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The impact of population and economic growth on the achievement of the Millennium Development Goals

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Introduction

In September 2000, the United Nations (henceforth UN) presented the Millennium Declaration, a milestone in international cooperation inspiring development efforts in order to improve the living conditions of millions of people around the world. The Millennium Declaration committed the world nations to a new global partnership to reduce extreme poverty and setting out a series of time-bound targets – with a deadline of 2015 – by which progress in reducing income poverty, hunger, disease, lack of adequate shelter and exclusion – while promoting gender equality, health, education and environmental sustainability – can be measured. These time-bound targets have become known as the Millennium Development Goals (henceforth MDGs). The MDGs project is one of the major efforts undertaken by the international community to raise global living standards and fulfill the promise for a better world.

The extent to which world countries have achieved the different MDGs is a matter of great interest for academics and policy-makers alike that depends on a long array of explanatory factors. Among these we are particularly interested in two of the most prominent ones: population and economic growth. It is hard to find any two other social phenomena that have attracted more attention in the last decades than the so-called 'population explosion' and the unprecedented boost in economic growth experienced in many areas of the world that some have denoted as the 'income explosion' (see Firebaugh 2003 or Easterlin 2000). On the one hand, the study of the impact of population growth on countries' well-being and living standards has been a matter of contentious debate for a long time and has reasons to continue for many years to come (see Ahlburg et al 1996). The views in this debate have ranged from alarmism – population growth has been depicted as a trigger of mass starvation, resource depletion, pollution and increased poverty (see Ehrlich 1968) – to optimism – economies of scale, technological innovation, globalization and behavioral adaptation are some of the channels through which the negative effects of population growth might be offset (see, for instance, Boserup 1981, Simon 1981, Lam 2011). While not being so central stage as it used to be back in the 60s and 70s[[[Endnote#1]]], population growth continues to pose enormous challenges for developing countries (e.g. ensure poverty reduction, universal education, better health systems, increasing gender equality or greater access to water and sanitation *simultaneously* might be a daunting task in face of growing populations), so it is still a fundamental ingredient to understand countries' performance in their attempt to reach the MDGs targets. On the other hand, the study of the impact of economic growth on countries' well-being has been much less investigated. Since it is usually taken for granted that economic growth naturally goes hand-in-hand with improvements in societies' living conditions, the matter has received scant attention from the specialized literature. Yet, a few recent studies have challenged such entrenched assumptions finding a small to null association between economic growth and (i) child undernutrition (Harttgen et al 2013, Vollmer et al 2014) and (ii) other quality of life indicators (Easterly 1999). All in all, these ideas call for a fresh and comprehensive analysis studying the effects of population and economic growth on countries' performance in the different dimensions of the MDG framework.

Taking advantage of the increasing availability of internationally comparable datasets, in this paper we investigate (i) the joint evolution of countries towards MDGs achievement, and (ii) the joint impact of population *and* economic growth on the improvement of key social variables belonging to the MDGs – an issue that, to the best of our knowledge, has not been empirically investigated so far and which has clear implications for the elaboration of policies aiming to fulfill the post-MDGs global development agenda that has recently been settled. Have the world countries achieved the MDGs simultaneously? Has the rise in the number of people been an obstacle to reduce poverty while improving global health, expanding education and promoting environmental sustainability? Or have the historically unprecedented increases in GDP per capita improved the overall quality of life around the globe? Which of these two forces has been more decisive in driving the success or failure of countries towards MDGs achievement? These are the main questions this papers aims to address. Having recently attained the MDG target date of 2015, it is a good moment to take stock with the most recently available data and reflect upon the factors that have contributed to countries' improvements towards the MDGs around the globe.

After this short introduction we turn to the data and methods section where we present the data sources, indicators and statistical techniques used in our analysis. We then present our descriptive findings, where we basically describe the evolution of the different MDG indicators across regions and countries. In addition, we investigate the extent to which the improvements in the different MDG indicators are related to one another. Finally, we introduce the results of our models investigating the impact of population and economic dynamics on countries' MDGs achievement both globally and regionally. We close with some reflections on possible explanations of our empirical findings.

Data and Methods

Monitoring the evolution during the last decades of around 200 countries towards the achievement of several MDGs is not an easy task. Given the large number of potential indicators to be included in the MDGs framework, one has to deal with several partially incomplete sources of data that typically do not have the same geographical and temporal coverage, a circumstance that usually forces the analyst to make difficult decisions involving trade-offs whose consequences are hard to quantify. Within each of the MDGs there are different targets and each target is monitored using several indicators. According to the UN Statistical office there are 8 goals, 21 targets and 60 indicators (see http://www.un.org/millenniumgoals). However, when it comes to incorporate these goals, targets and indicators into an international comparative analysis like the one performed here a number of difficulties arise. First, despite the increasing availability of internationally comparable datasets there are some variables for which data simply does not exist. Second, many of the targets are not clearly specified and/or are hard to quantify (or non-quantifiable at all). Third, some targets and indicators are not defined at the country level, so they cannot be incorporated in a country-basis analysis like the one we are carrying out in this paper. Finally, some targets and indicators are simply not defined for all countries of the world, so their inclusion would seriously compromise the comparative approach of our analysis. The final choice of targets and indicators to be included in our measures has been constrained by the aforementioned limitations and by the existing trade-offs between geographical coverage and inclusion of further indicators. As a result, we have decided to work with the following list of indicators (and the corresponding official targets proposed by the UN):

I_1: Percentage of population below $1.25 (PPP) per day (MDG#1, Target: Halve between 1990 and 2015 the proportion of people below the poverty line).

I_2: Net enrolment ratio in primary education (MDG#2, Target: Ensure that, by 2015, children everywhere will be able to complete a full course of primary education).

I_3: Ratios of girls to boys in primary education (MDG#3, Target: Eliminate gender disparity in primary education).

I_4: Under-five mortality rate (MDG#4, Target: Reduce by two thirds, between 1990 and 2015, the under-five mortality rate).

I_5: Maternal mortality ratio (MDG#5, Target: Reduce by three quarters, between 1990 and 2015, the maternal mortality ratio).

I_6: Death rates associated with tuberculosis (MDG#6, Target: Have halted by 2015 and begun to reverse the incidence of tuberculosis and other major diseases).

I_7: Percentage of population using an improved drinking water source (MDG#7, Target: Halve by 2015 the proportion of people without sustainable access to safe drinking water).

I_8: Percentage of population using an improved sanitation facility (MDG#7, Target: Halve by 2015 the proportion of people without sustainable access to basic sanitation).

Overall, this group of indicators offers a reasonably faithful portrait of countries' evolution towards the achievement of the MDGs. While the geographical and temporal coverage varies by indicator, we have been able to collect comparable information for around 150-200 countries during the last 25 years (at least). In the section of descriptive results world countries have been grouped in the following regions: Oceania (OC), North Africa (NA), East Asia (EA), South Asia (SA), South East Asia (SEA), West

Asia (WA), Caucasus and Central Asia (CCA), Latin America and the Caribbean (LAC), Developed Countries (DC) and Sub-Saharan Africa (SSA) – in appendix 1 we show what countries are included in each region. For our regression analysis section, the partition is somewhat cruder (only four large regions are considered) to simplify the presentation of our findings. The statistical data used in this paper has been accessed through the internet from the following sources and institutions: the World Bank, the Penn World Tables, the World Health Organization, UNESCO, UNICEF and the Center for Systemic Peace.

