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Income and Population Growth

Markus Brückner
Hannes Schwandt

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of Labor

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Markus Brückner
National University of Singapore

Hannes Schwandt
Princeton University
and IZA

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IZA

P.O. Box 7240
53072 Bonn
Germany

Phone: +49-228-3894-0
Fax: +49-228-3894-180
E-mail: iza@iza.org

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ABSTRACT

Income and Population Growth

Do populations grow as countries become richer? In this paper we estimate the effects on population growth of shocks to national income that are plausibly exogenous and unlikely to be driven by technological change. For a panel of over 139 countries spanning the period 1960-2007 we interact changes in international oil prices with countries' average net oil export shares in GDP. Controlling for country and time fixed effects, we find that this measure of oil price induced income growth is positively associated with population growth. The IV estimates indicate that a one percentage point increase in GDP per capita growth over a ten year period increases countries' population growth by around 0.1 percentage points. Further, we find that this population effect results from both a positive effect on fertility and a negative effect on infant and child mortality.

JEL Classification: O1, Q56

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Corresponding author:

Hannes Schwandt
Princeton University
Center for Health and Wellbeing
315 Wallace Hall
Princeton, NJ 08544
USA
E-mail: schwandt@princeton.edu

1. Introduction

During the past half century the world experienced an unprecedented increase in its population size (see Figure 1). In 1960 roughly three billion people inhabited the planet. Some fifty years later, in 2011, it were seven billion -- with almost one billion people being added in the last decade between 2000-2010 (UN, 2011). The increase in population size has also been highly unequal across regions. Southern Asia and Africa, where many of the world's poorest people live today, experienced among the highest population growth rates. These regions, inhabited by less than one-third of the world's population in 1960, contributed together nearly half of the world's four-billion population increase between 1960-2010.[1] While from an ecological point of view the tremendous increase in population size could be considered a success -- only a thriving ecosystem can generate and sustain a large species -- many development practitioners are concerned about environmental, socio-political, and economic challenges associated with the large and rapid population expansions of our time. Thus, a natural question to ask is: what has caused the tremendous expansion in population size?

We explore empirically one particular answer to the above question in this paper, namely, that the population growth was caused by growth in countries' national income. The hypothesis that the population size is a function of income has deep roots in economics and can be traced back at least to Malthus (1798) who postulated that the increase of population is limited by the means of subsistence. As intuitive as that hypothesis may seem, however, estimating causal effects of variations in national income on population size is complicated by the endogeneity of the former. Textbook macroeconomic models predict that changes in countries' population size positively affect output if they lead to increases in the workforce, even though the sign and size of the effect on output per capita is more controversial and depends on the details of the underlying model. Moreover, beyond reverse causality going from population size to national income there is the issue of omitted variables. Take for example technological change. Leading theories of population growth

1 Southern Asia's population size was around 600 million in 1960 and over 1.7 billion in 2010; Africa's population size was just a little less than 300 million in 1960 but exceeded 1 billion in 2010. (UN, 2011)

suggest that a negative correlation between income and population growth (see Figure 2) could be driven by technological change that increases not only incomes but also the opportunity costs of having children. On the other hand, the unconfounded income effect on population size is hypothesized to be positive in this literature.

To zoom in on causal effects of national income on population size we employ an instrumental variables approach. Our IV approach exploits that the effects of variations in the international oil price on national income differ across countries depending on whether countries are net oil importers or exporters. We construct a country-specific oil price shock variable as the change in the log of the international oil price weighted with countries' sample average net export shares of oil in GDP. This oil price variable has been used as an instrument for countries' national income in other contexts (see Brueckner et al., 2012, a, b; and Acemoglu et al., 2013, for an application to US states), but it has not been employed before to study how plausibly exogenous variations in countries' national income affect population size.

For a panel of over 139 countries spanning the period 1960-2007, we first document that the constructed oil price instrument has a positive effect on countries' real GDP per capita growth. Consistent with previous literature (Brueckner et al., 2012 a, b; Hamilton, 2009) our estimated first-stage effects are highly statistically significant and impulse response analysis indicates that the identified oil price shocks have permanent effects on the level of GDP per capita. We then examine the reduced-form effects on countries' population growth. There we find significant positive effects. In contrast to the first-stage effects on GDP per capita growth the reduced-form effects become quantitatively large and statistically significant after several years. Thus, the reduced-form analysis indicates significant lagged effects of oil price shocks on countries' population growth.

In the second stage of our instrumental variables analysis we find that countries' GDP per capita growth, as instrumented by the oil price variable, has significant positive effects on countries' population growth. Quantitatively, the estimated effects are sizeable. Controlling for country and time fixed effects, we find that a one percentage point increase in GDP per capita growth over a ten year period increases countries' population growth rate by around 0.1 percentage points, on average. Consistent with our reduced-form analysis, the effects of GDP per capita growth over a five-year period, while positive and significant, are quantitatively smaller: they are about half the size of the effects of GDP per capita growth when computed over a ten-year period. Our main finding from the instrumental variables analysis is thus that the effects of increases in countries' national income on population size are positive and significant, but they occur with a lag and tend to cumulate over time.

We document the robustness of the above finding to a variety of sensitivity checks, such as using population weights to account for the greater representativeness of aggregates derived from larger populations; excluding from the sample potential outliers (i.e. large positive and negative variations in GDP per capita growth, population growth, and oil price shocks); excluding countries located in the Middle East; excluding countries that are large oil importers; using initial shares of oil net-exports in GDP to compute the oil price instrument; and using 5-year non-overlapping panel data instead of annual data. Consistent with the urban economics literature (e.g. Henderson, 2003; Brueckner, 2012) our estimated second-stage effects of GDP per capita growth on urban population growth are larger than for rural population growth.

It is noteworthy that our IV estimates are larger than benchmark least squares estimates. In particular, if we do not control for country fixed effects least squares estimation yields a negative and significant coefficient on GDP per capita growth (in line with the negative cross-country relationship in Figure 2) while the corresponding IV estimate is positive and significant. If we control for country fixed effects, LS estimation yields a positive and significant coefficient on GDP per capita growth; however, quantitatively the LS coefficient is smaller than the IV coefficient, more precisely, it is roughly less than half the size of the IV coefficient. One possible interpretation of this difference in LS and IV coefficient is that endogeneity bias is particularly severe, and of negative sign, in the cross-section of countries. Once focus is on within-country variation the sign of the endogeneity bias is still negative but quantitatively smaller.[2]

A key assumption in our instrumental variables estimation is that the reduced-form effects of oil price shocks on population size work through countries' national income. In order to examine this exclusion restriction, we build on previous literature (Acemoglu et al., 2008) and use countries' trade-weighted world income as an additional instrument. This allows us to test whether beyond GDP per capita growth the oil price instrument exhibits significant direct effects on countries' population growth. Our main finding is that this is not the case. The conditional effects of the oil price variable on countries' population growth are quantitatively small and statistically insignificant. Moreover, overidentification tests fail to reject the hypothesis that the instruments are uncorrelated with the second-stage residual.

In order to gain an understanding of what is driving the positive effect of GDP per capita growth on population growth, we explore the effects of GDP per capita growth on fertility rates, mortality rates and measures of countries' demographic composition. Using the oil price variable as an instrument, we find that GDP per capita growth has a significant positive effect on within-country changes in fertility rates and a significant negative within-country effect on changes in infant as well as child mortality rates. In terms of the effects on demographic composition, higher GDP per capita growth has a significant positive effect on within-country changes in the share of population aged 0-14 and child dependency ratios, but a significant negative effect on within-country changes in the share of population aged 15-64 (i.e. the working age population). We do not find significant effects on the share of the population aged 64 and above or on the old age dependency ratio. These results suggest that the positive effects of national income on population size are likely to arise primarily from a positive effect on net fertility (i.e. the number of children

2 An alternative interpretation would be that the signal-to-noise ratio is lower when using within-country variation. If that is indeed the case then, in the presence of classical measurement error, the attenuation bias is larger when controlling for country fixed effects. Hence, even in the absence of endogeneity bias, a smaller LS coefficient could arise from classical measurement error. This type of measurement error would attenuate the LS estimate towards zero but not the IV estimate.

surviving the first years of life) rather than a decline in old-age mortality.

