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The demographic window of opportunity and economic growth at sub-national level in 91 developing countries

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Abstract

Data for 91 low- and middle- income countries (LMICs) are used to investigate the effect of the demographic transition on economic growth at sub-national level. We introduce a detailed classification of demographic window (DW) phases, determine how these phases are distributed among and within LMICs, and analyze the relationship between the DW and economic growth for 1,921 urban and rural areas of sub-national regions. Many regions in Asia, Latin America and the Middle East have entered the window, but most of sub-Saharan Africa is still in the traditional or pre-window phase. Multilevel analyses reveal higher growth rates in areas with lower and decreasing dependency ratios. Demographic effects are stronger in rural, more developed and more educated regions. Findings indicate that, in the coming years, the DW might strengthen economic growth in rural areas of LMICs, and particularly if accompanied by investments in education and rural development.

Key Words: Demographic Window · Economic Growth · Subnational level · Fertility Reduction · Developing Countries

JEL Classification Codes: J11, J13, R11, O57

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1. Introduction

Increasingly, the role of the population age structure as a potential source for economic growth has gained importance in the literature. Changes in age structures are of interest, because different age groups display different (economic) behavior**.** Fertility reduction may enable a region to have a period of rapid economic growth during the Demographic Window of Opportunity (DWO). The DWO is a period of several decades that countries go through when moving from a situation of high fertility and mortality to low fertility and mortality. This transition is generally characterized by a baby boom period, in which (child) mortality is already reduced, but fertility levels are still high. When later fertility also decreases, the baby boom generation moves up in the age distribution and after some time enters the working age population. During this period, more women also enter the labor force as less time is spent on children (Bloom et al. 2009). Given that there are still few elderly – as their generation suffered from higher mortality rates in the past – the region experiences a period in which the working age is large and the dependent population – the green and the grey – is small. Hence, there is high potential for economic growth, which, if realized, is called the “demographic dividend” (Bloom et al. 2003).

The demographic dividend is often used as an explanation for the rapid economic development that occurred in East Asian economies in the end of the twentieth century, accounting for as much as one third of the observed national economic growth (Bloom and Williamson 1998). The size of this demographic dividend, however, is found to depend on policies regarding labour markets, financial markets, education and health (Bloom and Canning 2008).

Due to issues of data availability, the current literature has not yet extensively analyzed the effects of the DWO on economic growth in low-income countries. These countries are often thought of as being stuck in a high-fertility high-mortality situation, i.e. not to have entered the DWO yet. Consequently, the empirical basis of the literature has been heavily biased towards growth in middle- income countries with a well-educated workforce and good infrastructure – such as the East Asian Tigers – where the potential for economic growth was better than in many of the current low-income countries (Bloom and Williamson 1998; Radelet et al. 2001)

The empirical literature has also been very focused on the national level, whereas fertility decline and economic growth may differ substantially between different areas within a country. For instance, cities may show entirely different patterns than rural areas (Sander and Charles-Edwards 2017; Williamson 2013). Furthermore, the national-level fertility transition has been shown to lead to within-country increases in fertility inequality (Eloundou-Enyegue et al. 2017). By analyzing data at a sub-national level – as is done in the current study – the added variation allows for a more refined analysis of the variables at hand. Indeed, a simple multilevel model of our dependent variable reveals that about 71% of variation occurs at the sub-national level, while 29% occurs at the national level.

There are a few published papers that have analyzed the effects of demographic variables at a sub-national level, but they tend to be restricted to regions within a single country. Firstly, Wei and Hao (2010) analyze the impacts of the growth rate and level of the dependency ratio, the total population, and population density, on economic growth in Chinese regions. They also use interactions to analyze under which conditions the dependency ratio has a different effect. While their analyses do not reveal effects of the level of population, urbanization, or the growth rate of the dependency ratio, they do find significant negative effects of the level of the dependency ratio and of population density. Secondly, Baerlocher et al. (2019) estimate the impacts of the participation rate, the working age population, the growth rates of the (working age) population, and the level of and change in the mean years of schooling in micro-regions in Brazil. They find that demographic variables do matter for economic growth, though predominantly through their effect on human capital accumulation. Lastly, Kumar (2013) analyzes the effects of the level of, and growth in, the working age share of the population on state-level net GDP per capita in 16 states of India for the period 1971-2001. Kumar finds positive and significant effects of both level and growth, thus pointing towards a favourable effect of DWO on growth.

The aim of the current paper is threefold. First, we aim to find out how the DWO has spread across subnational regions of low and middle income countries. Second, we want to determine whether the positive effect of the DWO on economic growth – which has been found for middle-income countries – is also present in low-income countries and in particular at the level of sub-national regions. Third, we aim to determine under which circumstances the effect of the DWO is strongest in order to help policy makers develop contextualized measures that facilitate reaping the demographic dividend in specific areas that have already entered the DWO. Therefore, our central research questions sound:

1 *What is the variation in DWO phases at the level of sub-national regions across the developing world?*
2 *To what extent does the DWO foster economic growth at the sub-national level?*
3 *Which factors are associated with a more effective use of the window in terms of economic growth*

Our study contributes to the literature in several important ways. It is the first to compare sub-national regions across the developing world in terms of the impact of the DWO on economic growth. We use a database with information for two points in time for 1,921 sub-national areas, both urban and rural, spread across 91 different countries. Second, a dataset with such richness offers more possibilities for analyzing context factors by including interactions and nonlinearities, than the national data on – at most – some 200 countries that are usually used for developing growth models. While our main effects model includes nine variables, the model with all significant interaction effects includes 19 variables. As will be shown, such variation is difficult to pick up in more restricted samples. Third, economic development at the subnational level is measured by the International Wealth Index (IWI), an asset-based wealth index that is comparable over time and across regions (Smits and Steendijk 2015). Analyzing the effects of demographics on the IWI will provide valuable new insights, as IWI measures the access of households to basic material wealth. As an outcome-based measure, IWI does not need arbitrary adjustments in terms of purchasing power parities, common baskets of goods or inflation, as is the case with GDP per capita.

The remainder of this paper is structured as follows. The second section will outline the theoretical model and the derived empirical specification. The third section describes the used data, the methodology and the control factors. The fourth section outlines the results, and the fifth section will discuss and conclude.

