share of the GDP. The policy interest in 2000-2024 is policy-relevant: it includes the world warming up to major global shocks (including the Global Financial Crisis and the COVID October and rebound), it is a time of further decline in fertility in many developing nations, and faster ageing in many more prosperous economies. It is also difficult to do permanently: the demographic variables change gradually compared to the volatility of annual growth, and other important indicators of the age-structure are mechanically connected (such as higher shares of working-age people usually mean low dependency ratios). The features ensure that identifying a panel is not an easy task that needs to be specified and interpreted closely.

The empirical strategy thus emphasizes inference within the country but it comes out clear about the identification restrictions. I approximate the two-way fixed-effects models including the country and the year dummies to eliminate the country-specific time-invariance characteristic and international shocks, and I cluster the standard errors at the country level to take the country-specific time-varying shocks into consideration. The baseline specification carries the GDP per capita growth to working-age shares, the dependency ratios, fertility and investment realizing that investments is a proximate path in which demographic structure can be relevant (e.g. via savings and capital accumulation) and an independent correlate of growth. The design also incorporates robustness tests that deal directly with the mechanical linkages such as specifications using working-age share, dependency ratio (but not both) along with heterogeneity tests by income group and region to test the hypothesis that demographic structure is more closely related to growth at specific development phases.

The contribution of the paper is not to indicate a causal effect, which is definite, between demographic structure and growth with a narrow range of covariates. Instead, it gives a punitive judgment of what can be gleaned using a commonly used, policy close-up grouping in a current, turbulent time. By so doing, it makes clear three practical points in the debate on the demographic dividend. One, demographic opportunity is essentially about timing: age structure influences economies with sluggish transitions that in any case may not conform to annual growth realizations. Second, dividends are contingent: to translate working-age shares into growth, for them, complementary investments and the ability to internalize labor productively is needful, as it has been in global policy analyses workforce (“Glob. Monit. Rep. 2015/2016 Dev. Goals an Era Demogr. Chang.,” 2016). Third, the same generation that creates potential dividends can create growth headwinds when the ageing gains momentum, an aspect also demonstrated in recent evidence on ageing and growth (Maestas et al., 2023). With an underpinning of these concerns in a new panel structure of 2000-2024, the paper will also aim to educate the empirical research design paradigm as well as how the demographics are being understood as being narrated in policy discourse.

## **2. Related literature**

*2.1 Ideological background: the explanation of the concept of demographic dividend in macro-development.*

*Demographic dividend:* The concept of a demographic dividend is based on the demographic transition: the stable decreases in mortality and with a lag, decreases in fertility transform the

age distribution of the population. The proportion of the work age population also increases during the transition compared to the dependents (children and older people) and this may lead to higher output per capita as long as the economies are in a position to productively utilize the increased workforce. Recent UN population trends including the fact that numerous states are already in the stages of population growth in terms of a larger working-age population; as well as the fact that most high-income nations are experiencing population ageing and an increased dependency ratio of older adults (Nations, n.d.).

The demographic dividend has traditionally been divided into (i) a first dividend due to a brief rise in the labour supply per dependent, and (ii) a second dividend due to age-related behaviour lifecycle behaviour higher savings and asset accumulation expected as cohorts have longer retirements potentially increasing capitals per worker and productivity. The central argument of the latest literature is that such dividends are not preprogrammed: age-structure transformation causes opportunities, but inheritance, labour market, schooling, gender standards, and macro-stability are the determinants of whether the opportunity is converted into enduring development. This conditional externality is the major one in policy-oriented syntheses as in the case of the World Bank discussion of the Africa demographic transition and the resultant threat that the youthful bulge lacking job-generating activities may generate social as well as fiscal strains instead of a dividend (“Africa’s Demogr. Transit. Divid. or Disaster?,” 2015).

One practical way emerging of the cross-country work practiced is that the so-called demography is not to be considered a single ratio. As fertility and child dependency tend to decline, so does a rising working-age share which, in its turn, tends to reverse in old age. These mechanical connections imply that empirical specification must be clear about what demographic margin is under evaluation (e.g. working age share vs. dependency ratio) as well as how much of the estimated relationship can be due to common transition forces. This is replicated in the ageing-growth literature, in which indicators, such as the old-age share can be misleading during an early ageing dexterity owing to the fact that a rise in the old-age share is likely to be accompanied by a rise in the working-age share (Lee and Shin, 2019).

## *2.2 Age structure to growth channels: labour supply, productivity, savings and human capital.*

The simplest pathway is the arithmetic one: it is possible to get higher output per capita with a greater working-age distribution, keeping employment rates and productivity equal. However, research on macro-development reminds us that there is nothing constant in the employment and productivity. The working-age share is important with the labour-force participation, unemployment, industry distribution, human capital and ability of firms to invest and embrace technology. That is why the literature on policies has always discussed the dividend as a simultaneous product of demography and other complementary reforms (“Africa’s Demogr. Transit. Divid. or Disaster?,” 2015).