The remainder of our paper is organized as follows. In Section 2 we discuss related literature. This is followed by a discussion of our estimation strategy as well as description of the data. Section 4 presents and discusses the main empirical results. Section 5 concludes.

2. Related Literature

To the best of our knowledge this paper presents the first empirical attempt to provide within-country estimates of the causal effects that growth in countries' national income have on population growth. This provides an important contribution to the voluminous literature on income and population size which dates back at least to the 18th century. By that time, as most famously described by Malthus (1798), income gains directly translated into population growth keeping income per capita constant and increasing only population density.[3] During the Industrial Revolution, however, population dynamics changed from the Malthusian model to the Modern Growth Regime which is characterized by economic growth coupled with declining fertility (Galor and Weil 2000). Over the past century, income per capita and population growth have been negatively correlated (see Weil, 2012; and Figure 2). Since children are considered a normal good in most modern discussions of fertility (Lee, 1997; Black et al., 2013) and life expectancy is higher in richer countries (Cutler et al., 2006) this is a puzzling relationship. Leading theories explaining this relationship suggest that technical progress underlying income growth since the Industrial Revolution increased the direct and opportunity costs of fertility.[4] These costs outweigh the positive income effects of economic growth, such that richer countries end up with lower fertility rates. In other words, technological progress can be interpreted as a confounder of the income-fertility

3 Already Adam Smith (1776) observed "*The most decisive mark of the prosperity of any country is the increase in the number of its inhabitants.*" (as mentioned in Galor and Weil, 2000)

4 Becker et al. (1990) hypothesize that technological progress increases the returns to investments into children and therefore induces parents to substitute quality for quantity. Galor and Weil (1996) argue that institutional and technological progress increased the returns to female labor input and thereby the opportunity costs of fertility. Caldwell (1976) points out that lower net flows from children to parents in more developed countries may also increase the direct costs of having children.

relationship that affects incomes and fertility in different directions. In turn, income increases that are not generated by technological progress should be associated with higher not with lower fertility. We directly test this hypothesis at the macroeconomic level, thus taking into account general equilibrium effects. Our instrument, the interaction of a country's average net-export share of oil in GDP with changes in world oil prices, identifies windfall GDP gains that are unlikely to be affected by country-specific technological changes.

Our paper further contributes to the literature on the effects of income on fertility and health. Lee (1997) reviews evidence on the wage-fertility relationship in pre-industrial economies, arguing that in these economies wage changes are less likely to be confounded with institutional and technological progress than in developed countries. He reports positive income elasticities of fertility for most countries. Black et al. (2013) analyze a homogenous sample of US women in the mid-1970s, finding that fertility is positively correlated to husbands' income. These findings are consistent with children being "normal goods". Our evidence of positive effects of national income growth on fertility support this notion.

The effects of health on economic growth are subject to a broad literature (see for example Weil, 2007, and Acemoglu and Johnson, 2007, for two central contributions, and Deaton, 2007, for an insightful review) but fewer papers have investigated effects running the opposite direction, from income to health. Pritchett and Summers (1996) use countries' terms of trade, investment ratios, black market premia and price level distortions as instruments for per capita GDP and estimate income elasticities of infant and child mortality between -0.2 and -0.4. While Pritchett and Summers' (1996) instruments are rather weak and exclusion restrictions could have been violated (see Deaton, 2007) their estimates are close to the elasticities that we find.

Cotet and Tsui (2009) investigate whether oil discoveries affect countries' population size and health outcomes. They compare changes in these outcomes in countries with and without major oil discoveries around the 1960s. Interestingly, they find that countries with oil discoveries experienced stronger population growth and lower child mortality. The effects on GDP growth are not significantly different from zero in the decade following oil discoveries but positive in the long run, contradicting the resource curse hypothesis.

Cotet and Tsui's empirical strategy differs from ours in a number of important aspects. First, as Cotet and Tsui (2009) note, unobservable factors that might affect both a country's oil discoveries and subsequent growth make a causal interpretation of their findings difficult. Haber and Menaldo (2011) and Haber et al. (2003) make a similar argument, pointing out that oil discoveries are correlated with predetermined country characteristics. Cotet and Tsui also present first-difference specifications in which they regress income, population and health changes on changes in per capita oil rents. However, while changes in oil rents due to changes in world oil prices are plausibly exogenous, changes in a country's oil production costs and volumes might be driven by time-varying country-specific factors that also affect income and population growth. The strategy in our paper is to exploit time-series variation in global oil prices interacted with countries' average GDP shares of net oil exports. Since the latter is time-invariant by construction, our instrument is not confounded by potentially endogenous time-series variations in countries' oil production.

A second key advantage of our instrumental variables approach is that it does not confound effects of GDP per capita growth on population growth with technological progress. Country-specific technological progress could imply both increases in oil production (discoveries) and population growth. Because the time-series variations in our instrument is exclusively driven by the time-series variation in the international oil price our IV estimation approach is immune to the confounding effects of technological progress.

Two recent papers by Maccini and Yang (2009) and Miller and Urdinola (2010) carefully identify transitory macro-economic shocks and analyze their effects on infant mortality and child health. Maccini and Yang (2009) show in Indonesian data that less rainfall at the year and location of birth leads to worse health outcomes and lower socio-economic status for women but not for men. They interpret these findings as evidence that negative income shocks around birth adversely affect those household members that are particularly vulnerable. Miller and Urdinola (2010), on the other hand, find that world coffee prices at the year of birth correlate positively with subsequent infant mortality among coffee farmers in Columbia. This negative income effect on child health is explained by a positive effect of coffee prices on the opportunity costs of child care. Lower coffee prices are associated with fewer hours worked, in particular for women (the primary caregivers of children), which decreases the costs of time investments in child health. The contrary effects found in these two papers, both well-identified and credible, point out that different sources of income shocks may translate differently into child health, depending on whether the substitution or the income effect dominates.

3. Estimation Strategy

The benchmark econometric model relates the change in the log of countries' population size to the change in the log of GDP per capita:

$$\Delta \ln(Pop_{it}) = a_i + b_t + \theta \Delta \ln(GDPp.c._{it}) + e_{it} \tag{1}$$

where a_i are country fixed effects and b_t are year fixed effects.

There are several important issues in the estimation of θ in equation (1). One is endogeneity bias. Endogeneity bias could arise due to within-country changes in population size having an effect on (contemporaneous) GDP per capita growth. A priori it is not clear what the direction of this bias is. With decreasing returns to scale in labor, as is the case in neoclassical models, the bias is negative; however, if there are increasing returns to scale in labor, say, due to a large population generating more ideas (see e.g. Jones, 2005), then the reverse causality bias could be positive. Endogeneity bias could also arise due to omitted variables that are varying at the within-country level. These would have to be variables that (i) affect GDP per capita growth *and* (ii) affect population growth beyond GDP per capita growth (i.e. are part of the error term, e). An example are growth spurring technological innovations that increase the opportunity costs of fertility, say, through higher returns to female labor supply or child quality (Becker et al. 1990, Galor and Weil, 1996). This would imply a negative correlation of (innovation-induced) GDP per capita growth and population growth. Likewise, medical or work place safety innovations might lead to higher productivity while lowering mortality and thereby increasing population size. For example, the introduction of new laser technologies and other computerized equipment that reduces the margin of error in surgeries; or think of the introduction of new drugs or disease prevention measures that either prevent or treat diseases which in turn enable an increase in work effort and may also lead to longer life expectancy. Such technological innovations which increase productivity are likely to have very large direct effects on population size, in particular, through life expectancy.