Estimation approach

In order to estimate the effect of population and economic growth on MDGs achievement we use multivariate statistical techniques. Because of the way in which it has been constructed, our dataset is an unbalanced panel (i.e. the same country is followed across several years but some observations might be missing). The panel nature of the data allows controlling for any unobserved heterogeneity across countries in the form of time-invariant characteristics that affect either the MDG-indicator being studied, its measured determinants, or both (examples of these factors can be cultural norms, climate, geography or the presence of continuous government development programs). To do so we estimate a country and time fixed-effects (FE) model [[[Endnote#6]]] which relies on the "within" variation (i.e. changes over time for each country and changes across countries for a fixed moment in time respectively) as follows:

$$I_{it} = \alpha + \sum_{k=1}^{K} \beta_k X_{k,it} + \mu_i + \lambda_t + v_{it}. \qquad [1]$$

In equation [1] α is a scalar, the βs are the regression coefficients we want to estimate corresponding to the independent variables X_k, μ_i are the unobservable country-specific time-invariant effects, λ_t are the time-effects and, lastly, v_{it} is the stochastic error term. The dependent variable (I) is one of the eight MDG indicators considered in this paper, so equation [1] is estimated for each of them separately. The key explanatory variables X_k considered in this paper are (logged) population size ('*logpop*') and yearly population growth ('*popgr1*') together with economic size (logged GDP per capita: '*loggdp*') and yearly economic growth ('*gdpgr1*'). Since the notion of 'growth' can be defined for different time frames (e.g. on an annual, quinquennial or decennial basis) and it is not a priori clear which one should be used, we have experimented not only with short term (i.e. 1-year) effects, but also with medium (5-years) and longer term (10-years) ones; the corresponding labels of the variables are '*popgr1*', '*popgr5*', '*popgr10*' and '*gdpgr1*', '*gdpgr5*', '*gdpgr10*'.

Several studies investigating the impacts of population growth on economic growth have highlighted the importance of considering not only the overall size of a given population but also its structure (see, among many others, Bloom et al 2000, Bloom and Williamson 1998 or Kelley and Schmidt 1995, 2005). Population as a whole is a broad entity that can be partitioned in several groups – some being much more relevant than others for the behavior of certain indicators – whose relative sizes might also have important consequences for the problem at hand. Failing to incorporate such more finely-grained population structure variables might muddy the waters when attempting to assess the impact of demography on countries' performance in MDGs achievement, an issue we investigate in this paper. For this purpose, we have enriched our models introducing other demographic variables that might be more highly related to our dependent variable (the different I_j) besides mere population size and growth[[[Endnote#8]]]. As a result, for each MDG indicator we have generated two kinds of implementations of the FE models shown in [1]: one that uses overall population size and growth and another that uses indicator-specific demographic related variables. As will be shown in the empirical section, the latter tend to generate sharper and more conclusive findings than the former.

What other variables might have a direct bearing on the different MDG indicators besides the core economic and demographic variables we have just discussed? Other control variables introduced in our models which have been commonly used in conceptually related studies analyzing the impacts of population or economic growth on living standards (see, for instance, Bloom et al 2000, Kelley and Schmidt 2001, 2005, Easterly 1999, Ahlburg et al 1996, Birdsall et al 2001) are the following:

Population density ('*pden*'): In several studies it has been hypothesized that the population per unit of land can exert an important influence on several quality-of-life indicators (e.g. Bloom et al 2000, Kelley and Schmidt 1995, 2001). On the positive side, higher densities can decrease per unit costs and increase transportation efficiency, irrigation, markets and communications. On the negative side, higher density might be associated with diminishing returns to land or several deleterious effects of over-concentration, so the predicted impact of population density is ambiguous and highly dependent on the MDG indicator we are dealing with.

Degree of urbanization ('*urb*'): Urbanization is a widespread phenomenon that is sweeping the world: for the first time in history, in 2000 more than half of the world population lived in urban areas. Cities, if well planned, can reap the efficiencies of economies of scale as governments can more easily deliver essential infrastructure and services at lower cost per capita than in rural areas. Cities have the potential to improve people's access to education, health, housing and other services, and to expand their opportunities for economic productivity. If badly planned, cities can host millions of slum dwellers without access to the most basic needs. Therefore, the impact of urbanization on MDGs achievement is, a priori, unclear.

Contraceptive prevalence rate ('*cpr*'): It is nowadays widely accepted that the accessibility to family planning services can be a quite cost-effective method to reduce poverty, foster gender equality while improving maternal and child mortality (see Ahlburg et al 1996). Quite recently, Cates et al (2010) have convincingly argued that ensuring a better access to reproductive health for all can be beneficial for the improvement in every MDG indicator. In this respect, we expect the contraceptive prevalence rate to have a positive impact on all our dependent variables.

Level of democracy (‘*demo*’): Many studies suggest the importance of democracy for improving countries’ well-being indicators like economic performance, life expectancy, infant mortality or other physical quality of life indicators (Barro 1991, Wickrama and Mulford 1996, London and Williams 1990, Kelley and Schmidt 2001). According to these and other studies, the impact of democracy is expected to be positive for all MDG indicators. In this paper, democracy is measured using an ordinal variable taking values between –10 and 10 obtained from the Polity IV database.

Capital formation (‘*capf*’): Capital formation considers additions to the fixed assets of the economy, including land improvements, plant machinery, equipment purchases, as well as construction of railways, roads, schools, hospitals and commercial and industrial buildings. A priori, we expect such domestic investment measure to be positively associated with improvements in all MDG indicators.

Other econometric issues

(i) Any study aiming at investigating the impact of population and/or economic growth on several quality of life indicators must address the problem of reverse causation. There are well identified mechanisms through which changes in the different MDG indicators can have an impact on population and/or economic growth. Therefore, to more directly ensure that a causal effect is being identified, and that only the causal portion of the observed relationship is represented by the regression coefficient estimates, we conduct endogeneity tests for those determinants where we suspect that bi-directional causality might be at work. Then, we take this endogeneity into account by estimating the above equations using instrumental variables (IV). Doing so is important for detecting and correcting reverse causality, incidental association and attenuation bias due to measurement error. To correct for these potential problems we instrument with classical variables from the empirical growth literature – appropriately lagged population and economic size and growth, inflation and financial depth.

(ii) What are the overall quantitative impacts of the various components of demographic and economic change on the pace of MDG indicators improvements? Besides the regression coefficients β_k from equation [1], in this paper we are also interested in assessing by how much the explanatory variables X_k have contributed to the corresponding MDG-indicator change that has been observed during the last decades. To do that, one must account both for the coefficient *size* and the magnitude of the relevant *changes* in the X_ks. Formally, these contributions are calculated as follows

$$\widehat{\beta_k}\Delta\overline{X_k} = \widehat{\beta_k}\left(\overline{X_{kt_2}} - \overline{X_{kt_1}}\right), \qquad [2]$$

where $\overline{X_{kt_i}}$ is the average value of X_k across countries in time t_i. In the empirical section of the paper we will assess the “importance” of demographic and economic change by reporting the values of these expressions for the corresponding β_k and X_k.

Descriptive results

Are countries achieving the MDGs?

In this section we briefly describe the evolution of the MDG indicators (from I_1 up to I_8) during the period of analysis (1990-2015). For that purpose, Figure 1 compares the values of the MDG indicators in 1990 and the most recently available date (typically around 2013) using scatterplots. In these scatterplots we have added several reference lines to indicate whether (i) the MDG indicators have improved or deteriorated over time, (ii) the corresponding targets have been achieved or not.

Generally speaking, we observe that most countries have improved the values of the different indicators over time (most observations lie on the 'right' side of the equality line – the main diagonal in the graphs). In this regard, there are two noteworthy exceptions. 1) The incidence of tuberculosis (I_6) has increased in 25% of the countries. 2) On many occasions, deteriorations over time are observed for those countries whose achievement levels in 1990 were already quite high and there was a very small room for further improvement. Instances of the latter have been quite common in the following domains: education (I_2), gender equality (I_3) and water and sanitation access (I_7 and I_8).