The second channel is the savings-investment channel. Lifecycle models propose that the lower fertility and the higher the longevity, then the higher saving rates in the household, the faster financial deepening, as well as higher the level of investment in the state in children and private investments in children. Mason et al. (2016) present evidence based on the National Transfer Accounts data, therefore, consistent with a more comprehensive framework

of the so-called demographic dividends, where the age structure does interrelate with human capital accumulation and physical capital accumulation. Their strategy is significant in the field of empirical cross-country research as it stresses the fact that the dividend, however, is no longer a labour-supply narrative; it is conditional on the presence in demographic change of higher investment and reforms that enhance productivity.

The third channel is the fertility trade off human capital. Recent empirical studies of decline of fertility posit that the change in high fertility towards decline may be linked to alterations in time use by women, investment in schooling and the quality of cohorts. Considering that an example, Chatterjee and Vogl (2018) analyse fertility change and development based on micro data and reveal the relationship between fertility decline and growth based on education and household decisions, demography and adjustments to human capital are interrelated.

The gender aspect is also emphasized in the literature. Improvement of education of girls, postponed marriage and reproductive health services in most developing situations is likely to hasten the reduction in fertility and increase female labour-force participation- both factors that can fulfil growth. Although such contributions are not necessarily macroeconomic, policy and population-health literatures underline that the dividend strategies can be largely dependent on the agency of women and human capital formation (Foley, 2022).

### *2.3 Evidence, cross country, on demographic dividends: what is likely to be robust.*

Growth regressions, which are estimated by a large empirical tradition, are in the form of growth of output or capita GDP relying on demographic structure and controls. Another example of a cross-country contribution is Cruz and Ahmed (2018), who add demographic indicators and development gains and determine that the growth in working-age shares and reduction in dependency ratio is related to higher GDP per capita growth (and reduction in poverty) in broad panels. Their analysis can be applied to later panels, since it points out two common patterns, namely: (i) child dependency turns out to be the crucial margin in early transition phases; and (ii) the estimated associations by income level and timing of the demographic change.

More contemporary studies make the efforts to go further than one coefficient fits all by permitting heterogeneity and interactions. A powerful demonstration is that the demographic dividend cannot be narrowed to an education dividend, Kotschy et al. (2020) states, whereas age structure and human capital might interact in determining growth. They focus on interaction effects which coincides with an empiricible practical lesson: one would explore whether the marginal effect of the working-age share becomes different in more or less developed countries or institutions, and not take a uniform universal form.

The establishments of the impacts of demographic profile on macroeconomics also increase the scope of outcomes beyond short-run growth. In the case of OECD economies, (Aksoy et al., 2019) approximate the impact of demographics on macro trends in the long-run by operating panel time-series models and this demonstrates that age structure can have various effect on investment, interest rates and productivity. Although their sample and methodologies are not comparable with those of dividend literature concerning developing

countries, their results again support the notion of demographic variables as low-speed state variables that have macro-level effects, hence being significant confounding and potentially driving variables in macro panels.

A similar, but growing field of interest examines demographic drag because of the ageing of populations. The subnational variation in ageing is identified in (Maestas et al., 2023) and the results indicate sizeable negative impacts of ageing on the growth of GDP per capita, with a significant portion of such effects working via productivity instead of just employment. Their location is the United States but the lesson is universal: ageing is no longer a dominant in that the signs and mechanisms of the effects of demographic may vary. In cross-country panels that cover the 2000-2024, this is important as many of the middle-income nations shift during the 2000-2024 sample window to early ageing as opposed to dividend phases.

#### *2.4 Non-linearity and the stage-of-transition effects.*

One theme that is recurrent is that the demographic effects may be nonlinear and stage-dependent. When a nation is at the initial phase of transition, a growing working age fraction can go hand-in-hand with declining child dependency and growing labour supply. Later on, with ageing, the working age ratio might halt and possibly fall and the old age dependency increases. This empirically lead to quadratic terms or threshold models, and motivates the researcher to think of coefficients as within-stage effects and no longer as universal laws.

A well-known example that ageing metrics can create seemingly contradictory results in the literature is given (Lee & Shin, 2019): when the share continuously increases since the working-age share remains increasing. Their intercountry analysis explains that close interpretation involves mapping demographic proxies in order to pass in phases.

The argument on whether ageing inevitably decreases growth is sharpened by the technology-adoption argument. According to (Acemoglu & Restrepo, 2017), in nations experiencing faster ageing, more automation tools can be deployed to replace the labour-supply headwinds, and so a straightforward negative relationship between ageing and growth being weakened. Subsequent literature regularises this relationship between demographic and automation, and demonstrates that technology adoption can be endogenous in response to labour supply. In the case of dividend studies, this implies that demographic coefficients can partially capture induced technological and structural responses - another rationale why dividend studies are not to be understood mechanistically.

#### *2.5 Institutions, labour market, and absorptive capacity.*

The policy oriented research always has the dividend as conditional response to job creation and the quality of institutions. Practically it may increase unemployment since a growing working-age population cannot be met by an equivalent increase in the labour demand and this can hold back output growth and influence political stability. This point of view is central in the Africa-oriented book of the World Bank (Africa Demographics. Transit. Investment in education, health and labour market reforms will generate a dividend, the article by (“Africa’s Demogr. Transit. Divid. or Disaster?,” 2015) is emphasizing the necessity to reduce fertility

and increase the percentage of working-age population by reducing fertilities and investing in better education, health and labour markets.