Another important issue is that θ is likely to differ depending on the source of the growth in national income. One natural distinction here is between transitory and permanent income shocks. Intertemporally optimal fertility decisions and public good provision should respond more strongly to permanent shocks than to temporary shocks. Hence, it is likely that θ is larger for variations in GDP per capita that are of permanent nature.

In order to address the above issues we use an instrumental variables approach. Our instrumental variable is the change in the international oil price multiplied with countries' sample average GDP shares of net oil exports. This instrument captures variations in countries' national income that arise due to plausibly exogenous variations in its terms of trade. Year-to-year variations in the international oil price are highly persistent see e.g. Hamilton (2009) or Brueckner et al. (2012). Hence our instrumental estimates should be interpreted as capturing the effects of permanent variations in countries' national income.

We estimate the effects of growth in national income on population size based on annual data. This allows us to examine both short-run and longer-run effects of income on population size. In equation (1) θ captures the short-run (i.e. contemporaneous) effect of income growth on population growth. It is possible, however, that the effects of oil price induced income growth on population growth build up over time. To examine dynamic effects we will present estimates from a reduced-form model that includes the year t oil price variable as well as lags of this variable up to ten years. That is, we estimate:

$$(2) \qquad \Delta\ln(Pop_{it})=\alpha_i+\beta_t+\Sigma\gamma_r OilShock_{it-r}+\varepsilon_{it}$$

The coefficients γ_r capture the dynamic effects of variations in the oil price variable on countries' population growth.

The data on population growth, fertility and mortality are drawn from the World Development Indicators (WDI, 2011). Real PPP GDP per capita data are taken from the Penn World Table (Heston et al., 2012). The oil price instrument is constructed using oil import and export data from the NBER-UN Comtrade (Feenstra et al., 2004) merged with oil price data from the UNCTAD Commodity Price Statistics (Unctad, 2011). Trade-weighted world income, as an additional income instrument, is taken from Acemoglu et al. (2008). For a description of the variables used in the estimation please see Data Appendix Table 1. Data Appendix Table 2 provides a list of the countries in the sample and Data Appendix Table 3 shows descriptive statistics.

4. Results

4.1 Effects of Income Growth on Population Growth

We begin our analysis by estimating the reduced-form effects that the oil price instrument has on population growth based on equation (2). The control variables are country and year fixed effects; standard errors are Huber robust and clustered at the country level. Figure 3 plots the coefficients with their 95 percent confidence bands. The main finding is that the coefficients on all lags from t-0 to t-10 are positive; however, statistically significant are only the lags from t-5 to t-10. This suggests that the oil price variable's effect on population growth arises with a lag, i.e. it takes time for the effects on population growth to materialize. Summing up the coefficients on lags t-0 to t-10 yields a cumulative effect of 0.72 with a standard error of 0.38. This cumulative effect is significant at the 10 percent significance level (p-value 0.06).

We repeat the exercise for GDP per capita growth. The coefficients and their 95 percent confidence bands are plotted in Figure 4. The main finding is that only the year t to t-2 coefficients are positive and significant. The other coefficients on further lags are insignificant and quantitatively small. Summing up the coefficients on lag t-0 to t-10 yields a cumulative effect of 2.43 with a standard error of 0.76. This effect is significant at the 1 percent significance level (p-value 0.002). Since the dependent variable is GDP per capita growth and the oil variable is defined as the change in the log of the international oil price weighted with countries' average (and thus time-invariant) net export shares of oil in GDP, the estimates suggest that variations in the oil price have permanent effects on the level of GDP per capita, which is consistent with previous research, see e.g. Hamilton (2009) and Brueckner et al. (2012).

We now turn to our baseline two-stage least squares estimates. The findings from the reduced-form analysis indicated that oil price driven income shocks have positive effects on population growth that accumulate over time. Hence, we use in our baseline two-stage least squares estimation the change in the log of GDP per capita over ten years, i.e. between t-0 and t-10. The oil price instrument is then constructed as the change in the log of the international oil price between t-0 and t-10 multiplied with countries' average net export shares of oil in GDP.

We report our baseline two-stage least squares estimates in Panel A of Table 1. In Panel B of Table 1 we report for comparison the corresponding least squares estimates. In column (1) we report pooled panel estimates without controlling for country or year fixed effects. In this case the coefficient on GDP per capita growth is 0.35 and has a standard error of 0.15. In column (2) we add year fixed effects. The year fixed effects are jointly significant at the 1 percent significance level. Adding the year fixed effects to the right-hand side of the regression implies that our estimates are identified by deviations from global (non-linear) trends. In other words, global economic conditions that have common effects on countries' economic growth and population growth are partialled out from the residual. In column (3) we substitute the year fixed effects for country fixed effects, and in column (4) we include both country and year fixed effects in the regression model. Including country fixed effects as right-hand-side control variables implies that our estimates are identified by deviations of economic growth and population growth from countries' 1960-2007 mean. Interestingly, the control for country fixed effects leads to a smaller coefficient on GDP per capita growth: the coefficient on GDP per capita growth is now around 0.1. The estimated effect is still significant at the 10 percent level however (the p-value is 0.05 in column (3) and 0.07 in column (4)). One possible interpretation of the smaller coefficient on GDP per capita growth in the regressions that control for country fixed effects is that the long-run effects of GDP per capita growth on population growth are larger than the medium-run effects. Quantitatively, the coefficient of 0.1 suggests that a one percent increase in GDP per capita over a ten year period increases the population size by around 0.1 percent.

A comparison of the least squares estimates, reported in Panel B of Table 1, with the instrumental variables estimates shows that the former are significantly smaller. This is especially so in the regressions that do not control for country fixed effects (columns (1) and (2)). In these regressions the least squares coefficients on GDP per capita growth are negative, and once year fixed effects are controlled for, the negative coefficient is significantly different from zero at the 1 percent level. On the other hand, in columns (3) and (4) that control for country fixed effects the least squares coefficient on GDP per capita growth is positive and significantly different from zero at the conventional significance levels. However, quantitatively it is less than half the size of the IV coefficient. One interpretation of this difference between IV and LS coefficient is that in the cross-section of countries the (negative) endogeneity bias on the least squares estimate is particularly severe.

The data on urban and rural population growth also enable us to explore whether the effects of oil price driven income growth are particularly large in urban or rural areas. A common view in the urban economics literature (see e.g. Henderson, 2003) is that economic growth is associated with structural transformation out of agriculture. This leads to a shift of the population from rural areas to cities. The instrumental variables estimates in column (5), where the dependent variable is urban population growth, yield a larger coefficient on GDP per capita growth than in column (6), where the dependent variable is rural population growth. In particular, the coefficient that captures the effects of oil price driven income growth on urban population growth is 0.16 while the effect on rural population growth is only 0.07.

The regressions reported in Table 1 weight each country-year observation equally which is common practice in macroeconomic cross-country regressions. In Table 2 we repeat the baseline regressions weighting observations by the countries' average population size. Population sizes in our sample vary by up to four orders of magnitude across countries. In the context of population growth the relevant mechanisms, such as fertility decisions and infant health operate at the level of the individual household. Observations representative for very large countries like India with one billion inhabitants are likely to tell us more about the income effects on the world's average household than observations from very small countries like Belize which has a population of less than 0.0002 billion. This is particularly relevant as we are interested in the determinants of world population growth rather than the (unweighted) average population growth across countries. We therefore report estimates that use population weights in all tables that follow.