Despite the generally favorable picture shown in the scatterplots of Figure 1, it turns out that many of the improvements that took place between 1990 and 2014 were not large enough to reach the corresponding target. As shown in the different scatterplots of Figure 1, a large amount of countries fall between the two reference lines (indicating improvements over time but failure to reach the MDG target). For the different MDG indicators from I_1 to I_8 except for I_6 (in that case the target is not specified anywhere so there is no reference line except the one for equality), the percentages of countries falling in such intermediate category are 30%, 37%, 24%, 72%, 80%, 28.5% and 48.5% respectively. The high levels observed in child and maternal mortality (I_4 and I_5) are noteworthy – suggesting either a global failure in the delivery of health services or an overly demanding criterion when designing the corresponding target. Lastly, the percentages of countries that have achieved the corresponding targets in the different MDG indicators (from I_1 to I_8) are 37%, 37%, 63%, 27%, 10%, 75%, 55% and 36% respectively. Therefore, countries have not been particularly successful in meeting the MDGs overall (the high success rate for I_6 – 75% – can be attributed to the fact that *any* improvement between 1990 and 2013 was labeled as a 'success').

[[[Figure_1_around_here]]]

Given the large heterogeneity that can be observed across countries (see Figure 1), it is convenient to aggregate results at the regional level to explore if some broad patterns can be discerned. In Table 1 we report the average values of each indicator at the regional level both in 1990 and in the latest available year. In addition, we show the target that each region should attain to consider that the corresponding goal has been achieved. To facilitate its interpretation, the cells of Table 1 have been colored depending on whether the corresponding goal has been achieved or not: the cells in green correspond to those regions and indicators where the goal has been achieved, those in orange denote those cases where the improvements that have occurred over time have not been enough to reach the target, while red cells correspond to those cases where the corresponding indicator has deteriorated over time.

As shown in Table 1, neither the world as a whole nor its different regions have been particularly successful overall in achieving the MDGs (except, perhaps, for the case of East Asia). The only variables where the targets have been achieved *for the world at large* are the 'poverty' and 'tuberculosis' ones (I_1 and I_6). On the one hand, the reduction in world poverty levels from 35% to 16% has been truly remarkable and is largely attributable to the success of India and, specially, China. However, five world regions have *not* been able to attain the poverty reduction goal (Oceania, North Africa, West Asia, the Developed Countries and Sub-Saharan Africa). On the other hand, even if the improvements in death rates associated with tuberculosis have not been particularly large, they have been enough to reach a quite undemanding target (unsurprisingly, the target associated to I_6 has been attained by all regions except for Oceania). Except for the case of maternal mortality (I_5) – where the improvements that have been observed across the board have not been enough to reach the target (the world as a whole has halved the 1990 level of maternal mortality, but it has not been able to reduce it by three quarters) – the regional attainments in the other variables have been quite heterogeneous. To illustrate: among the 10 regions partitioning the world, the targets corresponding to gender equality and child mortality (I_3 and I_4) have only been achieved in three of them and the targets of the two environmental sustainability indices corresponding to MDG#7 (I_7 and I_8) have been achieved in 5 and 4 regions respectively. Lastly, the target of achieving universal primary education enrolment has been achieved in none of the 10 regions – a discouraging result that is largely explained by the fact that regional results average the experience of many countries, so the target is only achieved when there is no variation and *all* those countries within the region achieve universal education (a particularly demanding scenario).

[[[Table 1 around here]]]

Have the MDGs been attained simultaneously?

When in year 2000 the world countries signed the Millennium Declaration, they implicitly committed to attain all MDG targets *simultaneously*. Yet, official UN reports and academic studies published so far investigate the evolution of the different MDG indicators *separately* but fail to take into consideration their *joint* evolution over time (see, for instance, UN 2014, Sahn and Stifel 2003, Easterly 2009). This way, we do not know whether improvements in, say, enrolment in primary education have been accompanied by improvements in children's health – although one typically assumes that they have. In other words, no attempt has been made to investigate the relationship between improvements in the different MDGs – an issue with implications for our understanding of societies' pathways to development. In order to explore this important topic in more detail, Figure 1 plots the *joint* country level changes between 1990 and the most recent available data for all possible couples of indicators among the ones considered in this paper. The scatterplots included in the Matrix of Figure 2 show how *changes* in one indicator 'i'($\Delta I_i = \log(I_{i_2}/I_{i_1})$) are related to *changes* in another indicator 'j'($\Delta I_j = \log(I_{j_2}/I_{j_1})$) for all possible pairs of MDG-indicators.

Interestingly, there is a remarkable lack of association between changes in alternative pairs of MDG-indicators. As suggested by the different scatterplots shown in Figure 2, large improvements in a given MDG indicator are not necessarily accompanied by large improvements in the other ones. Instead, pair-wise improvements and deteriorations seem to go hand in hand in an apparently random fashion. This is not particularly encouraging for international development agencies or national governments, as it seems that, at the moment, advances in one front are not necessarily accompanied by advances in other fronts as well (as opposed to what would happen if strong associations were observed between indicators).

[[[Figure_2_around_here]]]

Population and economic growth during the last decades

The key explanatory variables we are focusing on in this paper are demographic and economic growth. In Table 2 we show the regional evolution of population size and GDP per capita in PPP along the MDGs time frame (1990–2015). As can be seen, both population and economic size have increased dramatically since 1990 in all regions and in the world as a whole[[[Endnote#10]]]. While to world contained around 5200 million inhabitants in 1990, twenty years later such quantity increased to more than 6800 million. During the same period, and despite the large increase in overall population size, the world GDP per capita has more than doubled, from slightly above $5000 in 1990 to more than $11000 in 2010.

Notwithstanding these encouraging global trends, Table 2 also shows that the evolution has been quite uneven across world regions. On the one hand, all regions have increased their populations during the last 25 years, but some have done it at a faster pace than others: while Sub-Saharan Africa has increased its population by 70% since 1990, the group of Developed Countries has only increased by 8%. On the other hand, the regional GDP per capita the distribution is quite uneven as well – with the group of Developed Countries well ahead of the other regions. Given the disparities observed in both distributions it is a priori unclear whether the impressive record in global economic growth will have the same potentially beneficial impact across the different world regions – an issue we investigate in the following section.

[[[Table_2_around_here]]]

Estimation results

Before estimating the FE models shown in equation [1] it is interesting to visually inspect the relationship between population and economic growth and the different MDG-indicators changes ΔI_i that have occurred between 1990 and circa 2014. The last two rows and columns in Figure 2 show the corresponding scatterplots. Once again, the lack of clear associations seems to be the dominant result. More often than not, for a given level of population or economic growth we typically observe countries experiencing either large or small MDG-indicator improvements (or even deteriorations) indistinctly. The lack of correlation between population growth and other quality of life indicators is by now a well-established fact in the literature (see Birdsall et al 2001). On the other hand, the lack of apparent association between economic growth and changes in other MDG-indicators is in line with the findings of Easterly (1999) for the period 1960-1990 preceding the time frame of our analysis.

As is well known, plain associations and the corresponding correlation coefficients are problematic because their interpretation is hampered by many technical problems (e.g. unobserved heterogeneity or reverse causality). To reduce the impact that these factors might have in our estimates we have implemented the FE models referred to in the methodological section, which take advantage of the panel structure of our dataset.

The impact of population and economic growth

When it comes to estimate the FE models shown in equation [1] there are different a priori plausible alternatives. More specifically, there are three important decisions that must be made as regards: (i) the period of time for which we are going to define population and economic growth (here we have considered 3 alternatives: one, five and ten year intervals); (ii) the decision to instrument or not to instrument our regressions (2 alternatives), and (iii) the choice between overall population or indicator-specific demographic variables (2 alternatives). Given the uncertainty and arbitrariness involved in such choices, rather than privileging a unique model specification we have preferred to make room for different specifications in the aforementioned areas – therefore resulting in 3·2·2=12 model specifications per MDG indicator[[[Endnote#12]]]. Given the large number of results generated by such approach, we have summarized the main findings in Table 3 (the beta coefficients corresponding to each indicator and model specification are shown in appendix 2). For each cell in Table 3, a '+' (resp. '–') sign appears when all statistically significant betas corresponding to the different models have a positive (resp. negative) sign. When the different betas have positive and negative signs for alternative model specifications, then we display a '?' sign. In addition, we have colored the cells with '+' and '–' signs in green or in red depending on whether or not the sign of the estimated betas goes in the normatively desirable direction (which in turn depends on the scale of the underlying indicator, see row 1). To illustrate: in column 1 (corresponding to the results for I_1), the negative betas associated to '*loggdp*' are colored in green because higher economic level is associated with lower poverty levels (an indicator measured in a negative scale), whereas the positive betas associated to '*gdpgr1*' and '*gdpgr10*' are colored in red because higher economic growth is associated with higher poverty rates (an undesirable outcome). Lastly, the two columns dedicated to each of the first five MDG indicators (labeled as 'core' and 'spc.') refer to the model results associated to overall population or indicator-specific demographic variables respectively (see the Methods section).