The fact that demographic change is interacting with the macro stability, public finance and migration is also shown in the broader development-policy literature. The OECD, among others reports the effect of ageing to cultivate dependencies and may decrease per-capita income growth unless labour-force participation rates enhance, involving women and older workers (OECD Employment Outlook 2025 CAN WE GET THROUGH THE DEMOGRAPHIC CRUNCH?, 2025). The OECD contexts are not similar to that of most dividends economies, but the driving mechanism, which is participation and productivity responsiveness to level of demographic structure, is relevant across income lines, and can help explain why heterogeneity studies by income group are important in cross-country panels.

On the empirical work, such insights will stimulate specifications of interaction (e.g., working-age group share x income group) as well as region-specific estimates, since at least similar demographic changes may have contrasting growth effects based on labour-market frictions, education quality, and governance. The interaction strategy also conforms to the point in (Kotschy et al., 2020) that the effect of demographic factors can be observed to be systemically related to development levels and human capital.

#### *2.6 Macro panel identification complications: why causal claims are difficult.*

The causal demographic dividend is not easily determined in spite of intuitive mechanisms despite the challenges on empirical identification of the causal demographic dividend. These are three issues that are of particular concern.

Reverse causality. Fertility (including opportunity costs, urbanization, female education and labour demand) and even migration patterns may be affected by economic growth itself. As (Chatterjee & Vogl, 2018) emphasize, the process of fertility and growth co-evolves, which means that the naive regressions have the ability to confound the causal directions.

Omitted variables. Other countries that are enjoying favourable demographic change can also make reforms, commodity boom or structural change. Without these, the non-demographic effects could be incorporated in the demographic coefficients. This provides incentives to country fixed effects (to cancel time-invariant measures) and time fixed effects (to cancel global shocks), although this does not address all time-varying confounding.

Mechanical correlations between the demographic variables. Dependent ratios, working-age share and fertility are closely related related by population accounting. That is why certain research provides some specifications that do not include mechanically related variables at the same time or at least consider coefficients as partial correlation at the condition of the process of demographic transition (Lee & Shin, 2019).

This does not apply to demography alone; these are macro-wide issues. There is also methodological need of clustered standard errors due to within-country serial correlation to obtain credible inference in panels with fixed-effects. On how to make, and simply do,

cluster-robust inferences, (Colin Cameron & Miller, 2015) offers general principles used directly when estimating two-way fixed-effects models using nationwide clusters.

The extensions of dynamic panels have even more problems. The inclusion of lagged dependent variables in a panel model may cause a bias (Nickell, 1981), generalized method of moments estimators like (Arellano and Bond, 1991) assume serial correlation and instrument validity. In studies of demographic dividend, dynamic panels may be interesting since persistence of growth is empirically central, but demands more delicate diagnostics and almost uniform assumptions than two-way fixed effects which are usually less stringent.

### *2.7 The motivation of a 2000-2024 balanced-panel design by the recent literature.*

The major weakness of most traditional studies of dividends is that they work with long-run panels (e.g., 1950-2010) where measurement and structural breaks may be severe, or in studies of particular markets. Benefits of a balanced panel 2000-2024 Balancing ensured generally improved data quality; facilitated global integration and capitals flow; and the timeframe has major shocks (global financial crisis, commodity cycles, COVID-19) not amenable to time fixed effects. Meanwhile, 2000-2024 covers key demographic transition points: some middle-income economies will be shifting out of dividend window into early ageing, and many low-income economies will be staying in high-fertility regimes. Projections by UN also focus on divergent demographic trends in the 21st century further boosting the importance of considering heterogeneity as a core issue rather than a marginal one (Nations, n.d.).

The recent empirical evidence refines the anticipated dynamics. The studies with a focus on positive dividend impacts generally conclude that either working-age share increase or child dependency decrease are linked to faster growth provided with investments into the human and physical capital (Cruz and Ahmed, 2018; Mason et al., 2016). In the meantime, ageing-directed work demonstrates that dependency effects can turn negative once children begin to age, usually by inverting productivity (Maestas et al., 2023) and this can be reinforced by the adoption of technology (Acemoglu and Restrepo, 2017, 2022).

This mix of findings suggests that a contemporary dividend paper ought to (i) explicitly disaggregate working-age share with dependency measures to deal with mechanical correlations, (ii) test nonlinearity or stage dependence (e.g. quadratic strain), (iii) to deal with heterogeneity by income group, geography since the same demographic change can be in different phases of transition, and can be in different institutional environments. It is also confirmed in the literature that investment controls like gross fixed capital formation should be included, since the second dividend is partially driven by capital deepening and dynamic of savings-investment (Mason et al., 2016).

The tempered opinion of the recent literature tends to a common denominator. Growth is strongly linked to the demographic structure, and the positivity and the degree are based on the conditions of transition stage and complement. Growth-accommodating: Working-age share growth can be pro-cyclical when simple rise in the generation of jobs and higher productivity, fertility fall may sanction such shifts through human capital and supply of female labour, and effects can be multiplied when these institutions encourage savings and

investment. When further into the future, increasing old-age dependency can become a burden, but possible responses to technological adoption and engagement will partially counter it (Acemoglu and Restrepo, 2017, 2022; Lee and Shin, 2019; Maestas et al., 2023).