The main result from Table 2 is that the estimated effects in the population-weighted 2SLS regressions in the total and the urban samples are about half the size of the unweighted estimates while standard errors are decreased by two-thirds. The second-stage coefficient in column (1) of Table 2 is 0.06. The coefficient is significant at the one percent significance level and suggests that a 1 percent increase in GDP per capita over a ten year period increases population growth by 0.06 percent. The difference between the urban and the rural estimates in columns (2) and (3) is still positive though smaller compared to the unweighted regressions in Table 1.

In Table 3 we examine whether our instrumental variables estimates are driven exclusively by the countries in the Middle East. Over the 1960-2007 period countries in the Middle East have experienced tremendous population growth, in excess of 3 percent per annum on average. And many of these economies are highly dependent on oil exports. In column (1) of Table 3 we report IV estimates for the countries in the Middle East. In column (2) we report the corresponding least squares estimates. The main finding is that the coefficient on GDP per capita growth in the sample of Middle Eastern countries is positive and significant. In the sample that excludes the Middle Eastern countries the IV coefficient on GDP per capita is smaller but also positive and significant. However, the least squares coefficient is insignificant for the sample that excludes the Middle Eastern countries; see columns (3) and (4).

Our finding of a significant positive effect of GDP per capita growth is also robust to the exclusion of large positive and negative variations in GDP per capita growth, population growth, and oil price shocks. In column (1) of Table 4 we present IV estimates for a sample that excludes the top and bottom 1st percentile of population growth observations. In column (2) we present IV estimates that exclude the top and bottom 1st percentile of GDP per capita growth, and in column (3) we exclude the top and bottom 1st percentile of the oil price instrument. The second-stage coefficient on GDP per capita growth continues to be positive and significant. Quantitatively, it is around 0.05. Again the least squares estimates are quantitatively small and statistically insignificant. Hence it are not just large positive and negative observations that are driving the insignificant and quantitatively small LS estimates.

In Table 5 we present estimates that use GDP per capita growth over the past five years. In this case, the IV coefficient on GDP per capita growth is also positive and significant, see columns (1)-(4). However, quantitatively the estimated effect of GDP per capita growth over the past five years is smaller than the estimated effect of GDP per capita growth over the past ten years. This is consistent with our reduced-form analysis that showed that the effects of oil price shocks on population growth are particularly large after five to ten years. Again we find that the least squares estimates are insignificant. This, in turn, suggests that endogeneity bias is also substantial when examining shorter-run effects of GDP per capita growth on population growth.

4.2. Discussion of Instrument Quality

In this section we discuss the quality of our instrumental variables estimates. In terms of the instrument's relevance, the Kleibergen-Paap F-statistic is always in excess of 10. Hence, according to Staiger and Stock (1997) we can reject the null of weak instrument bias. Economically, the first-stage coefficient on the oil price variable is also sensible. The positive coefficient implies that increases in the international oil price lead to increases in the national income of countries that are net exporters of oil (the terms of trade effect).

One of the identifying assumptions in our instrumental variables estimation is that variations in the international oil price are exogenous to countries' population growth. This assumption seems plausible for the majority of countries as most countries are price takers, i.e. they import only a small fraction of world oil imports. Thus demand effects arising in these countries from population growth should have negligible effects on the international oil price. In order to underscore that our assumption of price-takership is reasonable for the sample at hand, we present in Table 6 estimates that exclude the handful of countries which during the sample period imported on average more than 3 percent of world oil imports.[5] The main finding is that the instrumental variables estimates of the effects that income growth has on population growth continue to be positive and significant in the sample that excludes potentially large oil importing countries where population growth might have effects on the international oil price.

In Table 7 we show that our instrumental variables estimates are also robust to using initial

5 The excluded countries are China, France, Germany, Italy, Japan, Netherlands, South Korea, United States and the United Kingdom.

shares of net oil exports in GDP. So far we used countries' period average shares of net oil exports in GDP to construct the oil price instrument. Period average net export shares have the advantage to capture more appropriately over the sample period countries' net exports of oil. However, one might be concerned that the period average net export shares of oil are endogenous. A priori, this bias should be small however since any feedback effects are discounted by a factor of 1/T. Indeed the IV estimates in Table 7 that use the 1970 net oil export GDP shares to construct the oil price instrument are very similar to our baseline estimates which use the period average net export shares.[6]

The exclusion restriction is that variations in the international oil price weighted with countries' GDP shares of oil net exports only affect countries' population growth through growth in national income. This exclusion restriction would be violated, for example, if increases in the international oil price lead to greater exploration of oil and this exploration of oil is associated with mass pollution that has adverse effects on peoples' health, and in particular infant health (Currie and Neidell, 2005; Currie et al. 2009; Currie and Walker, 2011). Likewise, for oil importing countries increases in the international oil price might be associated with more fuel efficient use and thus less pollution. Although it is unclear how large these pollution related effects on population growth are, they imply that the direction of the bias is such that our instrumental variables estimates constitute a lower bound of the true causal effect that income growth has on population growth.

We have also explored empirically whether the oil price instrument has significant effects on population growth beyond its effect on national income growth. In previous research Acemoglu et al. (2008) introduced countries' trade weighted world income as an instrument for national income. Building on this work, and using five-year non-overlapping panels as in Acemoglu et al. (2008), we present in Table 8 instrumental variables estimates that use countries' trade weighted world income as an additional instrument.

6 The estimates in Table 7 use the 1970 net export GDP shares and focus on the post-1970 period since data for the pre-1970 period for oil exports and imports is very sparse.

We first show in column (1) of Table 8 that conditional on GDP per capita growth the oil price instrument has an insignificant effect on population growth. Importantly, in this regression that uses the change in the log of trade weighted world income as an excluded instrument for GDP per capita growth the second-stage coefficient continues to be positive and significant at the conventional significance levels. On the other hand, unconditional on GDP per capita growth, the oil price instrument has a significant positive reduced-form effect on population growth, as it should have given its significant positive first-stage effect on GDP per capita growth. In columns (3) and (4) we repeat the exercise using lagged GDP per capita growth (i.e. between year t-6 and t-10) and find similar results.

4.3 Effects on Fertility, Mortality and Demographic Composition

Our instrumental variables analysis indicates a robust positive effect of income growth on population growth. This finding is in contrast with the negative income-population relationship that is observed in the cross-section of countries (Figure 2). The negative relationship has been explained with technological progress acting as a confounding factor which increases both income as well as the opportunity costs of fertility. The negative effects on fertility outweigh the positive income effects on survival and on fertility summing up to a decline in population growth. This implies that in the absence of such confounding factor the observed effect of income on both survival and fertility should be positive. As argued above, our oil price instrument is unlikely to be confounded by technological changes. Therefore it is of interest to examine the effects of instrumented income growth on changes in fertility and mortality rates.

Column (1) of Panel A in Table 9 presents instrumental variables estimates of the effects that oil price driven income growth has on within-country variations in fertility rates. The second-stage coefficient is 1.2 and has a standard error of 0.5. Hence, we can reject the null hypothesis that oil price driven income growth has no significant effect on countries' fertility rates at the 5 percent significance level. Quantitatively, the coefficient of 1.2 implies that on average a ten percent increase in countries national income over a ten year period increases the fertility rate by over 0.1 units. Thus, very roughly, a doubling of national income leads to one additional child born per woman. It is interesting to note that the corresponding least squares estimate that we present in column (1) of Panel B in Table 9 is of similar size as the IV estimate. These results are in line with the empirical finding that children are "normal goods" (Lee, 1997; Black et al., 2013).