The results summarized in Table 3 are complex and difficult to interpret. The diversity of regions and circumstances being compared makes it difficult to discern clear-cut patterns that are universally valid across all MDG-indicators considered in this paper. Nevertheless, a few broad findings seem to hold true in the majority of cases. Let's start with the core demographic and economic variables. Population *size* typically has significant positive impacts on all MDG-indicators except for the cases of 'tuberculosis' (I_6) and 'sanitation' (I_8), where the impact is non-significant or inconclusive (i.e. positive in some model specifications and negative in others). Other factors kept constant, larger countries have typically been more successful than smaller ones in terms of MDGs achievements. However, the effect of *overall* population *growth* is unclear on all MDG-indicators considered in this paper: the coefficients switch signs across different model specifications and quite often they are not significant (see the columns labeled as 'core' – referring to the models having *overall* population as the main demographic explanatory variable). The lack of strongly conclusive results regarding overall population growth effects is in line with previous findings attempting to estimate the impact of demographic change on economic growth and other well-being dimensions (e.g. Ahlburg et al. 1996, Birdsall et al. 2001). The fact that population growth can occur through a great variety of channels (e.g. increasing fertility, declining mortality, increasing migration) and affect different sectors of the population (e.g. the young, the adults, the working age-population or the elderly) varying from place to place and over time probably explains the impossibility of making blanket statements about overall effects. This is the reason why in some model specifications we have changed overall population by an indicator-specific demographic variable that might be more relevant for the problem at hand (the corresponding results are shown in the columns labeled as 'spc.'). As can be seen, it is often the case that the use of indicator-specific demographic variables results in sharper and more conclusive findings than the ones obtained when using overall population growth (this is the case for poverty (I_1) [[[Endnote#13]]], gender equality in education (I_3), maternal mortality (I_5) and, to a lesser extent, education (I_2) and infant mortality (I_4) – see Table 3).

As regards economic *size*, Table 3 shows that it has a 'positive' (i.e. normatively desirable) relationship with poverty (I_1), maternal mortality (I_5) tuberculosis (I_6) and sanitation (I_8), and an unclear relationship (mostly – yet not exclusively – consisting of 'positive' relationships) with education (I_2), gender equality in education (I_3), infant mortality (I_4) and water access (I_7). On the other hand, the relationship between economic *growth* and the MDG-indicators is quite irregular, depending very much on whether we are referring to short- , medium- or longer-term growth and on the choice of overall population or indicator-specific demographic variables ('core' and 'spc.' columns in Table 3). Despite such irregularity, it is noticeable that one finds so many instances where the relationship is normatively undesirable (red cells in Table 3) and so few of them being desirable (the ones marked in green).

The effect of the other control variables introduced in our models is quite heterogeneous as well. The effects of population density and those of the level of democracy can be positive, negative or unclear depending on the MDG-indicator we are dealing with, but the size of the coefficients tends to be quite small (see appendix 2). While the effect of population density on the MDG-indicators was a priori unclear, we were expecting a positive relationship between the democracy indicator and all our dependent variables. The level of urbanization has positive effects for child and maternal mortality and the access to water and sanitation, but it has a non-conclusive effect on the other variables. Interestingly, it turns out that the level of capital formation and the contraceptive prevalence rate have clear positive and significant effects on virtually all our MDG-indicators (as a priori expected in our model specification). This suggests that investments in countries' fixed assets (such as hospitals, schools, roads, railways and the like) and in family planning programs can have synergistic and cumulative effects on the simultaneous improvement of most MDG-indicators considered in this study.

[[[Table_3_around_here]]]

A common approach for assessing impacts within regression models is to apply estimated coefficients (the $\widehat{\beta_k}$) to changes over time of the corresponding variable period means (i.e: $\Delta\overline{X_k}$). The product $\widehat{\beta_k}\Delta\overline{X_k}$ can be interpreted as the change in the corresponding MDG indicator (I_j) that can be attributed to the change in the explanatory variable X_k. To simplify, we will refer to $\widehat{\beta_k}\Delta\overline{X_k}$ as 'the impact' of X_k on I_j. Since in this paper we have considered several model specifications per MDG-indicator (see appendix 2) and each of them generates the corresponding set of estimated betas, for each explanatory variable X_k and every I_j there is no single but multiple impacts to be reported. To simplify the presentation, in Table 4 we only show the maximal and minimal impacts coming from statistically significant betas that each explanatory variable X_k has on the different MDG-indicators (this is enough to have an approximate idea of the influence that the former have on the later). In addition, in appendix 3 we also present the global and regional evolution of the different explanatory variables X_k over time. As can be seen in Table 4, the impact of overall population *size* typically goes in the normatively desirable direction for virtually all MDG-indicators (i.e: it 'reduces' poverty, maternal and child mortality and tuberculosis while it 'increases' education, gender equality and water access, see row #3). On the other hand, the impact of overall population *growth* is typically unclear in direction (ranging from negative to positive) and not very large in relative terms when compared to the impacts of other explanatory variables (see row #4). Interestingly, when overall population is substituted by indicator-specific demographic variables, their impacts are clearer in direction (both maximum and minimum having the same signs) and larger in magnitude (see rows #8–#11). Observe that even if the relationship between X_k and the I_j (i.e: the betas) might go in the normatively undesirable direction, the corresponding impact might go in the 'right direction'. This is, for instance, the case of fertility: while it is related to increased poverty and worse children and maternal health, its reduction over time has had a positive impact on the evolution of these variables.

As regards the impact of economic *size*, we can see it has contributed to reduce poverty, maternal mortality, tuberculosis and water access while increasing access to sanitation (see row #1 for core variable models and #5 for indicator-specific ones). According to the indicator-specific results shown in row #5, economic size has also contributed to the expansion of education. Examining rows #2 and #6, we can see that economic *growth* has contributed to reduce poverty and maternal mortality but also water and sanitation access. It is important to highlight that the channel through which economic growth has contributed to reduce poverty is the opposite of what one might a priori expect. It is because (i) higher economic growth is associated with higher poverty levels (positive betas, see Table 3 and appendix 2) and (ii) average economic growth has decreased over time between 1980 and 2010 ($\Delta\overline{gdpgr} < 0$, see appendix 3) that the impact of the later has been beneficial to reduce poverty rates. For the other MDG-indicators, the impact of economic growth has been unclear (with positive and negative impacts depending on the model specification). When comparing the magnitude of economic size and economic growth impacts, it is noticeable that the former are typically much larger than the former, i.e. the impact of economic growth has been much less important than the impact of economic size.

Lastly, the impact of the remaining control variables has been quite heterogeneous as well. Population density has contributed to improvements in poverty, education and gender equality but deteriorations in children and maternal health and water and sanitation access. We have been surprised by the latter because a priori we would have expected that, other factors kept constant, water supply was facilitated by higher population densities. On the other hand, urbanization has contributed to reduce poverty, maternal and child mortality while increasing water and sanitation access. As regards the level of democracy it has benefited children and maternal health and water access but, surprisingly, it has deteriorated education expansion, gender equality, the incidence of tuberculosis and sanitation access. Yet, the impact of the democracy variable has been quite small in magnitude. As expected, capital formation has fostered poverty reduction, education expansion, gender equality, children's health, reduction in the incidence of tuberculosis and water access. And last but not least, contraceptive use has been beneficial for poverty reduction, education expansion, gender equality, improvements in children and maternal health and water and sanitation access. The large amount of quality of life dimensions benefited by higher contraceptive prevalence rates and the relatively large impact that the latter have had on the former suggests that family planning programs might have been a quite cost-effective method to improve the general living conditions in many societies worldwide.