2. The Theoretical & Empirical Model

We begin by defining a standard Cobb-Douglas aggregate production function for region *i* in country *j* in the year *T2*:

$$Y_{ij}^{T2} = A_{ij}^{T2} {K^{T2}}_{ij}^{\alpha} {H^{T2}}_{ij}^{1-\alpha}, \quad (1)$$

where Y_{ij} is GDP, A_{ij} is Total Factor Productivity (TFP), K_{ij} is the capital stock, and H_{ij} is the stock of efficient labour, which consists of the labour force, L_{ij}, multiplied by the human capital per worker, h_{ij}. Human capital per worker is determined by the years of schooling, s_{ij}, and the return to schooling, θ, which is assumed to be constant, in the following functional format:

$$h_{ij}^{T2} = e^{s_{ij}^{T2}\theta}. \quad (2)$$

Dividing output by the labour force allows us to rewrite the production function in per worker terms:

$$y_{ij}^{T2} = A_{ij}^{T2} {k^{T2}}_{ij}^{\alpha} {h^{T2}}_{ij}^{1-\alpha}, \quad (3)$$

where y_{ij} is GDP per worker, and k is the capital stock per worker. To simplify notation, the growth rate is assumed to refer to the growth in period T1-T2. Substituting Eq. 2 into Eq. 3, taking logs and the first difference gives us the following growth rate equation:

$$g_{ij}^{y} = g_{ij}^{A} + (1-\alpha)\theta\Delta s_{ij} + \alpha g_{ij}^{k}. \quad (4)$$

We join Baerlocher et al. (2019) in following Benhabib and Spiegel (1994) and Nelson and Phelps (1966) by allowing TFP growth to depend on the level of mean years of schooling, with the argument that countries with higher levels of schooling are better able to innovate and generate economic growth. Additionally, countries that are closer to the technological frontier, as proxied by GDP per worker in period T1, will have lower TFP growth:

$$g_{ij}^{A} = \delta + \psi s_{ij}^{T1} - \mu \ln(y^{T1}). \quad (5)$$

An important distinction is that we do not have data on the capital stock per worker at a sub-national level. As such, the rate of capital growth per worker will have to be estimated:

$$g_{ij}^{k} = bX_{ij}^{T1}, \quad (6)$$

where X_{ijt}^{T1} is a vector of variables that have been shown by previous literature to affect the capital stock per worker. These variables and their expected effects on the capital stock per worker (+/-) are (I) the level of governance (+), (II) the level of democracy (+), (III) whether or not a country is landlocked (-), and (IV) the level of globalization (+). The next section will elaborate on these variables.

Substituting TFP growth and the estimation of the growth rate of the capital stock per worker into the GDP per worker growth equation gives:

$$g_{ij}^{y} = \delta + \psi s_{ij}^{T1} - \mu \ln\left(y_{ij}^{T1}\right) + (1-\alpha)\theta\Delta s_{ij} + \alpha b X^{T1}. \quad (7)$$

To translate the model from GDP per worker to GDP per capita terms, we must adjust the neoclassical model and recognize that a population does not merely consist of workers, but also of dependents:

$$\left(\frac{Y}{N}\right)_{ij} = \left(\frac{Y}{L}\right)_{ij}\left(\frac{L}{N}\right)_{ij} = \left(\frac{Y}{WA}\right)_{ij}\left(\frac{WA}{N}\right)_{ij}, \quad (8)$$

where N_{ijt} is the total population, and WA is the working age share of the population, i.e. those aged between 15 and 65.

Thus, GDP per capita consists of a productivity component, $\frac{Y}{WA} = y$, and a demographic component: $\frac{WA}{N}$. Additionally, for reasons of data availability, we assume $L_{ijt} = WA_{ijt}$, i.e. full employment. Moreover, as in Wei and Hao (2010), we express the demographic component in terms of the dependency ratio, D_{ijt}, as opposed to share of the working age population to the total population: $D = \frac{N-WA}{WA}$, which gives:

$$\left(\frac{Y}{N}\right)_{ij} = \bar{y}_{ij} = \frac{y_{ij}}{1+D}, \quad (9)$$

where $\bar{y}_{ij}$ is GDP per capita.

As before, we take logs and the first difference to obtain growth rates. Additionally, we substitute the TFP growth and the capital stock per worker growth rate equations into the growth rate of GDP per capita equation. Moreover, note that TFP growth depends on the initial level of income per worker, which we now translate to the initial level of income per capita as well:

$$\mathrm{g}_{ij}^{\bar{y}} = \delta + \psi s_{ij}^{T1} - \mu \ln\left(\bar{y}_{ij}^{T1}\right) - \mu(1+D) + \alpha b X^{T1} +$$
$$(1-\alpha)\theta\Delta s_{ij} - \Delta\ln(1+D). \quad (10)$$

Transforming the above equation into an empirical specification with random error terms at the national, γ_j, and sub-national levels, ϵ_{ij}, gives:

$$g_{ij}^{\bar{y}} = \beta_0 + \gamma_j + \beta_1 s_{ij}^{T1} + \beta_2 \ln\left(\bar{y}_{ij}^{T1}\right) - \beta_3\left(1 + D_{ij}^{T1}\right) +$$
$$\beta_4 X_{ij}^{T1} + \beta_5 \Delta s_{ij} + \beta_6 \mathrm{g}^{1+\mathrm{D_{ij}}} + \epsilon_{ij}. \quad (11)$$

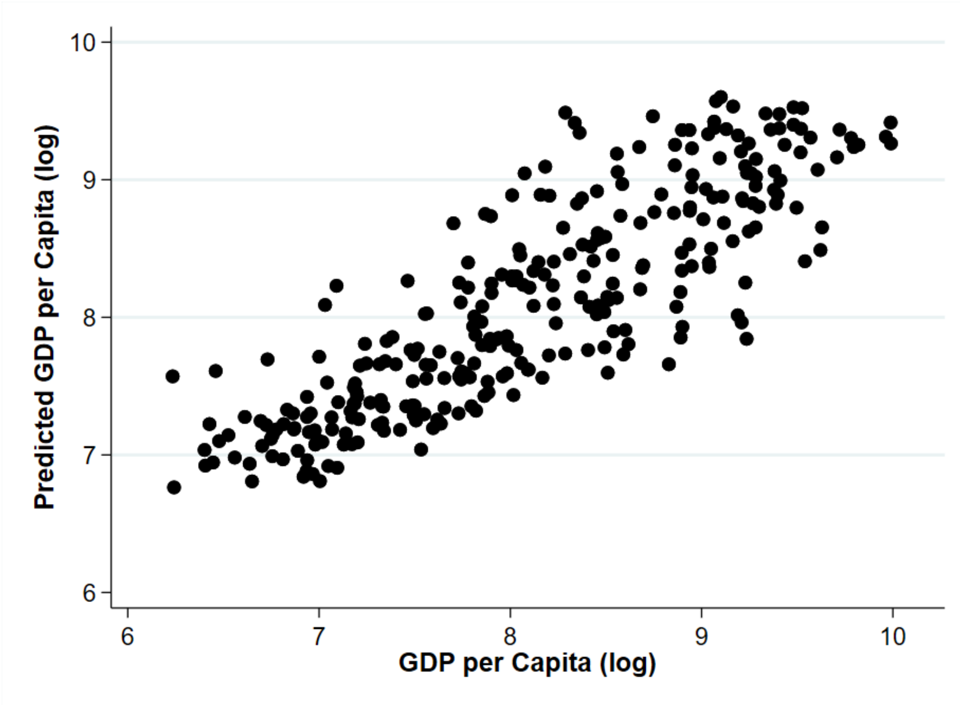
The usage of a random error term at the national level allows for the inclusion of national level independent variables, while still taking into account unobserved country-specific characteristics. Fixed effects would absorb all variation at the national level. This model is often termed to be a multilevel or a hierarchical linear model (Raudenbush and Bryk 2002).