Our instrumental variables estimates also show that increases in national income are associated with lower infant mortality rates. The second-stage coefficient on income in column (2) of Panel A in Table 9 is -14.3 and has a standard error of 4.3. Since infant mortality rates are calculated as the number of infants dying before reaching one year of age, per 1000 live births in a given year, the coefficient of -14.3 should be interpreted as a twenty percent increase in national income leading to a reduction in infant mortality of nearly three infants per 1000 live births. Column (3) presents estimates for the mortality rate under 5-years (calculated as the probability per 1000 that a newborn baby will die before reaching age five). The second-stage coefficient on income is in that case -27.1 and its standard error is 8.2. It is thus significantly different from zero at the 1 percent level. And quantitatively the estimated effect of income growth is larger for 5-year mortality than for infant mortality.

Next we examine the effects that oil price driven income growth has on countries' demographic composition. Consistent with our findings of income's effect on fertility and infant mortality, column (1) of Table 10 shows that income growth leads to significant increases in the share of the population aged 0-14. On the other hand, column (2) shows that there is a significant negative effect on the working age population share (population aged 15-64). Resonating these findings, column (4) shows that income growth leads to a significant increase in the child dependency ratio. Quantitatively, the coefficient of 0.16 suggests that a doubling of national income increases the child dependency ratio by about 0.16 units. In columns (3) and (5) we explore the effects that income growth has on the share of the population aged above 64 and the old age dependency ratio. The estimated effects are quantitatively small and insignificant. Column (6) shows that there is also no significant second-stage effect on the population ratio of males to females.

5. Conclusion

The question whether and to what extent countries' income growth affects population growth has been in the focus of economic research since the beginnings of the discipline. However, due to the endogeneity of national income this question is difficult to answer empirically. Cross-country scatter plots between GDP per capita growth and population growth show a negative correlation (see Figure 2). The leading explanation of stagnant economic growth before the Industrial Revolution was that increases in income lead to increases in population size (Malthus, 1798). One reason for why this positive effect of income on population growth is not observed in correlational studies is that population growth could have a negative effect on GDP per capita growth. Another reason is that, in a Modern Growth Regime, there could be confounding factors that affect population growth beyond national income growth, for example, technological progress that raises national income as well as the opportunity cost of fertility (Galor and Weil, 2000).

This paper's objective was to estimate the response of population growth to countries' income growth that is exogenous and unrelated to technological progress. To this end, we used for a panel of 139 countries spanning nearly half a century the change in the log of the international oil price interacted with countries' average net-export shares of oil in GDP as an instrument for GDP per capita growth. Another innovation of our empirical analysis is that we controlled for country and year fixed effects. The control for country fixed effects allowed us to account for time-invariant factors related to countries' geography, history and export structure that could affect both GDP per capita growth and population growth. The control for time fixed effects allowed us to account for world business-cycle effects.

The findings from our instrumental variables regressions suggest that countries' income growth has a significant positive effect on population growth: a one percentage point increase in GDP per capita growth over a ten-year period increases a country's population growth by around 0.1 percentage points. We documented that this result is robust to excluding countries located in the Middle East; excluding countries that are large oil importers; and excluding from the sample large positive and negative observations of GDP per capita growth, population growth, and oil price shocks. We also documented robustness to using initial shares of oil net-exports in GDP to compute the oil price instrument or using 5-year non-overlapping panel data. In terms of mechanism, the instrumental variables analysis showed that income increases that are independent of the technological development in a country increase a country's fertility rate. At the same time, there is a significant negative effect on infant mortality. This results in a strongly positive effect on surviving children which can also be detected in changes of countries' demographic composition.

An avenue for future research would be to explore the effects on countries' population growth of other sources of national income growth. For example, permanent changes in countries' national income that arise from changes in total factor productivity. One challenge that such research would need to address is that technology adoption in poor countries where production is not operating at the world's technology frontier is an endogenous process. Another challenge to the identification of causal effects is that the development of new technologies may itself be a function of population size (Jones, 2005).

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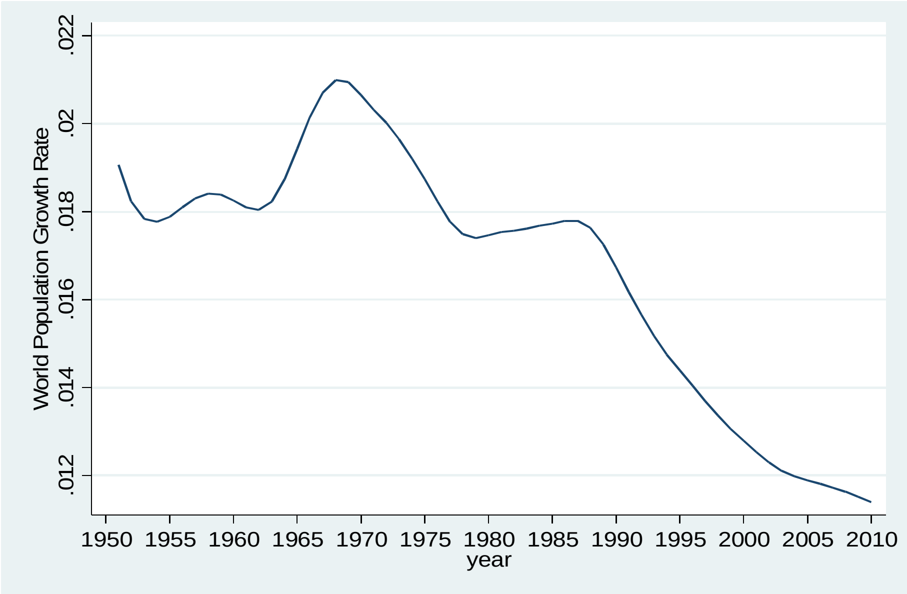
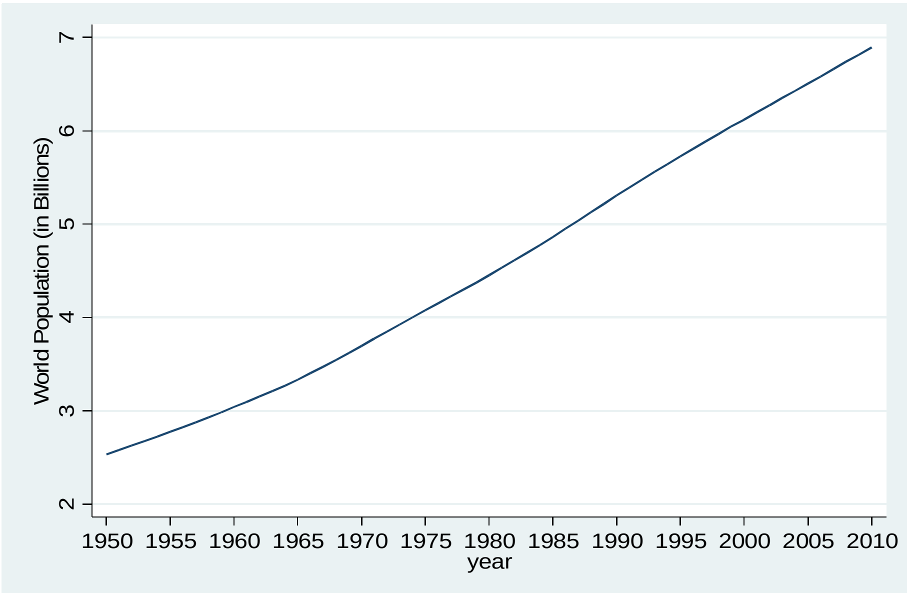
Figure 1. World Population Size and Population Growth