[[[Table_4_around_here]]]

Regional results

The findings we have reported so far refer to the world as a whole, so they document the existence of *global* associations, impacts and trends. Yet, given the huge heterogeneity existing across the world, it is convenient to estimate our models for its different regions as well – otherwise, our global findings might indeed mask offsetting or reinforcing trends occurring at lower levels of aggregation. For that purpose, we have chosen the following world partition: Africa, Asia, Latin America and the Caribbean and the group of Developed Countries. Our regional findings are summarized in tables 5 and 6 (which can be seen as regional replicas of tables 3 and 4 respectively). The detailed results of our models are too long to be presented here, so they can be found in appendix 4. Table 5 summarizes the estimated values of the beta coefficients($\widehat{\beta_k}$); for the sake of brevity and simplicity, we will only report the findings involving our key explanatory variables: population and economic size and growth. Once again, a '+' or a '–' symbol appearing in Table 5 means that all statistically significant betas corresponding to the different model specifications have a positive or negative signs respectively. Whenever the signs of the betas disagree across model specifications, a '?' sign appears in Table 5. As in Table 3, the 'core' and 'spc.' columns shown in Table 5 refer to the model results associated to overall population or the indicator-specific demographic variables.

[[[Table_5_around_here]]]

How can one make sense of the large amount of information summarized in Table 5? Given the heterogeneity across and within regions and the large amount of quality-of-life indicators we are incorporating into the analysis, the results are once again quite difficult to interpret. And yet, a few broad regularities seem to emerge when closely inspecting the findings shown in Table 5.

1. Among the four regions considered here, Africa is the one where our model specifications tend to be more conclusive (i.e. all models agree on the sign of the coefficient, thus showing a '+' or '–' sign in the table) and the group of Developed Countries is the region where they are less conclusive (more often than not, a '?' sign indicating inconsistent results across model specifications shows up in the table). Latin America and the Caribbean and Asia stand somewhere in between these two extremes. A plausible explanation for the generalized lack of conclusive results for the group of rich countries can be the irrelevance of many of the MDG indicators to identify socio-economic gradients in those countries. In many cases, most developed countries where very close to attain the corresponding MDG targets back in 1990 – thus having very small room for further welfare improvements. On the other hand, the MDG indicators can easily identify the large socio-economic gradients existing in Africa – the world region concentrating the largest amount of low-income countries.

2. For all world regions considered here without exception, the effects of population and economic *size* are much stronger and consistent than the effects of population and economic *growth*. For the latter, it is quite uncommon that all our model specifications agree on the sign of the population or economic growth effects. Somewhat

paradoxically, we observe strong cross-section effects and quite weak and inconclusive cross-time effects – something which was observed as well for the world as a whole.

3. When we substitute *overall* population by some other indicator-specific demographic variable (e.g. school-age population), our 'spc.' models tend to be sharper and more conclusive for all world regions considered here. Again, this supports the idea that since the effects of overall population can be quite varied and offsetting, it might be more meaningful to focus on a specific population subgroup that is more directly linked to the problem we are dealing with.

In Table 6, we summarize the impacts of our four key explanatory variables on the different MDG indicators (i.e. the $\widehat{\beta_k}\Delta\overline{X_k}$) at regional level. For the sake of brevity we only report the maximal and minimal statistically significant impacts that each X_k has on the different I_j. Once again, the large variety of indicators and regions considered in this study does not facilitate the possibility of reaching clear cut and universal conclusions. While we encourage readers to examine the complete results in detail (see appendix 4), here we briefly summarize some of the most outstanding patterns.

1. Generally speaking, the impact of population size tends to go in the normatively desirable direction for virtually all MDG indicators for the cases of Africa and Latin America and the Caribbean (i.e. reducing poverty and maternal and child mortality, increasing education and gender parity, and so on). However, such effect is quite unclear for the group of Developed countries and Asia. On the other hand, the impact of population growth is extremely irregular and unclear in direction (oscillating between positive and negative values) across MDG indicators and world regions. As regards the impacts of countries' economic size, they generally *tend* to be positive in all regions except for Latin America and the Caribbean. Lastly, the impacts of economic growth are surprisingly erratic and uneven across regions and MDG indicators, very often reaching opposing conclusions depending on the models we are dealing with. Summing up, we typically find that the impact of demographic and economic *size* tends to be more coherent (i.e. all impacts going in the same direction across model specifications) than the corresponding impact of *growth*.

2. The impact of economic size is not only more coherent (i.e. going in the same direction) than the corresponding impact of economic growth, but also tends to be larger in absolute value across all world regions and MDG indicators. On the other hand, the impact's magnitude for population size only tend to be bigger than the impact of population growth for the case of Africa – for the remaining regions there are no clear patterns, with both population size and growth effects being somehow similar in magnitude across MDG indicators.

3. In general, when comparing the impacts one obtains when shifting from models including *overall* population to models with indicator-specific demographic variables, the latter tend to be more coherent and larger in magnitude across regions and MDG indicators – but there are quite a number of exceptions as well (see appendix 4). Once again, these results reinforce the idea that overall population growth can occur through a

variety of channels with many different and potentially offsetting effects, which in turn are highly dependent on the MDG indicator we are dealing with.

[[[Table_6_around_here]]]

Summary and concluding remarks

For a long time there has been a contentious debate on the implications of demographic and economic growth for societies' and individuals' well-being. This is the first comprehensive study aimed at estimating the macro level effects of population and economic growth on the different quality of life domains belonging to the UN's MDG framework. Having recently reached the MDG target year of 2015 it is a good moment to take stock and investigate whether these two key factors have either benefited or hindered countries' development processes – an issue that can have implications for the formulation of informed policies in the post-2015 development agenda (for instance within the UN's Sustainable Development Goals framework).

Our empirical findings suggest that larger countries have typically been more successful than smaller ones in achieving the different MDGs. The impact of *overall* population growth is, however, quite unclear: depending on the model specification we are dealing with we either obtain positive or negative effects that very often are not statistically significant. Yet, when we substitute overall population growth by other demographic variables that are more directly related to the problem at hand (e.g. focus on the school aged population when studying the evolution of school enrolment rates) our findings are sharper and usually suggest a negative relationship between population growth and quality of life improvement. It is likely that specifications focusing on overall population only hide relevant but offsetting impacts, something that muddies the waters and generates overly parsimonious models – an issue that is line with the findings reported by Kelley and Schmidt (2005) in their study on the impact of population growth on economic growth. The results shown in this paper suggest that even if population growth has ceased to arise the worries it used to back in the 60s and 70s (when it was commonly referred to as 'the population problem'), it continues to pose formidable challenges that cannot be ignored to those fast growing countries that aim to improve the quality of life of their inhabitants.

As regards the impact of economic forces, our findings indicate that the *size* of the economy (as measured with the GDP per capita) has usually – though not systematically – benefited countries' achievement of the MDGs. However, the relationship between economic *growth* and quality of life improvement is very unclear: more often than not, the impact of economic growth has either been inconclusive or even negative. The fact that economic growth does not have a clear positive impact on most MDG-indicators – indeed, it does have a clear negative relationship with the key indicator of poverty in most model specifications – is truly remarkable. While surprising at first sight, such conclusion coheres with other similar findings reported in Easterly (1999) covering the earlier 1960-1990 period and, more recently, in Harttgen et al (2013) and Vollmer et al (2014), where the authors find a very small to null association between economic growth and improvements in several quality of life indicators. Given the blind reliance of many international institutions on economic growth as *the* main pathway to ensure countries' development, the results reported here might have far-reaching implications warranting discussion upon which it will be necessary to reflect.