In a cross-country balanced panel (2000-2024) where WDI based measures are GDP per capita growth, share of working age, dependency ratio, fertility, and investment the literature as such encourages an empirical approach focused on two-way fixed effects, clustered inference, resilience to other demographic specifications, and explicit heterogeneity tests variable by income group and region. One should focus on associations unless he/she can come up with more powerful identification approaches with the data at hand.

### **3. Data and variables**

#### 3.1 sources of data and construction.

The data used in the study were collected from the official website of World Development Indicators (WDI) data platform of World Bank and then we created a country-year panel to cover the period of time 2000-2024. After the indicators were extracted, we then cleaned and consolidated and the codes of respective WDI series used while extracting the data were recorded. The data was in the form of country-year panel and both quantitative data and categorical data was in the metadata. GDP per capita growth as the outcome of interest is given as `gdp_pc_growth` as the annual percent growth in real GDP per person, which directly compares across nations. At the demographic dividend scale, the scale on which one should judge whether the changes in the age structure are turned to higher living standards or merely the higher output in aggregate production should also be the per-capita growth.

The one population demographic explanatory variable is the working-age share, `workage_share`, which refers to the share of the population aged 15-64 of the total population. This variable is to provide a measurement of the size of potential workforce in regard to total population. Increases in the working-age share can theoretically increase the income per capita through the effect of increasing labor input per dependent and through the effect of making higher savings and investment, although whether the potential is meted out into actual growth depends on the ability to generate jobs and productivity.

The age dependency ratio, `dependency_ratio`, is the dependent population divided by the working-age population (15-64) which is expressed as a percentage. This action takes the demographic burden on working-age population. At the initial phases of demographic transition, the child dependency decreases the most due to the decrease in fertility. Subsequently, the dependency could increase once more due to ageing. Practically, the dependency ratio is not completely useless as it indicates the possible phases of dividend (lower dependency) and the possible phases of post-dividend or ageing (increasing dependency). International demographic forecasts show that these phases vary greatly between nations and regions with economies still experiencing increased working-age ratios and some rapidly ageing (Nations, n.d.).

The data is comprised of fertility, `fertility`, calculated as the total fertility rate (births per woman). Fertility is not only a descriptive indicator of demographic transition; fertility is also a structure facilitating age structure. The effect of the long-term decline in fertility is risky as

it downsizes cohorts of children and eventually poses a risk of increasing the working age proportion. Fertility may also be connected to growth in other ways, such as in terms of time of women, investment in human capital per child, and labor force participation. Due to these various channels, fertility is considered as one of the most important variables that would allow capture transitions dynamics and the identification discussion in the future treats fertility as a factor that can be determined by the economic outcomes.

To identify the capital accumulation channel, the dataset uses gross fixed capital formation as further share of GDP (*gfcf\_pct\_gdp*). It is a variable that measures investment in fixed assets, i.e. infrastructure, machinery, buildings etc. and thus, is an essential measure of the capital deepening process. Two reasons drive its inclusion, their connection. To begin with, in the traditional growth models, investment is used as a mediatory factor to accelerate output growth. Second, the demography-induced dividend literature is that an increasingly high proportion of people in the working-age population is more likely to increase savings and generate capital accumulation, sometimes dubbed as a second demographic dividend. The perception that demographic structure would interact with human capital and physical capital accumulation is supported by empirical findings based on data on National transfer accounts, thus suggesting that investment is not a control variable but constitutes a part of the mechanism on how the demographics would relate to growth end results (Mason et al., 2016).

The database also includes two categorical metadata variables namely Region and Income Group operated according to World Bank classifications. The variables make it easy to describe spatial patterns and test heterogeneity. In the literature on the demographic dividend, geographical area and income group could be used as a proxy of variation in the transition stage, structure of labour market, education levels and institutional capabilities. As an illustration, policy-based evidence of Africa assumes that the shift in an age-structure provides a dividend when accompanied by complementary conditions such as job creation and human-capital accumulation that help the economies to absorb a bigger cohort of working-age (Canning, Raja, & Yazbeck, 2015). As a result, one research question is the central, as it is based on the assumption that the relationship between the working-age share and growth is different among the development groups and regions.

### 3.2 Sample and missingness

The panel is made up of 266 entities that will be tracked over 25 years (2000-2024), totaling 6650 observations in an equal-weighted frame. A balanced panel has a number of benefits: individual entities in a balance contribute the same amount of observations in terms of time, which also makes the comparison of cross-specifications easier, and it also helps eliminate issues with good beings coming in and leaving. It is also conducive to lag based diagnostics because most countries have a continuous time ordered sequence which prevents missingness on specific variables.

The variables have different missingness. The indicators based on demographic-structure are *workage\_share* and *dependency\_ratio*, which are very complete, not including a rate of 0.38. GDP per capita growth (*gdp\_pc\_growth*) and fertility have a 4.36% missing rate; it is not

very problematic to estimate using panel data, but is large enough to affect the effective sample size of regressions that need complete cases. Conversely, the `gfcf_pct_gdp` variable is not present in 22.50 of the observations. This is consequential since investment will be in the baseline specification and statistically significant with in most growth regressions, models incorporating investment will be on a smaller essentially reduced sample. The variables (Region and Income Group) are not grouped on a few one-fifth of the sample, probably because some items are connected to aggregates or special classifications not assigned standard versions of the regional or income. To be more transparent, both the number of observations and the number of entities used should be reported in each regression table so that the readers would easily see the impact of missingness on the estimation sample.