Panel A: Population Growth

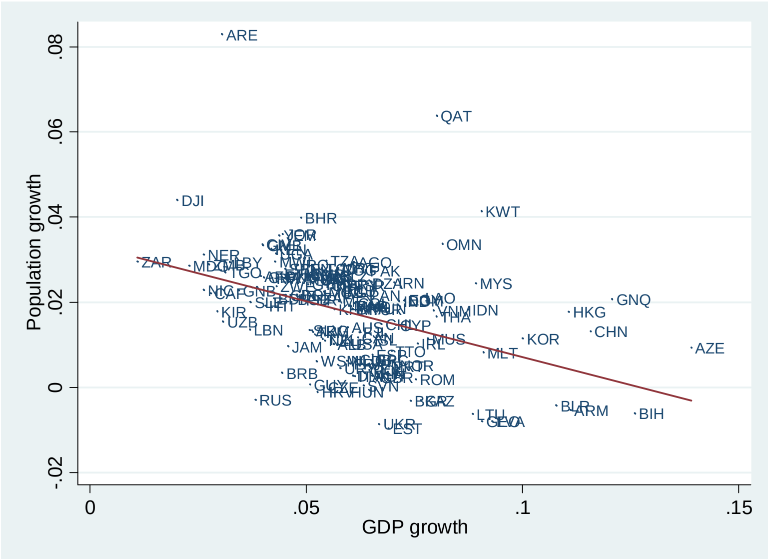


Panel B: Population Size



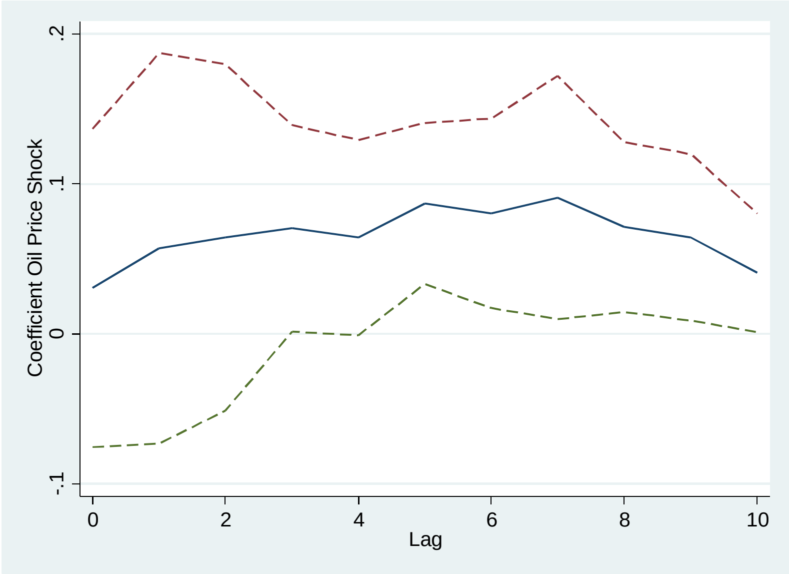
Note: Panel A of Figure 1 plots annual world population growth rates. Panel B of Figure 1 plots the level of the world population The data source is UN(2010).

Figure 2. GDP per capita Growth and Population Growth in the Cross-Section



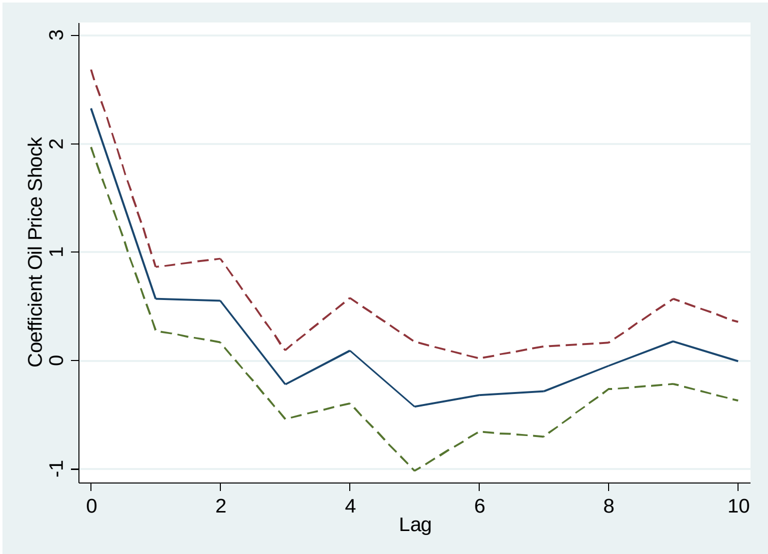
Note: Average annual population growth is plotted against average annual GDP per capita growth for 139 countries between 1950 and 2010.

Figure 3. Dynamic Effects of Oil Price Shocks on Population Growth



Note: Dashed lines are 95 percent confidence bands. The figure is generated from a panel regression with country and year fixed effects; Huber robust standard errors are clustered at the country level. The dependent variable in the panel regression is population growth.

Figure 4. Dynamic Effects of Oil Price Shocks on GDP p.c. Growth



Note: Dashed lines are 95 percent confidence bands. The figure is generated from a panel regression with country and year fixed effects; Huber robust standard errors are clustered at the country level. The dependent variable in the panel regression is GDP per capita growth.

Table 1: Effects of Income Growth on Population Growth
(Baseline Estimates)

	Population Growth					
	(1)	(2)	(3)	(4)	(5) Urban	(6) Rural
			Panel A: 2SLS			
GDP p.c. Growth	0.35**	0.45**	0.11*	0.14*	0.16*	0.07
[10-year Average]	(0.15)	(0.19)	(0.06)	(0.07)	(0.09)	(0.11)
Kleibergen Paap F-stat	25.73	26.91	56.18	53.63	53.63	53.63
			First-Stage			
Oil Price Shock	0.25***	0.20***	0.38***	0.28***	0.28***	0.28***
[10-year Average]	(0.05)	(0.04)	(0.05)	(0.04)	(0.04)	(0.04)
			Panel B: LS			
GDP p.c. Growth	-0.02	-0.06***	0.06***	0.04***	0.02	0.03*
[10-year Average]	(0.01)	(0.02)	(0.01)	(0.01)	(0.03)	(0.02)
Time FE	No	Yes	No	Yes	Yes	Yes
Country FE	No	No	Yes	Yes	Yes	Yes
Observations	4428	4428	4428	4428	4428	4428

Note: The method of estimation in Panel A is two-stage least squares; Panel B least squares. The dependent variable in columns (1)-(4) is total population growth; in column (5) urban population growth; column (6) rural population growth. The instrumental variable in Panel is the change in the international oil price between year t and t-10 multiplied with countries' average GDP share of net oil exports. Huber robust standard errors (shown in parentheses) are clustered at the country level. *Significantly different from zero at 10 significance, ** 5 percent significance, *** 1 percent significance.

Table 2: Effects of Income Growth on Population Growth
(Population-Weighted Estimates)

	Population Growth					
	(1)	(2)	(3)	(4)	(5)	(6)
	2SLS	2SLS	2SLS	LS	LS	LS
	Total	Urban	Rural	Total	Urban	Rural
GDP p.c. Growth [10-year Average]	0.06*** (0.02)	0.08** (0.04)	0.07** (0.03)	-0.01 (0.02)	0.10 (0.07)	-0.05 (0.05)
Kleibergen Paap F-stat	17.98	17.52	19.21	.	.	.
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4428	4428	4428	4428	4428	4428

Note: The method of estimation in columns (1)-(3) is population-weighted two-stage least squares; columns (4)-(6) population-weighted least squares. The instrumental variable in columns (1)-(3) is the change in the international oil price between year t and t-10 multiplied with countries' average GDP share of net oil exports. The dependent variable in columns (1) and (4) is total population growth; columns (2) and (5) urban population growth; columns (3) and (6) rural population growth. Huber robust standard errors (shown in parentheses) are clustered at the country level. *Significantly different from zero at 10 significance, ** 5 percent significance, *** 1 percent significance.