One factor that might partially explain the lack of association between economic growth and quality of life improvement is the mounting inequality that has recently been observed in many countries around the world. Increases in private incomes might not necessarily translate into increased public goods as the ones represented by the different MDG indicators: in the absence of redistributive or pro-poor policies, economic growth might not contribute to raise countries' overall living standards. As the experience in places like Sri Lanka, Kerala (India), Costa Rica, China or Cuba has shown, progress in several quality of life indicators can be achieved in low-income settings through investments in public services (see Drèze and Sen 1989 or Anand and Ravallion 1993 among others). The exploratory tests we have performed in which both the Gini index and the economic growth variables have positive coefficients when modeling the evolution of poverty levels (suggesting that unequal growth is deleterious for the reduction of poverty – results not reported here but available upon request) give support to a hypothesis that, if confirmed, would cast doubts on the efficiency of the so-called trickle-down effects of a growth-enhancing strategy to better countries' living conditions – but which, on the other hand, would require an entire paper on its own to be thoroughly tested and investigated.

In the light of the results shown in this paper, it remains to be seen how the different dimensions of human development can be advanced *simultaneously* for those countries with lower development levels. In this respect, further research is needed to explore the existence (or lack thereof) of underlying factors that might help to understand the mechanisms promoting joint improvement in the different MDGs. Our findings have identified three factors that can be helpful in that respect: capital formation, contraceptive prevalence and gender equality. This suggests that investments in countries' fixed assets (such as hospitals, schools, roads, railways and the like), in family planning and in gender equality programs can have synergistic and cumulative effects on the simultaneous improvement of most MDG-indicators considered in this study.

Endnotes

Endnote #1: The idea that population growth might be detrimental for countries' socio-economic development has gained traction over the years, so the classical population debate has cooled down and been replaced by other "demodystopias" (Domingo 2008), like population ageing, South-North migration or refugee crises. While there are several reasons that might explain the focus shift towards other population related problems, the observation that "the world has survived the population bomb" (Lam 2011, i.e. contrary to what the pessimists in the 60s had foreseen, the world has not (yet) experienced mass starvation or depletion of nonrenewable resources) is among the most important ones.

Another one might the high human costs entailed by certain neo-Malthusian policies like China's one-child policies or the massive sterilization campaigns that took place in giants like India or Brazil, which has led to a gradual abandonment of the "population problem" rhetoric in favor of the sexual and reproductive rights paradigm settled in the 1994 Cairo International Population Conference.

Endnote #6: Hausman tests have been run to choose between 'random' or 'fixed' effects models, resulting in favor of the latter (Hausman 1978).

Endnote #8: As will be seen in the empirical results section, such indicator-specific variables include fertility rates ('*fert*'), infant population (i.e. below five) size ('*logchpop*') and primary school aged (i.e. those between 5 and 14) population size and growth ('*logypop*', '*ypopgr1*', '*ypopgr5*', '*ypopgr10*').

Endnote#10: Such an increase in economic and population size is by no means novel, it dates back almost two centuries from now (see Easterlin 2000, Firebaugh 2003). The only reason for choosing the year 1990 is that it corresponds to the start of the MDGs time frame analyzed here.

Endnote #12: For I_6, I_7 and I_8 we have not found a clear indicator-specific demographic variable that can substitute overall population growth. In that case, we are only considering $2 \cdot 3=6$ different models.

Endnote #13: The statistically significant positive beta coefficients associated to fertility rates when modeling the behavior of I_1 (see appendix 2) suggest that higher fertility is associated with increasing poverty levels, a finding in line with the results reported by Eastwood and Lipton (1999).

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	I_1 (MDG1)			I_2 (MDG2)			I_3 (MDG3)			I_4 (MDG4)		
Region	**1990**	**2012**	**Goal 2015**	**1990**	**2012**	**Goal 2015**	**1990**	**2012**	**Goal 2015**	**1990**	**2014**	**Goal 2015**
OC	34.8	32.5	17.4	73.7	87	100	0.9	0.94	1	82.3	53	27.4
NA	4.6	2.9	2.3	81.4	96.3	100	0.82	0.97	1	77.3	23.6	25.8
EA	56	6.8	28	93.3	87.3	100	0.95	1	1	42.4	12.7	14.1
SA	51	25	25.5	76.6	90.3	100	0.77	0.96	1	114.9	53.5	38.3
SEA	42.8	11.9	21.4	90.8	91.2	100	0.96	1	1	61.9	28.1	20.6
WA	3	2.5	1.5	83.2	90.8	100	0.87	0.96	1	67.3	23	22.4
CCA	18.7	5.5	9.4	89.3	89.3	100	0.99	0.99	1	77.2	33.7	25.7
LAC	11.3	4.8	5.7	88.4	92.9	100	0.98	1.01	1	52.6	16.7	17.5
DC	0.7	0.8	0.4	96.5	95.6	100	1	1	1	13.8	5.9	4.6
SSA	59.2	48.8	29.6	56.6	72.5	100	0.85	0.92	1	180.4	89.2	60.1
WORLD	**35.4**	**15.9**	**17.7**	**85.4**	**88.9**	**100**	**0.91**	**0.98**	**1**	**70.3**	**34.3**	**23.4**

	I_5 (MDG5)			I_6 (MDG6)			I_7 (MDG7 - Water)			I_8 (MDG7 - Sanitation)		
Region	**1990**	**2013**	**Goal 2015**	**1990**	**2013**	**Goal 2015**	**1990**	**2012**	**GOAL 2015**	**1990**	**2012**	**GOAL 2015**
OC	382.8	189.6	95.7	242.4	264.81	<242.3	52	55.6	76	34.8	35.1	67.4
NA	162.8	68.5	40.7	64.23	49.7	<64.22	86.8	90.9	93.4	72.4	91.4	86.2
EA	94	32.9	23.5	156.53	77.25	<156.5	68	92.2	84	26.9	66.7	63.4
SA	524.2	180.4	131.1	211.62	178.57	<211.6	71.8	91.4	85.9	23.1	42.1	61.6
SEA	311.1	131.9	77.8	259.34	203.84	<259.3	70.8	89.1	85.4	47.9	70.7	73.9
WA	102.9	57.9	25.7	53.17	24.25	<53.17	84.7	90.7	92.4	68.8	88.7	84.4
CCA	70.8	37.9	17.7	121.33	99.05	<121.3	84.6	86.2	92.3	87	95.5	93.5
LAC	131.4	79.3	32.8	84.45	44.1	<84.45	85.2	94	92.6	67.4	82.2	83.7
DC	25.5	15.2	6.4	30.4	23.96	<30.40	97.9	99.1	98.9	94.9	95.3	97.4
SSA	965.2	488.5	241.3	279.1	285.78	<279.0	47.6	64.2	73.8	23.9	29.6	62
WORLD	**284.1**	**140.9**	**71**	**150.76**	**124.65**	**<150.7**	**76.1**	**89.4**	**88.1**	**48.5**	**64.4**	**74.3**

Table 1. Achievement of the 10 world regions in the 8 variables corresponding to the different MDGs (Oceania (OC), North Africa (NA), East Asia (EA), South Asia (SA), South East Asia (SEA), West Asia (WA), Caucasus and Central Asia (CCA), Latin America and the Caribbean (LAC), Developed Countries (DC), Sub-Saharan Africa (SSA)). Green cells indicate that the corresponding goal has been achieved. Orange cells indicate that the corresponding indicator has improved but the target has not been achieved. Red cells indicate that the corresponding indicator has deteriorated over time. Source: Author calculations using international data sources.

	Population (in millions)					GDP per capita (in PPP)				
Year	1990	1995	2000	2005	2010	1990	1995	2000	2005	2010
Oceania	6.43	7.21	8.06	8.93	9.84	1705	2139	2422	2759	3984
Northern Africa	119.67	131.02	141.31	151.49	163.37	2413	2728	3477	4855	6183
Eastern Asia	1206.50	1280.56	1341.99	1385.48	1421.89	1253	2195	3091	5129	9039
Southern Asia	1191.34	1319.90	1448.11	1569.15	1681.30	1158	1457	1814	2618	3923
South-eastern Asia	440.87	481.08	521.26	559.04	594.97	1945	2862	3128	4108	5603
Western Asia	126.46	143.66	160.36	181.50	206.09	5274	5634	7360	10655	15102
Caucasus and Central Asia	65.72	68.78	70.66	73.80	79.47	1427	2058	2575	4348	7503
Latin America & C.	444.16	485.21	525.27	561.47	594.99	4769	5715	6683	8208	10713
Developed Countries	1147.67	1175.11	1196.10	1216.80	1241.09	17053	18636	23056	28915	33532
Sub-Saharan Africa	507.83	582.09	664.97	758.05	865.55	915	948	1121	1497	1932
WORLD	**5256.64**	**5674.62**	**6078.09**	**6465.71**	**6858.57**	**5042**	**5797**	**6979**	**8945**	**11318**

Table 2. Regional evolution of population size and GDP per capita from 1990 to 2010. Source: United Nations Population Division and Penn World Tables 8.1.