## 4. Empirical Strategy

### 4.1 Base Line Two way fixed effect model

The empirical model is based on the two-way fixed-effects design that estimates relationships within a country and global shocks of time. The specifications of the initial model are:

$$g_{\{it\}} = \beta_1 WA_{\{it\}} + \beta_2 DR_{\{it\}} + \beta_3 F_{\{it\}} + \beta_4 I_{\{it\}} + \alpha_i + \gamma_t + \varepsilon_{\{it\}}$$

and  $g_{\{it\}}$  is the growth of the GDP per capita,  $WA_{\{it\}}$  is the working-age share,  $DR_{\{it\}}$  is the dependency ratio,  $F_{\{it\}}$  is the fertility and  $I_{\{it\}}$  is ratio of gross fixed capital formation. The country fixed effects are denoted by the term  $\alpha_i$ , which incorporates all the time-invariant factors such as geography, long-run institutions, and initial levels of development and the year fixed effects are denoted by the feature  $\gamma_t$ , absorbing the global shocks affecting all countries (i.e. financial crisis, commodity price fluctuations, global pandemics). This design eliminates the likelihood that any estimated effect of demographics will be due to permanently cross-country differences rather than demographic change in a particular country.

The standard errors are dependent on the country level to make an inference. The reason why such clustering is an imperative is that the macroeconomic shocks, measurement errors and policy regimes could be correlated over time within a country. The use of cluster-robust inferences in panel-based research is generally well-advocated because traditional standard errors may be inaccurate in situations where the residuals are clustered together (Cameron and. Under demographic dividend studies, where numerous variables change gradually and country level inertia is anticipated, the clustered mistake is not only a preferable improvement but also an imperative measure to guarantee unwarranted specificity.

### 4.2 Mechanical Linkages and Multicollinearity

The mechanical nature of the relationship between working-age share and dependency ratio is one of the key econometric problems: it is usually decreasing with an increase in the former

since dependency persons always represent a smaller share of the population compared to the working-age denominator. The value of 0.992 is too large to be called near-collinearity, therefore in this dataset there is complete correlation between the two measures. Near-collinearity increases standard errors, and estimates the coefficient values that are responsive to small shifts in the sample composition or specifications. More to the point, it is not a mere statistical convenience this is also harder to interpret since the model tries to deconstruct two measures that in fact represent the same underlying demographic transition.

The strategy therefore involves the use of robustness specifications which will not admit two variables at the same time. The working-age share is ignored in Model 2 and the most suitable age-structure indicator is dependency ratio, and in Model 2b the working-age share is ignored and the dependency ratio. This methodology sees every indicator as an alternative proxy measure of the demographic structure, thus checking if the consequences are sample-conditional on the measurement. This is generally in line with the recommendations of research on multicollinearity: instead of turning to arbitrary rules of thumb, it is preferable that researchers assume that collinearity has occurred, and thus provide the interpretation of unstable coefficients with care (O'Brien, 2007).

#### 4.3 Heterogeneity by developmental stage and region

Demographic dividend has long been understood as being dependent on both level of development, the level of labour absorption in the labour-market, and institutional capacity. To statistically determine if the relationship between demographic structure and growth is context-specific, interaction models are included in the empirical strategy that permits the slope on working-age share to be different by group:

- $\text{workage\_share } (WA_{\{it\}}) \times \text{Income Group (with country and year fixed effects)}$
- $\text{workage\_share } (WA_{\{it\}}) \times \text{Region (with country and year fixed effects)}$

#### 4.4 Shifting considerations and nonlinearity.

Demographic factors move gradually, and the processes in which age structure is incorporated into growth education investment, labour-market entry, structural change and capital deepening tend to take time before effecting significant changes. Thus the annual regression at the period could be ineffective in capturing the timing of the full effects of demographics. Three extensions are therefore brought by the strategy.

To begin with, a dynamic fixed-effects specification incorporates lagged GDP per capita growth in order to obtain persistence. Unlike many other types of models, which contain a lagged dependent variable, a fixed-effects model may be biased due to the small sample (when the sample size is not very large), so the results of a model in such cases can be seen as indicative of great strength but are never taken as conclusive (Nickell, 1981).

Secondly, the research approximates lagged regressor models with the help of  $t-1$  of demographic variables (and investment). This directly asks the question whether the predictive power of demographic structure in the previous year is stronger than the predictable power of the contemporaneous structure. These lag models are not entirely causal,

however; they demonstrate when, and can bring about reduced concerns with immediate reverse causality.

Third, there is an investigation of nonlinearity with the inclusion of a quadratic term in the share of working ages, which is denoted as, working age,  $WA_{\{it\}}^2$ . The nonlinear impacts are not impossible since the effect of age structure on growth can be different on both early and late transition. A quadratic specification is a convenient means to estimate the hypothesis on whether the marginal relation between increasing working-age share and growth varies with increases in share. Predicted turning points are viewed with caution and can only be found credible when it meets both the statistical significance and economical plausibility conditions within the data range observed.

