The effect of education on future energy demand and carbon emissions

Brian O'Neill,[1] Regina Fuchs,[2] Leiwen Jiang,[1] Samir KC,[2] Shonali Pachauri[2]

[1] National Center for Atmospheric Research (NCAR), Boulder, CO, USA
[2] International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria

Draft manuscript submitted to the 2011 Annual Meeting of the
Population Association of America

March 30, 2011

Abstract

Changes in the demographic and socio-economic compositions of populations are relevant to the climate change issue because these characteristics can be important determinants both of the capacity to adapt to climate change impacts as well as of energy use and greenhouse gas emissions. However, the incorporation of major trends such as aging, urbanization, and changes in household size into projections of future energy use and emissions is rare. Here we build on our previous work in this area by exploring the implications of future changes in educational attainment for emissions from energy use. On the one hand, improvements in education can be expected to lead to faster fertility decline and slower population growth which, all else equal, would be expected to reduce emissions. On the other hand, education can also be expected to lead to faster economic growth, which would tend to increase emissions, and also to changes in consumption patterns. The net effect of education on future emissions is therefore ambiguous. We employ a multi-region, multi-sector computable general equilibrium model of the world economy, driven with a new set of country-specific projections of future educational composition, to test the net effect of education on energy use and emissions on four world regions: China, India, Latin America, and Rest of Asia + Middle East. We find that a scenario with a faster education transition, relative to a baseline scenario, leads to a net increase in emissions in these regions of about 10%. This net effect is a result of an increase in per capita emissions of 13-14% and an only partly compensating decline in population size of 2-5% in 2050. The emissions effect is driven primarily by increases in labor productivity and economic growth due to education; changes in consumption preferences play a relatively minor role.

Background

Explicit analysis of the effect of demographic change on future emissions has been limited. Early exploratory analyses considered only population size or total numbers of households (Bongaarts, 1992; Mackellar et al., 1995) and used simple multiplicative models that did not account for important relationships between population and economic and technological factors. Meanwhile, a large emissions scenario literature (Nakicenovic et al., 2001) has developed that informs a wide range of climate change analysis and related policy discussions. Scenarios typically span timescales of decades to a century and include emissions of multiple gases and aerosols from a range of sectors. While nearly all scenarios include assumptions about future population growth, incorporation of other demographic trends has been lacking.

Recently, we assessed the global implications for emissions of demographic change including aging, urbanization, and changes in household size by developing a set of economic growth, energy use, and emissions scenarios using an energy-economic growth model, the PET model (O'Neill et al., 2010). We found that compositional change can be an important determinant of energy demand, with urbanization particularly important in several developing country regions and aging important in several industrialized country regions.

Education is another important characteristic of populations that is expected to change substantially in the future, at least in developing country regions. Alternative projections of future composition across four education categories have been produced for 120 countries of the world, over the period 2000-2050 (K.C. et al., 2010). These scenarios show the potential for large differences in educational composition over the next 50 years, with potential implications for both demographic and economic outcomes.

Methods

We produce a set of seven global emissions scenarios that make alternative assumptions about the pace of improvement in education enrollment rates in developing country regions. Emissions scenarios are generated with the PET model, a nine-region dynamic computable general equilibrium model of the global economy with a basic economic structure that is representative of the state of the art in emissions scenario modeling (Dalton et al., 2008; O'Neill et al., 2010). To best capture the effects of future demographic change, we distinguish among a large number of household types by household age (defined as age of the householder), size (number of members), and urban/rural residence. In four of the model regions, we replace the urban/rural distinction with a distinction by the educational status of the householder. These regions – China, India, Latin America and Other Developing Countries (essentially the rest of Asia plus the Middle East) – are the ones expected to experience the largest changes in educational composition.[1] We draw on data from national household surveys covering 34 countries and representative of 61% of the global population to estimate key economic characteristics of our household types (Zigova et al., 2009). We use these estimates to calibrate parameters in the PET model that represent household demand for consumer goods and labor supply over time.

To test the effect of educational change, we modify recently developed education projections (KC et al., 2010) and, since the PET model uses households rather than individuals as the demographic unit of analysis, convert them to household projections using an extended headship rate method (Jiang and O'Neill, 2009). These projections are then be used as input to the PET

[1] An additional region, Sub-Saharan Africa, has the potential for large educational composition changes, but we lack household-level data for this region to support analysis of these effects in the PET model.

model to estimate the associated effects on emissions outcomes.