	MDG 1 (core)	MDG 1 (spc.)	MDG 2 (core)	MDG 2 (spc.)	MDG 3 (core)	MDG 3 (spc.)	MDG 4 (core)	MDG 4 (spc.)	MDG 5 (core)	MDG 5 (spc.)	MDG 6	MDG 7 (water)	MDG 7 (sanit.)
Indicator scale	(-)	(-)	(+)	(+)	(+)	(+)	(-)	(-)	(-)	(-)	(-)	(+)	(+)
loggdp	-	-	?	+	?	?	+	?	-	-	-	?	+
gdpgr1	+	+	?	-	?	-	?	?	-	?	+	?	?
gdpgr5	?	+	?	-	-	-	?	?	?	?	+	?	?
gdpgr10	+	+	?	-	?	-	-	?	-	-	?	-	-
popsize	-	-	+	+	+	+	-	-	-	-	?	+	?
1-yr popg	?	+	?	?	?	-	?	+	?	+	?	?	?
5-yr popg	?	+	?	?	?	-	-	+	?	+	?	?	?
10-y popg	?	+	?	-	?	-	-	+	?	+	?	?	-
urb	-	?	?	?	?	?	-	-	-	-	?	+	+
pden	-	-	+	+	+	+	+	+	+	+	?	-	?
cpr	-	-	+	+	+	+	-	-	-	-	+	+	+
demo	?	?	-	-	-	-	-	-	-	-	+	+	-
capf	-	-	+	+	+	+	-	-	+	?	-	+	?

Table 3. Summary of the signs of the beta coefficients for economic and population size and growth across models for the 8 MDG indicators. '+' (resp. '–') signs appears when all statistically significant betas corresponding to the different models have a positive (resp. negative) sign. '?' indicates different beta signs across alternative model specifications. Green (resp. red) colored cells indicate whether the sign of the estimated betas goes in the normatively desirable (resp. undesirable) direction. Source: Author calculations.

	I_1 (Poverty)	I_2 (Education)	I_3 (Gender)	I_4 (IMR)	I_5 (MMR)	I_6 (TB)	I_7 (Water)	I_8 (Sanitation)
Core variables								
loggdp	[-19,-14.51]	[-4.9,3.92]	[-0.09,-0.09]	[7.09,28.45]	[-130.42,-48.1]	[-113,-40.75]	[-2.24,-0.56]	[1.55,7.44]
gdpgr-1,5,10	[-4.16,-0.06]	[-,-]	[-0.001,0.005]	[-1.9,0.07]	[-6.45,-0.9]	[1.49,28.2]	[-0.26,-0.04]	[-0.41,0.76]
logpop	[-6.66,-4.19]	[11.58,16.06]	[0.15,0.18]	[-35.96,-26.95]	[-96.7,-49.3]	[-24.65,-24.65]	[1.71,2.92]	[-2.49,2.03]
popgr-1,5,10	[-0.41,2.26]	[-8.16,2.64]	[-0.03,0.01]	[-6.39,25.94]	[19.65,19.65]	[1.93,5.81]	[-1.46,0.33]	[-2.99,1.79]
Indicator-specific variables								
loggdp	[-19,-15.64]	[5.92,9.09]	[-0.11,0.22]	[-13.42,17.89]	[-139.12,-52.86]			
gdpgr-1,5,10	[-3.59,-0.08]	[-0.01,0.45]	[-0.002,0.006]	[-1.77,0.01]	[-4.61,-0.95]			
logpop	[-6.27,-3.05]							
fert	[-3.95,-1.74]			[-18.58,-9.88]	[-34.71,-16.81]			
logchpop				[-12.62,-10.45]	[-3.3,-2.74]			
logypop		[5.8,8.42]	[0.051,0.109]					
yppgr-1,5,10		[-1.09,3.62]	[0.011,0.104]					
Control variables								
pden	[-5.97,-2.39]	[1.44,8.16]	[0.05,0.1]	[0.59,2.82]	[2.5,7.38]	[-,-]	[-0.31,-0.22]	[-0.22,-0.22]
cpr	[-4.66,-1.56]	[1.17,9.82]	[0.01,0.06]	[-38.66,-11.84]	[-26.14,-10.44]	[7.95,12.91]	[1.27,1.98]	[1.06,3.12]
Urb	[-1.8,-1.48]	[-1.5,2.21]	[-0.05,0.03]	[-9.44,-3.67]	[-26.55,-11.57]	[-,-]	[0.99,1.76]	[1.5,3.69]
Demo	[-,-]	[-0.57,-0.23]	[-0.01,-0.01]	[-2.95,-0.9]	[-4.91,-1.82]	[1.51,2.3]	[0.13,0.21]	[-0.13,-0.07]
Capf	[-0.86,-0.25]	[0.8,1.17]	[0.002,0.007]	[-3.2,-0.97]	[1.06,1.16]	[-11.36,-5.73]	[0.05,0.09]	[-0.21,0.15]

Table 4. Impact of different explanatory variables on the changes in the indicators of poverty (I_1), net enrolment ratio (I_2), gender parity index on the net enrolment ratio (I_3), under-five mortality rate (I_4), maternal mortality rate (I_5), incidence of tuberculosis (I_6), percentage of population with access to improved water source (I_7), percentage of population with access to improved sanitation facilities (I_8). Note: We have only considered the impacts corresponding to 10% statistically significant betas. Source: Author calculations.

MDG	Key var.	WORLD Core	WORLD Spc.	Africa Core	Africa Spc.	Asia Core	Asia Spc.	DC Core	DC Spc.	LAC Core	LAC Spc.
I_1	popsize	-	-	-	-	?	?	?	?	?	?
	popgr	?	+	?	?	?	?	?	?	?	+
	econsize	-	-	-	-	-	-	?	?	?	?
	econgr	+	+	+	+	+	+	?	?	?	?
I_2	popsize	+	+	+	+	?	+	?	?	+	+
	popgr	?	?	?	?	?	?	?	?	?	-
	econsize	?	+	+	+	?	+	?	?	?	?
	econgr	?	?	?	?	?	?	?	?	?	?
I_3	popsize	+	+	+	+	+	+	?	?	+	?
	popgr	?	-	?	?	?	?	?	?	?	?
	econsize	?	+	?	+	-	?	?	?	-	-
	econgr	?	-	?	?	?	?	?	?	?	?
I_4	popsize	-	-	-	-	?	-	?	?	-	-
	popgr	-	+	?	+	?	?	?	+	?	+
	econsize	+	?	-	-	?	?	-	-	+	+
	econgr	?	?	?	?	?	?	?	?	?	?
I_5	popsize	-	-	-	-	?	?	+	?	-	-
	popgr	?	+	?	?	?	?	?	?	?	+
	econsize	-	-	-	-	-	-	-	-	?	?
	econgr	-	-	?	?	?	?	?	-	?	?
I_6	popsize	?	NA	-	NA	+	NA	+	NA	?	NA
	popgr	?	NA	?	NA	?	NA	?	NA	+	NA
	econsize	-	NA	?	NA	?	NA	-	NA	?	NA
	econgr	?	NA	?	NA	?	NA	?	NA	?	NA
I_7	popsize	+	NA	+	NA	?	NA	?	NA	+	NA
	popgr	?	NA	?	NA	?	NA	?	NA	?	NA
	econsize	?	NA	-	NA	+	NA	?	NA	?	NA
	econgr	?	NA	?	NA	-	NA	?	NA	?	NA
I_8	popsize	?	NA	-	NA	?	NA	?	NA	+	NA
	popgr	?	NA	?	NA	?	NA	?	NA	?	NA
	econsize	?	NA	?	NA	+	NA	?	NA	?	NA
	econgr	-	NA	?	NA	?	NA	?	NA	?	NA

Table 5. Summary of the signs of the beta coefficients for economic and population size and growth across models for the 8 MDG indicators across world regions. Source: Author calculations.