Table 3: Effects of Income Growth on Population Growth
(Are the Middle Eastern Countries Different?)

	Population Growth			
	(1)	(2)	(3)	(4)
	2SLS	LS	2SLS	LS
	Middle East	Middle East	Excl. Middle East	Excl. Middle East
GDP p.c. Growth	0.09*	0.02**	0.04*	-0.00
[10-year Average]	(0.05)	(0.01)	(0.02)	(0.02)
Kleibergen Paap F-stat	16.75	.	23.02	.
Time FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	385	385	4043	4043

Note: The method of estimation in columns (1) and (3) is population-weighted two-stage least squares; columns (2) and (4) weighted least squares. The instrumental variable in columns (1) and (3) is the change in the international oil price between year t and t-10 multiplied with countries' average GDP share of net oil exports. The dependent variable is total population growth. Columns (1) and (2) report estimates for the sample of Middle Eastern countries. These are: Bahrain, Cyprus, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, Turkey, United Arab Emirates, Yemen. Columns (3) and (4) report estimates for the sample that excludes countries from the Middle East. *Significantly different from zero at 10 significance, ** 5 percent significance, *** 1 percent significance.

Table 4: Effects of Income Growth on Population Growth
(Excluding Outliers)

	Population Growth					
	(1)	(2)	(3)	(4)	(5)	(6)
	2SLS	2SLS	2SLS	LS	LS	LS
	Excluding Top and Bottom 1st Percentiles of:					
	Pop Growth	GDP Growth	Oil Shock	Pop Growth	GDP Growth	Oil Shock
GDP p.c. Growth	0.05**	0.06**	0.06***	-0.00	-0.00	-0.00
[10-year Average]	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)
Kleibergen Paap F-stat	17.27	27.66	30.16	.	.	.
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4337	4337	4337	4337	4337	4337

Note: The method of estimation in columns (1)-(3) is population-weighted two-stage least squares; columns (4)-(6) population-weighted least squares. The instrumental variable in columns (1)-(3) is the change in the international oil price between year t and t-10 multiplied with countries' average GDP share of net oil exports. The dependent variable is total population growth. Huber robust standard errors (shown in parentheses) are clustered at the country level. Columns (1) and (4) exclude observations in the top and bottom 1st percentile of population growth. Columns (2) and (5) exclude observations in the top and bottom 1st percentile of GDP per capita growth. Columns (3) and (6) exclude observations in the top and bottom 1st percentile of the oil price shock. *Significantly different from zero at 10 significance, ** 5 percent significance, *** 1 percent significance.

Table 5: Effects of Income Growth on Population Growth
(5-Year GDP p.c. Growth)

	Population Growth							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	2SLS	2SLS	2SLS	2SLS	LS	LS	LS	LS
	Excluding Top and Bottom 1st Percentiles of:							
	None	Pop Growth	GDP Growth	Oil Shock	None	Pop Growth	GDP Growth	Oil Shock
GDP p.c. Growth [5-year Average]	0.03*** (0.01)	0.02* (0.01)	0.04** (0.02)	0.04* (0.02)	-0.01 (0.02)	-0.01 (0.02)	-0.01 (0.02)	-0.01 (0.02)
Kleibergen Paap F-stat	43.82	42.78	32.24	12.90	.	.	.	.
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5119	5009	5009	5009	5119	5009	5009	5009

Note: The method of estimation in columns (1)-(3) is population-weighted two-stage least squares; columns (4)-(6) population-weighted least squares. The instrumental variable in columns (1)-(3) is the change in the international oil price between year t and t-5 multiplied with countries' average GDP share of net oil exports. The dependent variable is total population growth. Huber robust standard errors (shown in parentheses) are clustered at the country level. Columns (2) and (5) exclude observations in the top and bottom 1st percentile of population growth. Columns (3) and (6) exclude observations in the top and bottom 1st percentile of GDP per capita growth. Columns (4) and (8) exclude observations in the top and bottom 1st percentile of the oil price shock. *Significantly different from zero at 10 significance, ** 5 percent significance, *** 1 percent significance.

Table 6: Effects of Income Growth on Population Growth
(Excluding Large Oil Importing Countries)

	Population Growth			
	(1)	(2)	(3)	(4)
	2SLS	LS	2SLS	LS
GDP p.c. Growth [10-year Average]	0.049** (0.022)	0.029*** (0.008)		
GDP p.c. Growth [5-year Average]			0.035*** (0.011)	0.019*** (0.006)
Kleibergen Paap F-stat	12.17	.	32.55	.
Time FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	4124	4124	4475	4475

Note: The method of estimation in columns (1) and (3) is population-weighted two-stage least squares; columns (2) and (4) population-weighted least squares. The instrumental variable in column (1) is the change in the international oil price between year t and t-10 multiplied with countries' average GDP share of net oil exports; column (3) the change in the international oil price between year t and t-5 multiplied with countries' average GDP share of net oil exports. The dependent variable is total population growth. Huber robust standard errors (shown in parentheses) are clustered at the country level. The excluded countries are China, France, Germany, Italy, Japan, Netherlands, South Korea, United States and the United Kingdom. *Significantly different from zero at 10 significance, ** 5 percent significance, *** 1 percent significance.

Table 7: Effects of Income Growth on Population Growth
(Using 1970 Net Export Shares and Restricting the Sample to the Post-1970 Period)

	Population Growth			
	(1)	(2)	(3)	(4)
	2SLS	2SLS	2SLS	2SLS
	All Countries	Excluding Large Oil Importers	All Countries	Excluding Large Oil Importers
GDP p.c. Growth [10-year Average]	0.081*** (0.019)	0.080*** (0.022)		
GDP p.c. Growth [5-year Average]			0.035*** (0.013)	0.039** (0.016)
Kleibergen Paap F-stat	18.87	16.47	16.94	14.96
Time FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	3959	3639	4039	3719

Note: The method of estimation is population-weighted two-stage least squares. In columns (1) and (2) the instrumental variable is the change in the international oil price between year t and t-10 multiplied with countries' 1970 GDP share of net oil exports. In columns (3) and (4) the instrumental variable is the change in the international oil price between year t and t-5 multiplied with countries' 1970 GDP share of net oil exports. The dependent variable is total population growth. Huber robust standard errors (shown in parentheses) are clustered at the country level. The excluded countries in columns (2) and (4) are China, France, Germany, Italy, Japan, Netherlands, South Korea, United States and the United Kingdom. The regressions are done for the 1971-2010 period. *Significantly different from zero at 10 significance, ** 5 percent significance, *** 1 percent significance.

Table 8: Effects of Income Growth on Population Growth
(Examination of Exclusion Restriction, 5-Year Non-Overlapping Panel)

	Population Growth			
	(1)	(2)	(3)	(4)
	2SLS	LS	2SLS	LS
GDP p.c. Growth, t	0.21** (0.10)			
Oil Shock, t	-0.39 (0.27)	0.65*** (0.24)		
GDP p.c. Growth, t-1			0.18** (0.09)	
Oil Shock, t-1			-0.25 (0.25)	0.43** (0.16)
Kleibergen Paap F-stat	35.61	.	35.61	.
		First Stage for GDP p.c. Growth		
Oil Shock, t	2.18*** (0.47)			
Trade Weighted World Income Growth, t	0.27*** (0.05)			
Oil Shock, t-1			2.18*** (0.47)	
Trade Weighted World Income Growth, t-1			0.27*** (0.05)	
Time FE	Yes	Yes	Yes	Yes
Country FE	No	No	No	No
Observations	738	946	738	946

Note: The method of estimation in columns (1) and (3) is population-weighted two-stage least squares; columns (2) and (4) population-weighted least squares. The dependent variable is total population growth in a 5-year non-overlapping panel. Huber robust standard errors (shown in parentheses) are clustered at the country level. *Significantly different from zero at 10 significance, ** 5 percent significance, *** 1 percent significance.