Economic Development at Sub-National Level

A key issue to overcome is that data on economic growth at sub-national level is not available for most countries. Therefore, we will use the International Wealth Index (IWI) (Smits and Steendijk 2015). The IWI is an asset-based wealth index for assessing household wealth in LMICs, which is comparable across countries and over time. Conveniently, one can aggregate IWI from the household level to higher levels, such as the sub-national and the national levels. It thus allows us to observe changes in development at the sub-national level, despite the lack of sub-national GDP data.

To strengthen the case for using IWI as a proxy for GDP per capita, we present the empirical relationship between IWI and GDP per capita at the national level. Figure 1 shows a scatterplot of the relationship between the logarithm of GDP per capita, which was taken from the Penn World Tables (Feenstra et al. 2015), and the predicted logarithm of GDP per capita as predicted on the basis of a regression model by IWI. The predictions are only based on countries that are in our sample. It is clear that there is a strong relationship between the IWI and the logarithm of GDP per capita. The measured Pearson's r is .86, and the explained variance of IWI in a simple regression model is 74.2%.

Fig. 1 *– Scatterplot of the relationship between the actual natural logarithm of GDP per Capita (x-axis) and the predicted natural logarithm of GDP per Capita based on IWI (y-axis)*



Thus, $IWI_{ijt} \approx \ln(y_{ijt})$, i.e. we assume IWI to be an appropriate proxy for the logarithm of GDP per Capita. This changes the specification as follows:

$$g_{ij}^{y} = \ln(y_{ij}^{T2}) - \ln(y_{ij}^{T1}) \approx \Delta IWI_{ij} = \beta_0 + \gamma_j + \beta_1 s_{ij}^{T1} + \beta_2 IWI_{ij}^{T1} - \beta_3(1 + D_{ij}^{T1}) + \beta_4 X_{ij}^{T1} + \beta_5 \Delta s_{ij} + \beta_6 \mathrm{g}^{1+\mathrm{D_{ij}}} + \epsilon_{ij}. \quad (12)$$

3. Data and Methods

3.1 Data

A subnational indicator database was constructed from data of the Database Developing World of the Global Data Lab (GDL) (www.globaldatalab.org), which contains harmonized data for over 30 million persons in 130+ LMICs. The data is derived from Demographic and Health Surveys (DHS, www.dhsprogram.com), Unicef MICS Surveys (mics.unicef.org), IPUMS census data (international.ipums.org) Afrobarometer surveys (www.afrobarometer.org) and several stand-alone surveys (Smits 2016). Variables obtained from these surveys were aggregated to the level of sub-national regions using the regional/provincial codes available in the datasets. In this way, a dataset was created with information for two points in time (T1 and T2) for 1,921 sub-national areas within 91 countries. For each country, data from the last two available surveys were used that were at least four years apart. Because the surveys were held in different years for the different countries, the time period between the last two surveys could vary between four and 16 years. To obtain a simple and comparative measure of economic growth, the average annual change in IWI between the two most recent years with data (T1 and T2) was used for the analyses of all regions. Also the other change variables in the model measure the average annual change between times T1 and T2. In this way a dataset was obtained with for each of the 1,921 regions the value of the regional characteristics in the first survey (T1) and the annual changes in these characteristics between the first and the second survey (T2).

3.2 Methods

A multilevel analysis with a random country-level intercept was used, to address the clustering of the regions within the countries. The dependent variable is the average yearly growth rate of the IWI between T1 and T2. The level of IWI at T1 was also included as an independent variable to control for the distance to the technological frontier (convergence). Given that within the regions only data for two years was used, a two-period panel data analysis could be performed (Wooldridge 2013) and no further control for multiple observations within the regions was needed.

The main independent variables are the dependency ratio and the growth of the dependency ratio. The dependency ratio is measured as the ratio of the share of the working age population to the share of the dependent population. We define the working age population as all individuals aged between 15-64. All individuals aged below 15 or above 64 are considered to be the dependent population.

Of the independent variables, education was measured as the mean years of schooling of male individuals aged 20 and above in the region. Additionally, we made a distinction between men and women to capture gender inequality. The analyses included the mean years of schooling for men, and the difference between the mean years of schooling for men and women. An urbanization dummy was also included, which is equal to zero in rural regions and to one in urban regions.

At the national level, a range of control variables was used. First, governance is included as a proxy for institutional quality, as done in Baerlocher et al. (2019) and (Bloom and Williamson 1998). The governance variable was measured as the sum of the six worldwide governance indicators of the World Bank (Kaufmann et al. 2011): control of corruption, rule of law, political stability and violence, voice and accountability, government effectiveness and regulatory quality. The scores for these dimensions were all obtained through expert surveys.

Second, the level of democracy was included, as Kelley and Schmidt (2005) found a non-linear effect on GDP per capita. The democracy variable ranges from -10 to 10, where 10 indicates the highest level of democracy, and was taken from the POLITY IV database.

Third, a dummy variable was included that indicates whether or not a country is landlocked. Geographical components have been included in most of the analyses in the literature. It was hypothesized that landlocked countries will suffer from lower growth, as a consequence of, for instance, increased transportation costs.

Fourth, globalization was hypothesized to increase economic growth. Increased globalization allows for more foreign direct investment, more specialization and thus productivity. The globalization measure was taken from the KOF. The KOF globalization index ranges from zero to 100 and measures the degree of economic, social and political globalization.

For the purposes of this analysis, we only included the degree of economic globalization, which focusses on trade and finance (Dreher 2006; Dreher et al. 2008; Gygli et al. 2019).

Finally, the number of years between the data points and the starting year of the time period are included as control variables. The main regression model, which includes all significant interactions, nonlinearities and (sub-)national level variables, has also been estimated with a dummy for each specific period. This did not affect the qualitative results in any manner.

Some adjustments were made to the data in terms of missing values. For main variables, we simply accepted that no information was available and those observations were thus removed. This led to the loss of three of the 1,924 regions within the 91 countries in the sample. For control factors, i.e. mostly the national variables, missing values were addressed using dummy variable adjustment, whereby the mean of the valid cases was computed and a dummy was added to nullify them (compare Allison 2002).