To go one step further, a natural extension that can be done under the dynamic approach is that of a GMM estimator adapted to dynamic panels via internal instruments based on lagging values of the variables. These strategies require a strong level of diagnostic testing of the serial correspondence as well as instrument validity and it does not necessarily better than fixed-effects, however they also offer a systematic manner of obtaining lagged dependent variables in panels (Arellano and Bond, 1991).

## 5. Results

### 5.1 Descriptive Statistics

Table 1: Summary Statistics

Variable	N	Mean	Std. Dev.	Min	Max
gdp_pc_growth	6,360	2.091	5.454	-55.294	91.781
workage_share	6,625	63.18	6.591	47.346	85.249
dependency_ratio	6,625	60.225	17.613	17.303	111.21
fertility	6,360	2.835	1.457	0.586	7.829
gfcf_pct_gdp	5,154	23.304	7.248	1.097	78.001

(Note: Authors own calculation; N differs by variable due to missingness)

A prominent characteristic is the volatility of annual growth: the lowest is approximately -55 and the highest approximately 92 that is a crisis and upswing in small economies and exceptions. On the contrary, working-age share is restricted in a smaller range and varies gradually at the national level. The average within country standard deviation of working-age share (in the same direction within time) is about 1.70 percentage points showing that most identifying variation in the fixed effects models is small when compared to shocks to yearly growth.

Furthermore, The correlation table indicates:

- Working-age share and dependency ratio: -0.992 (near-mechanical connection).
- working-age share and fertility: -0.892 (greater fertility is coupled with less working-age share).

- gfcf\_pct\_gdp, growth: -0.206 (positive correlation).

This trend encourages the reporting specifications aiming to remove the working-age share and dependency ratio at the same time, although the basic model has both.

Figure 1: Global Trends

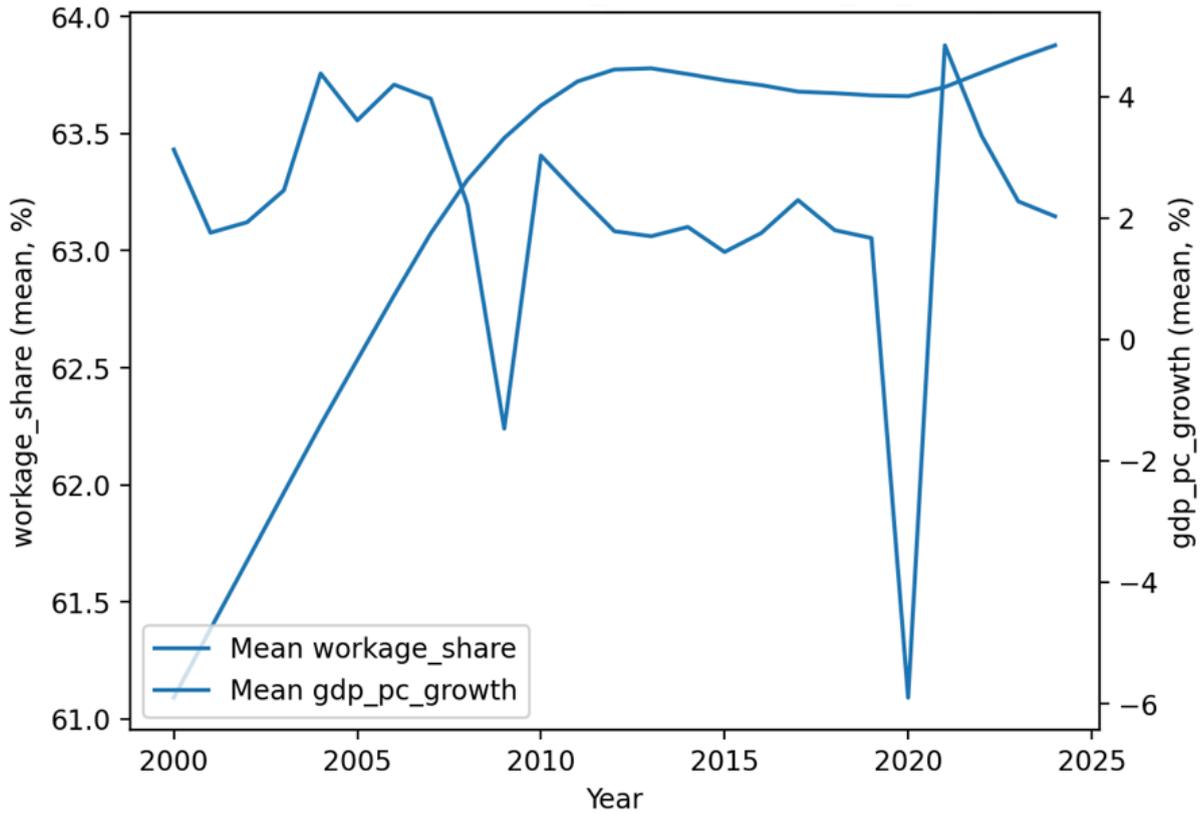


Figure 1 graphs the center of the world working age portion and global GDP of each individual in a similar way. The working-age share increases at a slow pace whereas mean growth is unstable with significant declines and recovers.