Table 9: Effects of Income Growth on Fertility and Mortality

	ΔFertility Rate	ΔInfant Mortality	ΔUnder Five Mortality
	(1)	(2)	(3)
		Panel A: 2SLS	
GDP p.c. Growth [10-year Average]	1.23** (0.47)	-14.32*** (4.31)	-27.06*** (8.20)
First-Stage F-stat	18.01	17.91	17.91
		First Stage GDP p.c. Growth	
Oil Price Shock [10-year Average]	0.36*** (0.08)	0.36*** (0.08)	0.36*** (0.08)
		Panel B: LS	
GDP p.c. Growth [10-year Average]	1.11* (0.60)	2.31 (7.40)	3.26 (12.30)
Time FE	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
Observations	4450	4401	4401

Note: The method of estimation in Panel A is population-weighted two-stage least squares; Panel B least squares. The dependent variable in column (1) is the change in the fertility rate; column (2) the change in the infant mortality rate; column (3) the change in the under-five-year mortality rate. Huber robust standard errors (shown in parentheses) are clustered at the country level. The instrumental variable in Panel A is the change in the international oil price between year t and t-10 multiplied with countries' average GDP share of net oil exports. *Significantly different from zero at 10 significance, ** 5 percent significance, *** 1 percent significance.

Table 10: Effects of Income Growth on Demographic Composition

	ΔShare of Population Age 0-14	ΔShare of Population Age 15-64	ΔShare of Population Age 65+	ΔChild Dependency Ratio	ΔOld Age Dependency Ratio	ΔFemale to Male Ratio
	(1)	(2)	(3)	(4)	(5)	(6)
			Panel A: 2SLS			
GDP p.c. Growth	0.05**	-0.05***	0.00	0.16***	0.01	-0.24
[10-year Average]	(0.02)	(0.01)	(0.01)	(0.05)	(0.01)	(0.29)
First-Stage F-stat	18.01	18.01	18.01	18.01	18.01	18.01
			First-Stage: GDP p.c. Growth			
Oil Price Shock	0.27***	0.27***	0.27***	0.27***	0.27***	0.27***
[10-year Average]	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
			Panel B: LS			
GDP p.c. Growth	-0.26	0.30*	-0.04	-0.69	-0.11	-2.17**
[10-year Average]	(0.20)	(0.17)	(0.06)	(0.44)	(0.09)	(0.91)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4452	4452	4452	4452	4452	4452

Note: The method of estimation in Panel A is population-weighted two-stage least squares; Panel B population-weighted least squares. The instrumental variable in Panel A is the change in the international oil price between year t and t-10 multiplied with countries' average GDP share of net oil exports. Huber robust standard errors (shown in parentheses) are clustered at the country level. The dependent variable in column (1) is the change in the share of population aged 0-14 years. In column (2) the dependent variable is the change in the share of population aged 15-64 years. In column (3) the dependent variable is the change in the share of population aged 65 years and above. In column (4) the dependent variable is the change in the child dependency ratio (defined as the ratio of people ages 0-14 to the working-age population). In column (5) the dependent variable is the change in the old age dependency ratio (defined as the ratio of people older than 64 to the working-age population). In column (6) the dependent variable is the change in the ratio of female population to male population. *Significantly different from zero at 10 significance, ** 5 percent significance, *** 1 percent significance.

Data Appendix Table 1. Description of Variables

Variable	Description	Source
Population Growth	Population growth (annual %) is the exponential rate of growth of midyear population from year t-1 to t, expressed as a percentage.	WDI (2011)
GDP p.c.	GDP per capita is gross domestic product in PPP terms divided by midyear population.	PWT (2011)
Oil Price Instrument	Change in the international oil price multiplied by countries' average GDP share of net exports of oil.	NBER-UN Comtrade; UNCTAD Commodity Price Statistics.
Trade Weighted World Income	Sum of the change in trading partners' GDP multiplied by average bilateral trade shares.	Acemoglu et al. (2008)
Fertility Rate	Total fertility rate represents the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children in accordance with current age-specific fertility rates.	WDI (2011)
Infant Mortality	Infant mortality rate is the number of infants dying before reaching one year of age, per 1,000 live births in a given year.	WDI (2011)
Under Five Mortality	Under-five mortality rate is the probability per 1,000 that a newborn baby will die before reaching age five, if subject to current age-specific mortality rates.	WDI (2011)

Data Appendix Table 2. List of Countries

Afghanistan	Croatia	Ireland	Norway
Albania	Cuba	Israel	Oman
Algeria	Cyprus	Italy	Pakistan
Angola	Czech Republic	Jamaica	Panama
Argentina	Denmark	Japan	Papua New Guinea
Armenia	Djibouti	Jordan	Paraguay
Australia	Dominican Republic	Kazakhstan	Peru
Austria	Ecuador	Kenya	Philippines
Azerbaijan	Egypt	Kiribati	Poland
Bahrain	El Salvador	Korea, Republic of	Portugal
Bangladesh	Equatorial Guinea	Kuwait	Qatar
Barbados	Estonia	Laos	Romania
Belarus	Finland	Madagascar	South Africa
Belize	France	Malawi	Spain
Benin	Gabon	Malaysia	Tajikistan
Bolivia	Gambia, The	Mali	Tanzania
Bosnia and Herzegovina	Georgia	Malta	Thailand
Brazil	Ghana	Mauritania	Togo
Bulgaria	Greece	Mauritius	Trinidad &Tobago
Burkina Faso	Guatemala	Mexico	Tunisia
Burundi	Guinea	Mongolia	Turkey
Cambodia	Guinea-Bissau	Morocco	Turkmenistan
Cameroon	Guyana	Mozambique	Uganda
Canada	Haiti	Nepal	Ukraine
Central African Republic	Honduras	Netherlands	United Arab Emirates
Chad	Hungary	New Zealand	United Kingdom
Chile	Iceland	Nicaragua	United States
China	India	Niger	Uruguay
Colombia	Indonesia	Nigeria	Uzbekistan
Congo, Dem. Rep.	Iran	Russia	Venezuela
Congo, Republic of	Iraq	Rwanda	Vietnam
Costa Rica	Latvia	Samoa	Yemen
Cote d`Ivoire	Lebanon	Senegal	Zambia
Ethiopia	Libya	Sierra Leone	Zimbabwe
Fiji	Lithuania	Slovenia	

Appendix Table 3. Descriptive Statistics of Population Variables

Variable	Mean	Stdv.	Variable	Mean	Stdv.
Population Growth	0.02	0.01	Share of Population Age 0-14	0.36	0.10
Urban Population Growth	0.03	0.02	Share of Population Age 15-64	0.58	0.07
Rural Population Growth	0.01	0.03	Share of Population Age 65+	0.06	0.04
Fertility Rate	4.11	1.99	Child Dependency Ratio	0.64	0.23
Infant Mortality Rate	57.01	44.62	Old Age Dependency Ratio	0.10	0.06
Under 5-Years Mortality Rate	87.24	78.41	Female to Male Ratio	1.89	1.35