Although the risk of endogeneity bias was restricted, because the current growth of the working age population is based on fertility decision taken in the past, it remains possible that an omitted variable bias in our model was caused by migration. The classic push-pull migration model (Lee 1966) postulates that migration is caused by the uneven processes of development. Economic opportunities in the form of wage differentials may drive migration streams. Additionally, the demographic transition will lead to a large labor supply (Preston et al. 1989), and mostly in urban areas (Sander and Charles-Edwards 2017; Williamson 2013), which may lead to immigration/emigration if there are many/few opportunities available in the area. Given that migration in low- and middle income areas consists mostly of young adults, as they are the most mobile group (Sander and Charles-Edwards 2017), this may lead to a positive relationship between economic development and immigration. As a robustness test, we therefore repeated our analysis with an indicator for migration in the study period. Given that such a measure is not available at the subnational level, we developed our own proxy of migration as follows:

$$Migration_{ij} = \frac{(100+Actual\ change\ working\ age\ share)}{(100+Expected\ change\ working\ age\ share)} \quad (13)$$

Substituting for the actual and expected changes in the working age share gives us:

$$Migration = \frac{100+\sum_{k=15}^{64}\Delta \mathrm{share}_k}{100+\sum_{m=15-T}^{15} share_m^{T1} - \sum_{n=64-T}^{64} share_n^{T1} - \sum_{p=0}^{T}\Delta share_p \times \frac{WorkAge^{T1}}{Elderly^{T1}}}, \quad (14)$$

where *share* is the share of the population of a certain age, *T* is the total amount of years in the time period of the subnational region, *T1* indicates that the value is from the start of the period, *WorkAge* is the share of the population aged 15-64, and *Elderly* is the share of the population aged 65 or over. Simply put, the migration measure is the ratio of the actual changes of the 15-64 population shares, divided by the expected changes of the 15-64 population shares, with an adjustment for fertility. This measure is expected to provide a reasonable indication of the role of migration, as the population dynamics in the younger age groups are appropriately included and labor migration is a process that involves mostly young people.

As a second robustness test, we repeated the main analysis, but using data from the period before the T1-T2 setup, i.e. the T0-T1 period. This allowed the reader to see to what extent the results depended on the used sample.

In a third robustness test we perform the same analysis using data at the national level, but we split up the national area in a rural and an urban one in order to maintain comparability with the other analyses. This setup may show the importance of using sub-national data in order to capture context factors that are important during the DWO.

4. Results

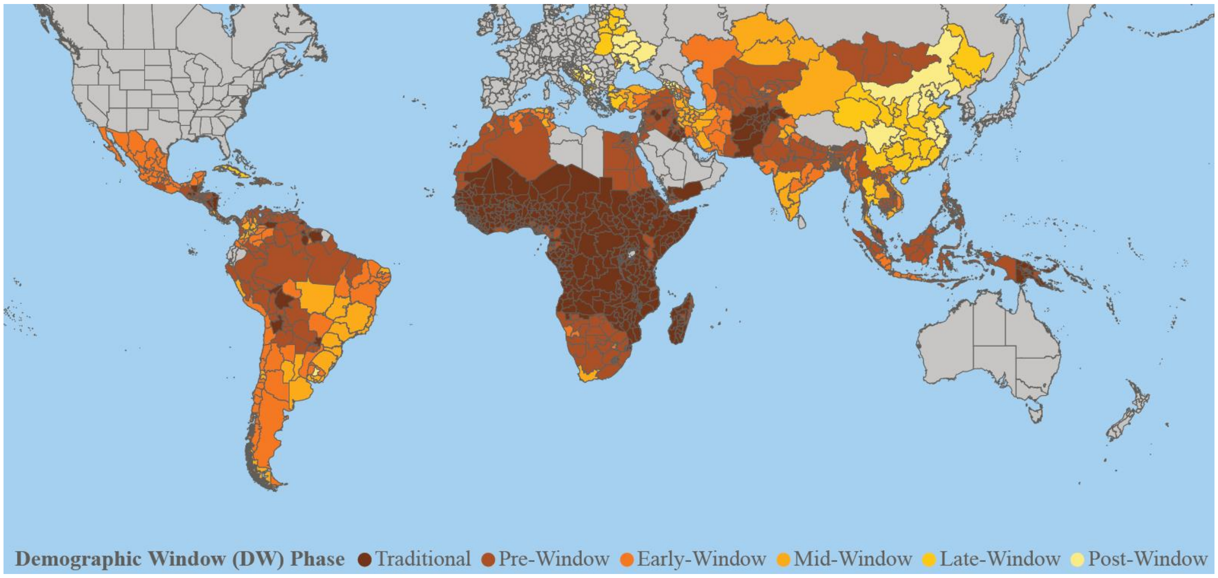
Descriptive Analyses

Before the discussion of the regression results, this section offers a descriptive perspective on the status of the DWO across the developing world. Because a detailed classification scheme for the DWO phase a region is in was lacking, we developed a new one taking a simpler scheme used by the United Nations (UN) Population Division (UN 2004, p. 70) as a starting point. The UN scheme distinguishes between three DW phases: a pre-window phase with 30 or more percent of the population under 15 years old, a window phase with less than 30 percent under 15 years old and less than 15 percent above 64 years old, and a post-window phase with 15 or more percent above 64 years old. To get a more refined picture of the window, the GDL added a traditional phase, for countries that show hardly any sign of fertility reduction, and further subdivided the first two phases of the UN classification to obtain the following scheme:

1. Traditional phase (>40% under 15 and <15% over 64),
2. Pre-window phase (30-40% under 15 and <15% over 64),
3. Early-window phase (25-30% under 15 and <15% over 64),
4. Mid-window phase (20-25% under 15 and <15% over 64),
5. Late-window phase (<20% under 15 and <15% over 64),
6. Post-window phase (>15% over 64).

Figure 2 displays the DWO phase for 1,921 subnational regions in 91 LMICs. The map reveals a substantial amount of variation in terms of DW phases both between and within LMICs. China is the only country where some sub-national regions are already in the post-window phase, while its northern neighbor, Mongolia, is mostly in the pre-window phase. India, on the other hand, has a clear north-south divide. While most of the south is in the mid-window phase, the north is still mostly in the pre-window phase. The MENA region shows a diverse pattern, with many regions in Turkey, Tunisia and Iran already in the early-window phase, while other countries are still in the pre-window or traditional phases. In South America, countries such as Brazil and Argentina are in the lead in terms of the demographic transition.