5. 2 Base Line fixed-effect (FE) estimates (Model 1)

Table 2: Base Line two-way fixed-effects results (clustered by country)

Regressor	(1) Two-way FE
workage share	0.032 (0.311)
dependency_ratio	0.048 (0.138)
fertility	-0.814 (0.665)
gfcf_pct_gdp	0.128*** (0.028)

In the model of the baseline, the strong and robust relationship is that between the investment share (gfcfpctgdp) and the increase in GDP per capita. This sample sample associates an increase in gross fixed capital formation (measured as a percentage of GDP) by one percentage point with an increase in annual per capita growth by an amount of 0.13 as percentage, within countries and without the year effect.

On the contrary, using the current demographic coefficients on the contemporary generation in Model 1 is inaccurate and non-significant. This imprecision conforms with the extreme collinearity in working age share and dependency ratio and with strong within-country persistence in alterations of age structure as compared to that with annual growth volatility.

Table 3: Robustness: alternative specifications

Variable	(2) Dep. only	(3) Workage only	(4) Nonlinear	(5) 5-year avg	(6) Dynamic FE
workage_share		-0.081 (0.067)	-0.148 (0.748)	0.136 (0.357)	-0.144** (0.060)
dependency_ratio	0.035 (0.030)			0.073 (0.163)	
fertility	-0.796 (0.607)	-0.726 (0.553)	-0.747 (0.648)	-0.420 (0.874)	-1.219*** (0.417)
gfcf_pct_gdp	0.128*** (0.028)	0.128*** (0.028)	0.128*** (0.028)	0.140*** (0.028)	0.114*** (0.027)
workage_share_sq			0.001 (0.006)		
gdp_pc_growth_ll					0.033 (0.097)

(Note: The column is a dynamic FE which contains lagged growth and is estimated using country and year fixed effects. This is not an Arellano-Bond estimator, and can be subject to Nickel bias, it is only reported as a descriptive robustness test.)

### 5.3 Heterogeneity (Income Group and Region)

#### 5.3.1 Income Group heterogeneity

It is implied in an interaction model of working times of share, Income Group, that the marginal effect of working times of share varies significantly across income groups. The working age share slope is estimated to be negative and statistically significant in this sample in terms of high-income and low-income but is close to zero in terms of the middle-income groups.

Table 4a: Marginal effect of workage\_share by Income Group (from interaction model)

Income Group	Effect of workage_share (SE)
High income	-0.191** (0.091)

Low income	-0.556** (0.281)
Lower middle income	0.008 (0.108)
Upper middle income	0.043 (0.104)

An unfavorable predictor of a rise in working-age shares based on an annual-capita growth is not the canonical prediction of dividend. One way that could help understand this is that, in 2000-2024, many of the high-income and some of the low-income entities experienced working-age change coinciding with wider transition process (for example, pre- and post-crisis change, structural change) that the limited covariate set does not fully enforce. The other alternative is that the annual growth is significantly influenced by the annual shocks and policy cycles, whereas the demographic structure aspects affect the growth over longer-term periods and through the mediators (human capital, labour absorption) which are not evident in this case. Such findings must not be interpreted, however, as causal disillusionment of the demographic dividend hypothesis; instead, they are the suggestion that the modern-dissonance association amid groups is administered not as firmly in this fixed-effects model, but differs across parts.

### 5.3.2 Region heterogeneity

Table 4b: Marginal effect of workage\_share by Region (from interaction model)

Region	Effect of workage_share (SE)
East Asia & Pacific	0.008 (0.123)
Europe & Central Asia	-0.325*** (0.116)
Latin America & Caribbean	0.195* (0.107)
Middle East & North Africa	-0.117 (0.136)
North America	-1.066** (0.480)
South Asia	0.195 (0.148)
Sub-Saharan Africa	0.083 (0.205)

Once again, these are domestic associations. The negative North American estimate is very big and thus it bears a particularly cautious interpretation since there are a limited number of entities in North America in this data and a low degree of within-region variation in the same.

## 6. Discussion mechanisms and interpretation

The proximate-structural driver of growth and time profile under which the demographic transitions act are the best ways to see the empirical pattern in this paper. There are three messages which make results but each message should be interpreted carefully.

To begin with, the steady positive correlation between investment (gross fixed capital formation as the share of GDP) and GDP per capita growth is not surprising through the

prism of the classical theory and economically consistent. In conventional growth theories, an increase in investment will raise the capital stock and may work to boost output it can enhance output per worker as an adaptation is being made to a high steady-state level (Solow, 1956). In practical cross-country empirics, investment also provides a significant forecast as it will generalize a number of border complementary conditions; e.g. in conditions of macroeconomic stability, credit availability, state ability to develop infrastructure, and private-sector confidence, which are likely to co-alter with a greater growth pace (Barro, 1991). Noteworthy, the time series of investment-growth relationship may capture both the medium-run capital deepening nature and the shorter run cyclical nature: as the economies grow, the rate of investment tends to increase and as they shrink, the investment rates tend to sink. This renders the coefficient cost effective but does not necessarily make it causal in a strict sense. There is classic evidence which shows that the equipment investment is specifically growth-relevant, which supports the fact that the large investment coefficient in any cross-country setting is plausible, though its magnitude will depend on the measurement of investment, and on time horizon (De Long and Summers, 1991).