		I_1 (Poverty)	I_2 (Education)	I_3 (Gender)	I_4 (IMR)	I_5 (MMR)	I_6 (TB)	I_7 (Water)	I_8 (Sanitation)
Africa	**Core variables**								
	Pop_size	[-23.85, -18.03]	[14.69, 31.04]	[0.13, 0.29]	[-86.53, -38.79]	[-251.74, -71.93]	[-244.55, -129.47]	[4.86, 9.68]	[-3.97, -1.22]
	Pop_growth	[-0.74, 2.9]	[-0.23, -0.07]	[-0.001, 0.001]	[-1.17, 0.75]	[4.88, 29.26]	[1.92, 1.92]	[-1.26, 0.42]	[-0.27, 0.32]
	Econ_size	[-27.67, -3.56]	[-11.1, 26.52]	[0.02, 0.64]	[-69.64, 23.69]	[-127.6, -59.87]	[-182.28, -109.37]	[-2.88, -1.74]	[0.55, 5.23]
	Econ_growth	[-7.21, 0.77]	[0.004, 3.05]	[0.0001, 0.003]	[-14.94, -0.1]	[-38.95, 11.9]	[37.07, 103.86]	[-0.38, -0.38]	[-2.95, 0.76]
	Indicator-specific variables								
	Pop_size	[-23.11, -18.96]	[11.16, 28.23]	[0.05, 0.13]	[-71.29, -42.51]	[-120.63, -84.70]			
	Pop_growth	[8.67, 27.96]	[-4.06, -0.86]	[-0.05, 0.009]	[-17.01, -11.51]	[-69.08, 60.77]			
	Econ_size	[-30.03, -4.11]	[4.95, 36.73]	[0.03, 0.56]	[-97.51, -18.21]	[-133.67, -72.91]			
	Econ_growth	[-9.5, 0.9]	[0.003, 1.51]	[0.0001, 0.007]	[-13.76, -0.14]	[-30.83, 12.18]			
Asia	**Core variables**								
	Pop_size	[6.77, 10.95]	[9.8, 16.01]	[0.14, 0.30]	[-19.6, 37.78]	[18.31, 66.68]	[35.43, 183.03]	[-2.63, -1.29]	[-3.02, -3.02]
	Pop_growth	[-7.69, -7.69]	[-2.32, 1.44]	[-0.07, 0.02]	[-0.89, 26.16]	[16.05, 16.05]	[-9.63, 66.78]	[0.15, 0.71]	[-0.85, 5.88]
	Econ_size	[-30.86, -24.54]	[5.08, 9.23]	[-0.25, -0.09]	[34.33, 71.11]	[-171.97, -23.37]	[-104.8, -25.76]	[4.95, 16.07]	[6.86, 21.3]
	Econ_growth	[-3.79, -0.24]	[-0.5, -0.03]	[0.009, 0.009]	[-0.98, -0.68]	[-10.8, 2.96]	[-2.45, 7.6]	[-1.07, 0.08]	[-0.55, 0.04]
	Indicator-specific variables								
	Pop_size	[6.54, 13.72]	[2.99, 8.87]	[0.08, 0.19]	[-9.91, -5.65]	[1.67, 1.67]			
	Pop_growth	[-18.67, -18.67]	[-6.72, 2.74]	[-0.08, 0.08]	[-11.08, 21.68]	[11.66, 73.80]			
	Econ_size	[-41.68, -25]	[7.96, 15.65]	[0.09, 0.09]	[18.62, 48.89]	[-75.78, -18.85]			
	Econ_growth	[-14.42, -0.23]	[-0.67, -0.05]	[-0.005, 0.009]	[-0.7, -0.55]	[-0.52, 2.68]			

Developed regions	**Core variables**								
	Pop_size	[-0.74, 0.99]	[-, -]	[-, -]	[-, -]	[1.88, 3.56]	[1.82, 7.23]	[-0.17, -0.12]	[-0.10, -0.10]
	Pop_growth	[0.15, 0.15]	[-2.93, -0.19]	[-0.003, -0.002]	[0.78, 2.13]	[-0.79, -0.79]	[-0.42, 0.72]	[-0.04, 0.16]	[-0.14, 0.10]
	Econ_size	[-3.37, -1.34]	[-11.85, -11.85]	[0.01, 0.02]	[-19.36, -15.79]	[-19.38, -4.61]	[-14.76, -4.37]	[0.33, 1.00]	[-, -]
	Econ_growth	[-2.26, 0.54]	[0.22, 2.60]	[-, -]	[-1.46, -0.27]	[-0.33, 0.1]	[-0.16, 1.61]	[-0.16, -0.06]	[-0.03, 0.02]
	Indicator-specific variables								
	Pop_size	[-0.68, 0.79]	[0.71, 2.24]	[-, -]	[0.7, 1.04]	[-, -]			
	Pop_growth	[0.20, 0.20]	[-2.13, -0.72]	[0.002, 0.002]	[-3.24, -2.08]	[-0.61, 0.35]			
	Econ_size	[-1.41, -0.63]	[-, -]	[0.01, 0.02]	[-25.17, -12.31]	[-20.80, -3.06]			
	Econ_growth	[-1.22, 0.55]	[-2.42, -0.37]	[-, -]	[-0.38, 3.00]	[-2.91, 0.26]			
Latin America and the Caribbean	**Core variables**								
	Pop_size	[-4.83, -3.55]	[5.15, 8.63]	[0.06, 0.1]	[-22.37, -10.57]	[-9.44, -4.11]	[-6.49, -6.49]	[0.31, 0.73]	[0.97, 2.56]
	Pop_growth	[-11.75, -8.25]	[1.56, 5.63]	[-0.14, -0.006]	[3.91, 3.91]	[45.3, 45.3]	[-42.75, -7.52]	[-2.08, -1.72]	[0.71, 12.53]
	Econ_size	[5.81, 5.81]	[-, -]	[-0.11, -0.04]	[21.95, 78.41]	[-65.12, 85.27]	[-37.97, -10.44]	[1.86, 1.86]	[-3.52, 0.89]
	Econ_growth	[0.49, 1.08]	[1.95, 2.36]	[-0.004, -0.003]	[-10.36, 3.24]	[-33.39, 25.02]	[-10.6, 14.56]	[-1, 0.19]	[-0.56, -0.18]
	Indicator-specific variables								
	Pop_size	[-, -]	[2.99, 9.63]	[0.02, 0.04]	[-2.66, -1.7]	[4.13, 5.16]			
	Pop_growth	[-26.55, -10.71]	[1.34, 8.51]	[-, -]	[-26.3, -21.73]	[-87.15, -46.75]			
	Econ_size	[-3.05, 5.19]	[7.04, 7.04]	[-0.07, -0.04]	[13.65, 66.35]	[-41.94, -12.51]			
	Econ_growth	[1.83, 1.83]	[-3.73, 0.42]	[-0.02, -0.003]	[-7.47, 3.24]	[4.16, 4.16]			

Table 6. Regional impact of population and economic size and growth on the changes in the indicators of poverty (I_1), net enrolment ratio (I_2), gender parity index on the net enrolment ratio (I_3), under-five mortality rate (I_4), maternal mortality rate (I_5), incidence of tuberculosis (I_6), percentage of population with access to improved water source (I_7), percentage of population with access to improved sanitation facilities (I_8). Note: We have only considered the impacts corresponding to 10% statistically significant betas. Source: Author calculations.