Fig. 2 - *Demographic Window Phases across the developing world. Source: Global Data Lab*



In sub-Saharan Africa (SSA), the picture is rather different from the other continents, with much less variation between countries and regions. Although a few areas, mostly in the south, appear to be past the traditional or pre-window phases, the majority of the central African region remains in the traditional phase. Also in Figure 3, which zooms in on the SSA region, the picture remains more or less the same, with only a limited number of areas in the South, around the Gulf of Guinea and at a few other places that are in a later stage. These areas largely coincide with the countries called ‘vanguard countries’ by Eloundou-Enyegue and Hirschl (2017), i.e. those countries that started the earliest with the DWO as measured by having a Total Fertility Rate (TFR) of less than 3.5.

Fig. 3 *- Demographic Window Phases across the African continent. Source: Global Data Lab*

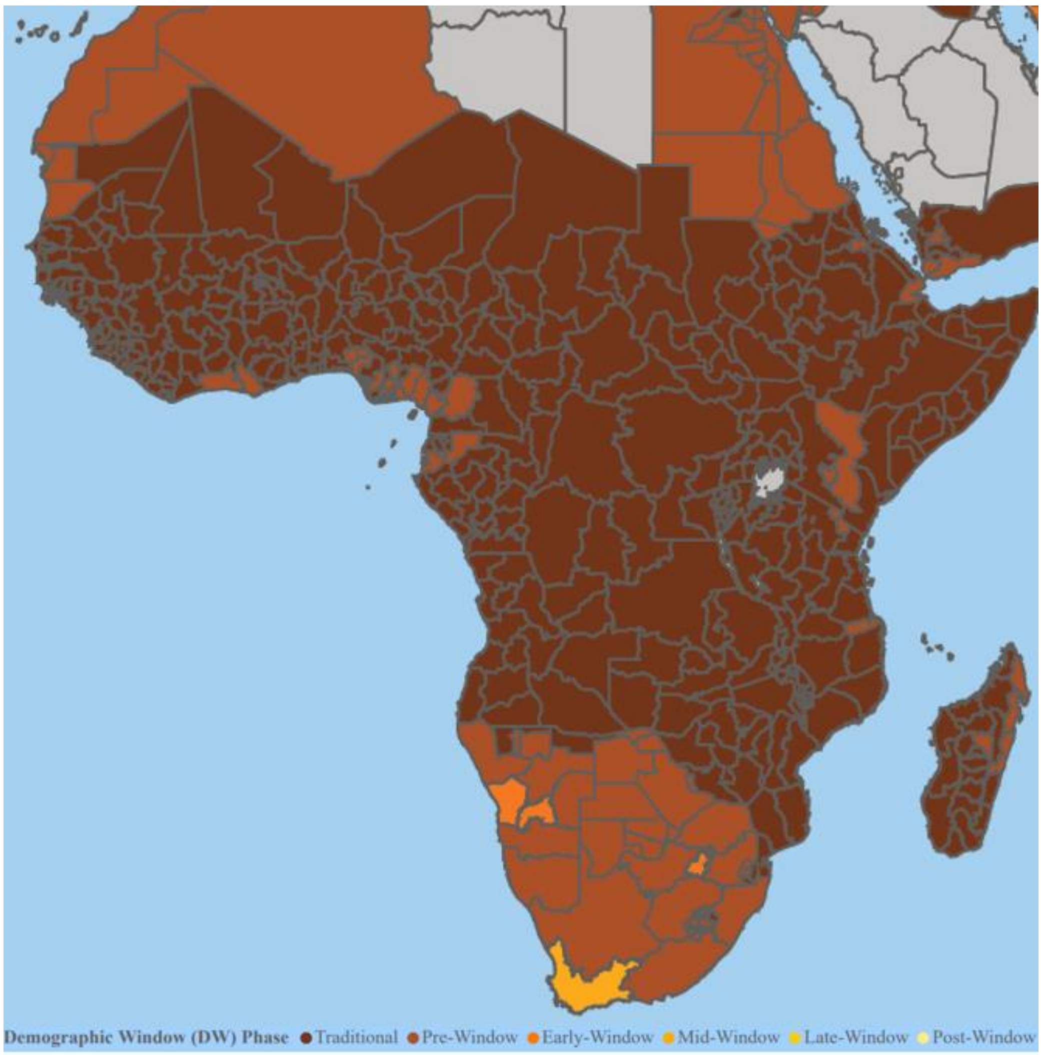


Table 1 – Demographic window phases of SSA countries with national or urban areas that are not in the traditional demographic window phase

Country	National Phase	Urban Phase	Country	National Phase	Urban Phase
Mauritius	5	-	Ethiopia	1	2
Cape Verde	3	-	Ghana	1	2
Eswatini	2	2	Guinea Bissau	1	2
Gabon	2	2	Kenya	1	2
Lesotho	2	3	Madagascar	1	2
Namibia	2	2	Mauritania	1	2
South Africa	2	3	Malawi	1	2
Burundi	1	2	Rwanda	1	2
Burkina Faso	1	2	Senegal	1	2
Cote D'Ivoire	1	2	Sierra Leone	1	2
Cameroon	1	2	Togo	1	2
Comoros	1	2	Tanzania	1	2
Eritrea	1	2	Zimbabwe	1	2

To have an even more refined view of the demographics in SSA, Table 1 displays the SSA countries that, at the national level, are not in the traditional phase anymore. The tourist destinations Mauritius (Phase 5) and Cape Verde (Phase 3) turn out to be the most developed in this respect, while Gabon and the four most southern countries are in phase 2. Thus, in SSA, only seven countries are not in the traditional phase when countries as a whole are considered.

However, demographic developments are generally not homogeneously spread within countries. As was already clear from Figure 2, in many countries there is substantial subnational variation in terms of DW phases. Given that fertility reduction tends to start earlier in urban than in rural areas (Easterlin 1971), we would expect the first signs of an emerging window to be found in the cities (Williamson 2013). For the SSA region, variation in fertility has already been observed for countries like Nigeria and the Democratic Republic of Congo, where fertility is substantially lower in more urban and capital areas than in rural and remote areas of the countries (Jimenez and Pate 2017; Shapiro et al. 2017). To see whether such signs can be discerned in the SSA region, Table 1 also displays the DW phases of the SSA countries with an urban DW phase above phase one (excluding Mauritius and Cape Verde for which no sub-national DW data were available). In 22 countries, the urban areas are in phase two, and in two countries, Lesotho and South Africa, already in phase three.

To look even more in depth, Table 2 displays the urban areas of sub-national regions that have a DW phase of two or over (i.e. the urban areas that have surpassed the pre-window phase and have thus actually entered the window). It shows that the DW is opening up in more places than one would expect based on Table 1. For instance, while South Africa as a whole is only in the second phase of the DWO and its urban areas on average in phase three, the urban areas of two of its regions -- Western Cape and KwaZulu Natal -- are already in the fourth phase, i.e. the mid-window phase. Lastly, while Ethiopia as a whole is in phase one and its urban areas on average in phase two, the country's capital Addis Ababa is already in phase four.