Second, the poor and inaccurate current fixed-effect estimates of demographic traits can not be regarded as an indication that demography does not matter. Instead, they are indicators of a mixture of limitations of the econometric elements and the gradually-changing aspect of demographic factors. Relative to country and year fixed effects, identification is based on within-country variations to long-run paths, country-specific, and global shocks. It is a purposely rigorous design: it eliminates cross-sectional variations (which are big in terms of age structure) and enquires whether yearly changes in working-age share, dependency or fertility are consistent with yearly changes in per-capita growth. Although demographic transitions may be of relevance to development, the within-country yearly signal may be insignificant compared with the volatility of growth.

Mechanical linkage is also a serious statistical concern. The dependency ratio and working-age share are two sides of the same demographic accounting coin; almost perfect correlation in the sample implies that the addition of the two variables in the regression attempts to disaggregate two proxies used to describe the same transition. With this degree of extreme collinearity, coefficients may get fluctuous and standard errors blow out therefore “non-results are in part due to weak partial identification. This does not negate the theoretical applicability of age structure; it is an indication that the data - which is very coverage rich - is not well placed to disaggregate these two variables at the same time when there is fixed effect present.

The second reason has to do with omitted mediators and time -varying confounders. The processes typically postulated that could result in a demographic dividend namely absorption of employment, supply of female labour or human-capital accumulation, a transformation in the sector or savings behaviour are not empirically evident in the present data. When age structure influences growth by the channels of these mediators, then a regression model, including age structure, fertility and investment, can underemphasize the effects of demography or falsely ascribe demographic effects to it. In a broader sense, the income differences may be dominated by differences in productivity, along with social infrastructure, and these dynamics may evolve through time within domestic countries (Hall & Jones, 1999).

Similarly, institutional quality and policy regimes may be a determining factor of development paths and may be related to demographic transition as well as investment booms (Rodrik et al., 2004). Especially having limited controls, fixed effects still minimize such concerns but do not make them disappear; estimated demographic coefficients should thus be conceived as conditional relations of association and not as clean causal effects.

Third, the more robust patterns of lagged specifications are in line with the notion that demographic change is slow moving. The age structure transformation does not have a speedy impact on the labour markets because of their cohort entry and exit, and also, the savings-investment mechanism is intrinsically intertemporal. There is extensive evidence in the economic-demographic modelling movement that reflects the views of many authors that demographic variables do play a role in determining growth in a manner that is not immediate by translating the effects on productivity and employment into the final performance in per-capita terms (Kelley and Schmidt, 2005). In addition, the reductions in fertility may impact output per capita in a variety of delayed ways, including schooling and capital accumulation and altered age composition with significant impacts felt not in one year but instead manifested over decades (Ashraf et al., 2013). This aids the rationalisation of why the current annual fixed-effects regressions might fail to identify the effect of demographics when err at large even when the general development story is accurate.

The lag structure, is also consistent with a significant substantive interpretation, namely, whether or not the economies are tapping into the potential to secure productive jobs and raise their productivity the size of the working-age population. That conversion requires complementary investments of human capital as well as limitations that define labour supply, namely the female labour supply, which are interrelated with fertility processes and gender disparities. The formal theory has demonstrated that gender inequality and human-capital differences can both affect long-run growth via fertility using age structure and thus future age structure can be used to proxy invoking underlying processes of social processes and human-capital processes (Lagerlof, 2003).

Combined, the findings point towards a tentative conclusion: investment is an effective proximate correlate of growth in this data, but the impact of demographic factors has a little contemporaneous explanatory information on it when requiring fixed effects. The better evidence is the timing-sensitive specifications, which leads toward late associations although still short of proving causality due to the shortage of data. Policymakers should construct policy implications in terms of enabling conditions (jobs, human capital, well-established investment climate) and not make deterministic assertions of a greater working-age share triggering growth in a mechanical fashion.

## **7. Conclusion and Implications**

With a balanced sample of 266 entities across 2000-2024, the analysis shows that investment in the form of gross fixed 2000-2024 fixed-capital formation is a constant correlate of yearly GDP growth per capita in two-way specifications of fixed effects. This result is in line with existing macroeconomic theory: capital accumulation and investment motion is an era of the crucial driver of medium-run development, whereas share of investment on an annual basis is a measure of structural accumulation and cyclical tendencies at the same time.

Contrarily, the current demographic measures like the working-age share, the dependency ratio, and the fertility are usually inaccurately measured under the baseline yearly TWFE model. This should not be taken to imply that the aspects of demography are insignificant, but instead that (i) demographic measures are mechanically correlated and hence challenging to separate econometrically; (ii) the annual variation in demographics within a country is not a big part of annual growth volatility; and (iii) the most important mediating relationships - education, labour-force participation, structural change and institutional dynamics - cannot be observed in the provided data. Accordingly, TWFE estimates are to be perceived as describing relationships and not causing one.

The agglomeration results and the lagged-specification results indicated that the role of demographic structure can be larger when it is delayed and that the association between growth can be different across the context of development. This also agrees with the idea that a demographic dividend is contingent on the ability of an economy to translate the potential in labour supply into productive work and deepening of capital formation.

The practical result of this, as far as policy is concerned, is conditional as opposed to deterministic: those countries which are in a position of gain at the hands of favourable shift of age-structure are the ones that increase also human capital and maintain an environment in which productive investment is possible.

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