In the PET model, households can affect emissions either directly through their consumption patterns or indirectly through their effects on economic growth. The direct effect on emissions is represented by disaggregating household consumption for each household type into four categories of goods (energy, food, transport and other) so that shifts in the composition of the population by household type produces a shift in the aggregate mix of goods demanded. Because different goods have different energy intensities of production, these shifts can lead to changes in emissions rates. To represent indirect effects on emissions through economic growth, the PET model explicitly accounts for the effect of: (a) population growth rates on economic growth rates; (b) age structure changes on labor supply; (c) educational composition changes on labor productivity; and (d) anticipated demographic change (and its economic effects) on savings and consumption behavior.

In the following sections we describe the education projections, household projections, and household survey data used in the analysis, and then discuss PET model results and conclusions.

Education Projections

Our aim is to compare the implications of a relatively rapid increase in educational enrollment rates, and its associated shifts in the educational composition of the population, with a more modest rate of increase. For this purpose we adopt two of the IIASA educational scenarios for the period 2000-2050 presented in KC et al. (2010): Fast Track (FT) and Global Education Trend (GET). The Fast Track (FT) scenario is extremely ambitious; it assumes that all countries expand their school system at the fastest possible rate which would be comparable to best performers in the past such as Singapore and South Korea. The Global Education Trend (GET) scenario is more moderately optimistic and assumes that countries will follow the average path of school expansion that the countries immediately ahead of them (in terms of enrollment rates) have experienced. The projections disaggregate the population by four levels of education:

- E1: no education
- E2: some primary to some secondary education
- E3: completed secondary education to some tertiary education
- E4: completed first level of tertiary education

They are carried out separately for 123 countries representing 93% of the world population.

To produce a population-education projection, these enrollment rate scenarios must be combined with assumptions about trends in education-specific fertility, mortality and migration over time. How these demographic rates across education groups are specified can affect the differences in outcomes between the FT and GET scenarios. We therefore take three alternative approaches to specifying education-specific demographic rates.

In the first two approaches, we establish a baseline population-education scenario that is consistent with the national-level fertility from the UN medium population projection (UNPD, 2008). The education-specific fertility levels that will produce an aggregate TFR equal to the UN scenario depends on the education scenario assumed to be occurring in the baseline. For example, in order for a rapid education transition to be consistent with a given UN fertility pathway, fertility can fall relatively slowly *within* each education category, because the relatively large shift in population *across* education categories will also tend to lower the average national-level fertility. In contrast, a slower education transition would imply more within-category fertility decline, and a smaller across-category effect on national TFR.

In our first baseline (scenario 1-CER), we assume that the UN fertility projection for each country is consistent with a relatively conservative education scenario, the Constant Enrollment Rate (CER) scenario (KC et al., 2010). The Constant Enrollment Rate (CER) scenario assumes that countries keep the proportions of cohorts attending school constant; in other words, there is no progress in schooling except for keeping pace with population growth. Differentials in fertility, mortality, and migration across education groups are introduced in the multistate population projection model such that the outcome of the projection in terms of age-sex distribution is identical to that of the UN Medium Variant projection. The projection produces the age-sex-education distribution for the period 2000-2050, and also the age-sex-education-specific survival ratios and migration number, and the age-education-specific fertility associated with our "CER-UN" baseline scenario.

We then produce two variants of this baseline assuming the CER-UN education-specific fertility rates and enrollment rates that follow either the FT scenario (scenario 1-FT) or the GET scenario (scenario 1-GET).

In our second baseline (scenario 2-GET), we assume that the TFR under the GET enrollment rate scenario is consistent with the UN fertility projection, and then produce a variant (scenario 2-FT) using the education specific fertility rates implied by this GET-UN baseline in combination with the more optimistic FT education scenario.

Finally, we develop a third baseline that does not match the level of TFR assumed by the UN medium scenario, but rather assumes the education-specific fertility levels will decline at the same rate as the UN national-level fertility reduction. In other words, the absolute difference in education-specific TFR is kept constant throughout 2000-2050. These fertility assumptions are combined with the GET enrollment rate scenario to generate our third baseline, scenario 3-GET. We then produce a variant (scenario 3-FT) with the same education-specific fertility assumptions, but with the FT enrollment rate scenario. In both of these cases the national-average fertility is lower than the UN assumptions due to the assumption that the decline in the education specific TFR is not constrained to result in same overall TFR as that of UN, but rather to follow the same trend, leading to a faster decline in all education-specific TFRs.

Table 1 summarizes the seven population-education scenarios. Our primary comparisons of interest in the PET model application are between the FT and GET scenarios in each of the three baseline cases. Each of these pairs compares the FT to the GET scenarios under different assumptions about the demographic baseline. Within each of the three groups of scenarios, the more optimistic the enrollment rate assumptions (FT > GET > CER), the better educated the population and the lower the fertility (and therefore the smaller the population size). Figure 1 shows TFR results for all seven scenarios for India as an illustration. Note that fertility paths are identical (and equal to the UN path) for scenarios 1-CER and 2-GET, and that fertility is lower than the UN assumptions for scenarios 1-GET and 1-FT, and for 2-FT, because they assume faster education transitions than in their respective (UN-based) baselines. The TFR path for scenario 3-GET, which assumes the GET education scenario, is similar to scenario 1-FT, essentially by coincidence. The faster education transition in 1-FT is offset by slower rate of within-education-category fertility decline.