Table 2 – Demographic window phases of urban areas of subnational regions that are not in the traditional demographic window phase

Country	Urban Regions	Phase	Country	Urban Regions	Phase
Ethiopia	Addis Ababa	4	Lesotho	Leribe	3
South Africa	Western Cape	4	Lesotho	Berea	3
South Africa	KwaZulu Natal	4	Lesotho	Maseru	3
South Africa	Eastern Cape	3	Lesotho	Mafeteng	3
South Africa	Northern Cape	3	Lesotho	Quthing	3
South Africa	Free State	3	Namibia	Erongo	3
South Africa	North West	3	Namibia	Khomas	3
South Africa	Gauteng	3	Namibia	Ohangwena	3
South Africa	Mpumalanga	3	Eswatini	Hhohho	3
South Africa	Northern Province	3	Eswatini	Lubombo	3
Ethiopia	Oromiya	3			

The different countries and the time periods used in the analyses are displayed in Table 3 in the Appendix. In terms of the descriptive statistics, Table 4 in the Appendix shows there is substantial variation in terms of all variables. T1 IWI, i.e. the value for IWI at the start of the analyzed period, ranges from 0.78 to 94.99. Thus, there are regions where the average household in the first year owned almost none of the assets that are included in the index, while there are also regions in which households owned almost all assets in the first year. In terms of economic growth, there is also substantial variation, as the lowest average yearly change between T1 and T2 in IWI was -3.96 while the largest yearly change was 5.72. In terms of male education, the average mean years of schooling ranged from as low as 0.23 years to as high as 13.40 years. Lastly, there are regions where the men, on average, went to school 5.77 years longer than women, while there are also regions where women, on average, went to school 2.08 years longer than men.

Multivariate Analyses

Tables 5, 6 and 7 show the results of our multivariate analyses. Table 5 shows the full empirical results of the theoretical model. Column (1) includes all sub-national determinants of the absolute change in IWI. We find the predicted negative effect of IWI at T1 on the change in IWI. The demographic effect is also clearly present, as the results show that a lower T1 dependency ratio or a lower growth rate of the dependency ratio, will increase IWI growth. IWI growth tends to be higher in urban regions, in regions with higher levels of male schooling, and in regions with a higher growth in male schooling. Furthermore, IWI growth tends to be lower in regions with a larger absolute difference and increase in education between men and women.

Column (2) introduces sub-national interaction terms. The negative effect of IWI at T1 on the change in IWI remains, but it is now non-linear, and it is conditional on the growth rate of the dependency ratio and the level and change in male schooling. The larger the growth rate of dependency, or the level of or increase in male schooling, the stronger the T1 IWI effect. Conversely, one could argue that decreases in the growth rate of dependency have a stronger effect in regions with an initially higher level of development, and that (faster) increases in the level of male schooling have a stronger effect in regions with an initially lower level of development.

Table 5 – Coefficients of multilevel regression models of selected independent variables on economic development in subnational regions of LMICs

Dependent variable: Δ IWI	(1) S-L	(2) S-LI	(3) SN-LI
T1 IWI	-0.0453***	-0.0483***	-0.0485***
	(-21.03)	(-22.62)	(-22.79)
T1 IWI * T1 IWI		-0.000298***	-0.000302***
		(-4.93)	(-5.01)
T1 Dependency Ratio (log)	-3.187***	-3.297***	-3.298***
	(-10.20)	(-9.37)	(-9.40)
Growth Dependency Ratio	-0.185***	-0.196***	-0.195***
	(-8.32)	(-7.22)	(-7.17)
Urban	0.0889	0.131**	0.162***
	(1.90)	(2.83)	(3.43)
T1 Male Education	0.0674***	0.0787***	0.0676***
	(3.90)	(4.60)	(3.94)
T1 Male-Female Education	-0.0711**	-0.0891**	-0.0754*
	(-2.73)	(-2.98)	(-2.52)
Δ Male Education	4.045***	4.261***	4.222***
	(26.69)	(27.77)	(27.53)
Δ Male-Female Education	-2.890***	-3.302***	-3.248***
	(-12.44)	(-14.12)	(-13.90)
T1 Dependency Ratio (log) * T1 Male Education		-0.442***	-0.449***
		(-5.00)	(-5.10)
T1 Dependency Ratio (log) * Urban		1.430***	1.391***
		(4.10)	(3.99)
Growth Dependency Ratio * Urban		0.0747*	0.0738*
		(2.29)	(2.26)
Growth Dependency Ratio * T1 IWI		-0.00261**	-0.00262***
		(-3.29)	(-3.30)
T1 IWI * T1 Male Education		-0.00185**	-0.00191**
		(-2.78)	(-2.88)
T1 IWI * Δ Male Education		-0.0195**	-0.0196**
		(-3.19)	(-3.21)
Urban * T1 Male-Female Education		-0.119***	-0.117***
		(-4.40)	(-4.32)
T1 Male Education * Δ Male-Female Education		0.254***	0.260***
		(3.92)	(4.02)
T1 Male-Female Education * Δ Male Education		-0.377***	-0.378***
		(-4.75)	(-4.77)
Economic Globalization			0.0276***
			(3.83)
# Observations	1921	1921	1921
# Countries	91	91	91

t statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In terms of dependency, we find that the effect of the T1 dependency ratio is conditional on urbanization and the T1 level of male schooling, while the effect of the growth rate in dependency is now conditional on urbanization and, as explained, the T1 level of IWI. Overall, the T1 dependency ratio and the growth rate of the dependency ratio have a less negative effect in urban regions.

Column (3) introduces the *significant* national level and interaction terms. The only significant national variable after including the level of governance, democracy, whether or not a country is landlocked and the level of economic globalization, is the economic globalization variable as estimated by the KOF index. Economic globalization, however, does not seem to condition any of the effects of the sub-national variables.

Table 6 - Coefficients of multilevel regression models of effects of the demographic window phases on economic development in subnational regions of LMICs

Dependent variable:	(1)	T1 Demographic Window Phase						
Δ IWI	T1 IWI	2	3	4	5	6	# Observations	# Countries
Coefficient	-0.0403^{***}	0.283^{***}	0.300^{***}	0.345^{**}	0.212	0.0922	1,921	91
	(-18.86)	(5.39)	(3.66)	(2.98)	(1.34)	(0.51)		

t statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In Table 6, instead of the use of the T1 dependency ratio and the growth rate of the dependency ratio, the T1 DW phases were used as independent variables. Although not shown, all independent variables were included in the model. The table shows that regions in the second, third and fourth DW phase have significant higher growth rates than the traditional DW phase. This effect is strongest in Phase 4, the mid-window phase, and still positive but not significant in the late window phase. In the post-window phase it has disappeared completely. As such, the results are in line with the idea that the DWO is a temporary period of higher growth. However, given that the effect is already positive in the pre-window phase and not significant anymore in the late window phase, it seems that the positive effects of a decrease of the dependency ratio can already be felt earlier than has been assumed before (e.g. UN, 2004).

Robustness Tests

The models presented in Table 7 use the same strategy as those in Table 5, but with different data, estimation techniques or variables. The first column shows the coefficients of the model that controls for migration flows within and between regions. Although the coefficient of the migration variable has the expected positive sign, it is not significant at the conventional confidence level of 95%. All other effects are robust to the inclusion of the proxy for migratory flows. In the T0-T1 column, we use the same strategy as before, but we go back *one period* in time for all countries where another period of at least four years is available. Thus, instead of explaining the variation in changes in the period between times T1 and T2, we now analyze the variation in changes in the period between times T2 and T3.

Table 7 - Coefficients of multilevel regression models of selected independent variables on economic development in subnational regions of LMICs (robustness tests)

Dependent variable: Δ IWI	(1) Migration	(2) T0-T1	(3) National
T1 IWI	-0.0487***	-0.0588***	-0.0211***
	(-22.83)	(-17.01)	(-4.81)
T1 IWI * T1 IWI	-0.000307***	-0.000830***	-0.000509***
	(-5.09)	(-8.39)	(-5.31)
Dependency Ratio (log)	-3.145***	-3.862***	-2.341**
	(-8.55)	(-7.46)	(-2.94)
Growth Dependency Ratio	-0.179***	-0.286***	-0.174
	(-6.10)	(-6.75)	(-1.90)
Urban	0.174***	0.136	-0.197
	(3.63)	(1.68)	(-1.80)
T1 Male Education	0.0679***	0.116***	-0.0449
	(3.96)	(4.17)	(-1.32)
T1 Male-Female Education	-0.0751*	-0.0934	-0.0221
	(-2.52)	(-1.83)	(-0.37)
Δ Male Education	4.206***	3.529***	3.437***
	(27.36)	(16.03)	(6.13)
Δ Male-Female Education	-3.215***	-1.472***	-2.193*
	(-13.69)	(-4.30)	(-2.38)
T1 Dependency Ratio (log) * T1 Male Education	-0.443***	n.s.	-0.304*
	(-5.02)		(-2.30)
T1 Dependency Ratio (log) * Urban	1.425***	n.s.	n.s.
	(4.08)		
Growth Dependency Ratio * Urban	0.0763*	0.109*	n.s.
	(2.34)	(2.10)	
Growth Dependency Ratio * T1 IWI	-0.00256**	n.s.	n.s.
	(-3.22)		
T1 IWI * T1 Male Education	-0.00191**	0.00307***	n.s.
	(-2.88)	(3.59)	
T1 IWI * Δ Male Education	-0.0197**	-0.0223*	n.s.
	(-3.23)	(-2.50)	
Urban * T1 Male-Female Education	-0.117***	0.206***	n.s.
	(-4.34)	(4.49)	
T1 Male Education * Δ Male-Female Education	0.264***	0.246*	n.s.
	(4.07)	(2.38)	
T1 Male-Female Education * Δ Male Education	-0.379***	n.s.	n.s.
	(-4.79)		
Economic Globalization	0.0271***	0.0305*	0.0204**
	(3.75)	(2.53)	(3.00)
Migration	0.946		
	(1.39)		
# Observations	1,921	1,254	182
# Countries	91	55	91

t statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

This is possible for 1,254 regions in 55 countries. The effects of the main variables – dependency ratio and change in dependency ratio – remain significant and even look somewhat stronger. Of the other variables, we observe that urbanization and the T1 difference between male and female schooling, and some interactions, lose their significance. The third column shows the results we would have obtained if we only had data at the national level, but with a split between urban/rural regions. This analysis is based on data for 91 countries and 182 observations in total. In this setup, the T1 dependency ratio remains important, but the change in dependency ratio is not significant any more. In addition, some of the control factors and most interactions lose their significance.

5. Discussion and Conclusion

In this study, we aimed to contribute to the existing literature on the effects of the DWO on economic development in sub-national areas in LMICs. Our data reveal that there is substantial variation in in terms of the DWO at the sub-national level, not only in middle- income countries, but also low-income countries. As such, significant informative value can be gained from analyzing the effect of population age-structures on economic development at a sub-national level in all LMICs.

To achieve this, we created a dataset of 1,921 regions in 91 LMICs and we used a multilevel model with a random country intercept to explain the variation in development (measured by the International Wealth Index) among these regions. The results indicate that the DWO is indeed a statistical reality. Economic development was largest in regions with a lower dependency ratio, as well as in region where the dependency ratio decreased during the study period. A more detailed analysis in which economic development was compared between regions in different phases of the DW revealed that economic development was largest in regions that are in the third and fourth phase of the DW, called here the early and mid-window phase.

Our analyses also revealed that the positive effects of dependency reduction on economic development are not everywhere the same. The positive associations between a lower dependency ratio and economic development, as well as of a reduction of the dependency ratio and economic development, are stronger in rural areas. This indicates that these areas can profit more of the DW than more urban areas. Also in areas with a higher starting level of economic development a reduction of the dependency ratio is associated with more growth than in areas with a lower starting value. This is particularly so if those areas have a relatively high starting level of (male) education. Together, these finding suggest that rural areas, which have already reached a certain level of development and have invested in reasonable educational facilities, have the highest propensity to reap the demographic dividend.

We did not find a significant interaction between the change in education in the study period and the dependency ratio effect. Together with the positive role played by the starting level of education his suggests that improvements in schooling can better occur in an early stage of the demographic transition, in order to be most effective. Regarding gender differences in education, no interaction effects with the dependency ratio were found. Hence, although educational gender inequality is associated with less economic development, as has been found in the literature at the national level (Klasen 2002; Klasen and Lamanna 2009), there seems to be no effect of educational gender inequality on the effects of the dependency ratio.

Important is also our finding that already in the second phase of the DW, called pre-window phase, in comparison with the traditional phase a significant increase in economic growth was observed. Hence, regions in an early phase of fertility reduction might already experience benefit in terms of economic growth. On the other hand, regions that are in the late window phase (with less than 20% under 15 and still less than 15% over 65) seem to experience less advantage of their demographic situation than countries in an earlier phase. This might mean that in those countries growth chances already start to be affected by the growing number of elderly, and that the effect of the old-age dependency ratio on growth is relatively strong.

Three robustness tests were conducted. First, we have tested the role of migration, by including an indicator of regional migration in the model. This factor was not significant and the coefficients of the other variables were hardly affected. Second, we have re-estimated the model using data from an earlier time period. This could be done for 1,254 regions in 55 countries. Although a few control factors and interactions lost their significance, the main conclusion were upheld. Finally, we repeated the analysis using only national data, as most other studies on the DW did. Even though we increased the explanatory power by splitting up the country data into urban and rural areas (as we did in our subnational analyses), many factors – including the change in dependency ratio – lost their significance. This result highlights the importance of studying DW effects with data aty the subnational level.

In terms of the interaction effects, there is no effect that is not significant in at least one of the robustness tests. The result that dependency matters less in urban regions, and that reductions in dependency are more beneficial in regions with higher levels of male average years of education seem to be among the most robust results. Nevertheless, we are most confident about our main results, as the main model has the most degrees of freedom, more variation in terms of the amount of countries, and the most recent, i.e. reliable, data.

A potential weakness in our estimation strategy may be the use of changes in variables as predictors, while the dependent variable is also a change in that same period. As such, there may be issues of reverse causality. However, given that (changes in) the current window phase are based on fertility choices rather far in the past, the risk that these changes are the result of the current level of economic growth seems very low.

In conclusion, our paper contributes to the existing literature by being the first to look at the effect of the DWO at subnational level for a very large sample of LMICs. Population age-structures matter for economic development, and the effects differ at the sub-national level. Additionally, where previous literature has managed to find a maximum of one or two interaction effects in terms of the relationship between demography and economic growth, this paper has identified nine interactions and non-linearities, where four interaction effects focus specifically on the DWO. Thus, the relationship between demography and economic development is not a simple one, but depends to a large extent on the context in which the changes are taking place. Consequently, the implementation of policies such as family planning, labour market policies and education policies should be focused on the sub-national level and take the unique characteristics of a specific area into account.

6. References

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Appendix

Table 3 – Main sample regions and main sample (T1T2) or robustness (T0T1) time periods.

Country	T1T2	T0T1	# Regions
Afghanistan	2010-2015	-	16
Albania	2009-2017	2005-2009	24
Algeria	2002-2013	-	14
Angola	2011-2016	-	29
Armenia	2010-2016	2000-2010	21
Bangladesh	2004-2014	-	45
Belarus	2005-2012	-	12
Belize	2006-2011	-	8
Benin	2011-2018	2006-2011	12
Bolivia	2003-2008	1998-2003	18
Bosnia Herzegovina	2006-2011	-	10
Botswana	2001-2011	-	16
Brazil	2000-2010	1996-2000	54
Burkina Faso	2003-2010	1998-2003	25
Burundi	2010-2017	2005-2010	10
Cambodia	2005-2014	2000-2005	34
Cameroon	2004-2011	1998-2004	20
Central African Republic CAR	2006-2010	1994-2006	11
Chad	2010-2015	2004-2010	15
China	2002-2015	-	33
Colombia	2010-2015	2005-2010	63
Comoros	1996-2012	-	6
Congo Brazzaville	2005-2015	-	15
Congo Democratic Republic	2007-2013	-	21
Cote d'Ivoire	2005-2011	1999-2005	20
Dominican Republic	2007-2013	2002-2007	18
Egypt	2008-2014	2000-2008	40
Eritrea	1995-2002	-	12
Eswatini	2006-2014	2000-2006	8
Ethiopia	2011-2016	2005-2011	21
Gabon	2000-2012	-	19
Gambia	2006-2013	2000-2006	14
Ghana	2008-2014	2003-2008	20
Guinea	2012-2018	2005-2012	15
Guinea Bissau	2006-2014	-	17
Guyana	2009-2014	-	14
Haiti	2012-2017	2005-2012	18
Honduras	2005-2011	-	32
India	2006-2016	1999-2006	52
Indonesia	2007-2012	2003-2007	57
Iraq	2011-2018	2006-2011	36
Jordan	2012-2017	2007-2012	24
Kazakhstan	2010-2015	2006-2010	11

Kenya	2008-2014	2003-2008	15
Kyrgyzstan	2012-2018	2006-2012	15
Lao	2012-2017	-	34
Lesotho	2004-2014	-	20
Madagascar	2009-2018	-	43
Malawi	2010-2016	2004-2010	26
Mali	2013-2018	2006-2013	11
Mauritania	2007-2011	2001-2007	22
Mexico	2010-2015	2000-2010	64
Moldova	2005-2012	-	8
Mongolia	2005-2010	-	9
Monte Negro	2005-2013	-	6
Morocco	1992-2003	-	14
Mozambique	2003-2011	1997-2003	21
Myanmar	2000-2016	-	28
Namibia	2006-2013	2000-2006	25
Nepal	2011-2016	2006-2011	10
Niger	2006-2012	1998-2006	14
Nigeria	2013-2018	2008-2013	73
North Macedonia	2005-2011	-	16
Pakistan	2012-2018	2007-2012	12
Palestine	2010-2014	-	12
Peru	2006-2012	2000-2006	12
Philippines	2008-2017	2003-2008	33
Rwanda	2010-2015	2005-2010	10
Sao Tome & Principe	2009-2014	2000-2009	8
Senegal	2011-2017	2005-2011	20
Serbia	2005-2014	-	8
Sierra Leone	2008-2017	-	27
Somalia	2006-2011	-	16
South Africa	2011-2016	1998-2011	18
Sudan	2008-2014	2000-2008	30
Suriname	2006-2010	-	8
Tajikistan	2012-2017	2005-2012	9
Tanzania	2010-2015	2004-2010	47
Thailand	2012-2017	2006-2012	9
Timor Leste	2009-2016	-	26
Togo	2006-2014	1998-2006	11
Tunisia	2012-2018	-	14
Turkey	2008-2013	2003-2008	24
Turkmenistan	2006-2015	-	11
Uganda	2011-2016	2006-2011	17
Ukraine	2007-2012	-	10
Uzbekistan	1996-2006	-	11
Vietnam	2006-2014	2002-2006	12
Yemen	2006-2013	1997-2006	16
Zambia	2014-2018	2007-2014	18
Zimbabwe	2006-2015	1999-2006	18
Total	-	-	1,921 (91 countries)

Table 4 - Sample Descriptive Statistics

Variable	Mean	Weighted Mean	St. Deviation	Minimum	Maximum
Δ IWI	0.994	1.110	1.103	-3.964	5.723
T1 IWI	49.91	50.46	24.27	0.78	94.99
T1 Dependency Ratio (%)	77.90	60.85	25.37	15.30	204.60
Growth Dependency Ratio (%)	-0.20	0.62	2.45	-7.96	17.95
T1 Male Schooling (Years)	6.80	7.06	2.80	0.23	13.40
Δ Male Schooling (Years)	0.10	0.06	0.15	-0.82	0.89
T1 Male-Female Schooling (Years)	1.29	1.71	1.17	-2.08	5.77
Δ Male-Female Schooling (Years)	-0.009	-0.018	0.106	-0.448	0.818
Economic Globalization	47.84	44.82	10.37	27.31	73.52
Migration	0.888	0.889	0.049	0.668	1.100