Scenario	Education	TFR	Education-specific TFR
1-CER	CER	UN	CER-UN
1-GET	GET	<UN	CER-UN
1-FT	FT	<UN	CER-UN
2-GET	GET	UN	GET-UN
2-FT	FT	<UN	GET-UN
3-GET	GET	<UN	UN-rate
3-FT	FT	<UN	UN-rate

Table 1. Seven education-demographic scenarios for the period 2000-2050 used in the PET model.

Figure 2 shows the population size outcomes of the seven scenarios for India and for our four regions combined. In all cases, population grows more slowly in the faster education scenarios, as expected. In general however the differences in population size between the GET and FT scenarios by 2050 are relatively small, although it is slightly larger between 1-GET and 1-FT given the larger difference in fertility between these two scenarios (see Figure 1). Figure 3 shows the change in educational composition of the population for the GET vs the FT scenarios in 2000 and 2050. Shifts across education categories are more pronounced in the FT scenarios, and the pattern of shifts is consistent across all three pairs of GET and FT scenarios. For example, the share of the population with tertiary education grows from less than 5% today to about 15% in the GET scenarios, but to nearly 30% in the FT scenario. In general, by 2050 about 40% of people, mostly children, have primary or lower education in all scenarios. Under FT scenarios, there will be 5-8% more of these people shifting from no school to primary education.

Household Projections

Since the PET model uses households rather than individuals as the demographic unit of analysis, we convert the education projection conducted at individual level to household projection, using an extended headship rate household projection model. For a detailed description of the extended headship rate method, see Jiang and O'Neill (2004, 2009). In the current projection, the extended headship rate model uses headship rates differentiated by household size, age, and education.

The age-size-education specific household headship rate is calculated from the number of household heads by age, household size, and education over the population of corresponding age and education categories, using data from national censuses or household surveys. The China 2000 Census 1% sample of long form micro-level data is used to calculate headship rate for China. The headship rate for India is derived from the India 2005 Human Development Survey. The Indonesia National Socioeconomic Survey (SUSENAS) data is used to derive headship rates for the Other Developing Country region. The headship rates for Latin America are derived from national survey data of Brazil and Mexico, weighted by their populations by education category. The Brazil and Mexico surveys used in the analysis are respectively Pesquisa de Orcamentos Familiares 2002-2003 and Encuesta Nacional de Ingresos y gastos de hogares (ENIGH) 2005.

Figure 4 demonstrates a general pattern of headship rate by age, size and education, using China as an example. More educated people are more likely to live alone when younger, but less likely to live alone when they become elderly. More educated Chinese people are also more likely to head middle sized (2-4) households. People with primary and secondary education are most likely to head large (5+) households, while the most educated young and middle-aged population are least likely to head a household larger than size 4.

We assume the age-size-education specific headship rates of all regions remain constant over the period 2000-2050, and multiply them with the projected population by age and education from the education projection, in order to derive the number of households by age, size and education, as well as the number of people living in the households of different categories. To ensure consistency of the population size in the education projection and the population size implied by the household projection, we make an adjustment to all headship rates by applying a ratio to scale up/down the number of all types of households, so that the population sizes from the two projections are the same.

The household projection results show that future living arrangements will differ significantly under different education scenarios, given the differences in education transition rates and their impacts on fertility. As an example, Figure 5 shows the projected Indian population living in households by size, age and education level of the householders. In this figure, we focus on changes between year 2000 and 2050, under the second pair of FT and GET scenarios. It is evident that the number of people living in households with a head of no education will decline under both the 2-GET and 2-FT scenarios. The decline will be more profound for young households, particularly under the 2-FT education scenarios. While the population living in households with head of primary education under scenario 2-FT will increase in the middle aged groups, it will be quite similar under scenario 2-GET, except that this type of household will be substantially aged due to fertility decline and population aging. The number of people living in households with a head of secondary education will increase substantially under both 2-GET and 2-FT. The population in households with a head of tertiary education will also increase significantly, particularly under scenario 2-FT, given the assumption of rapid education and fertility transition.

Household data

The processing and use of household survey data in the PET model are fully described in Zigova et al. (2009), a technical report that is available online, and therefore we only provide here a brief general sketch of the data and analysis. In general, we use household survey data both to calibrate the PET model to current conditions, and, in combination with the household projections, to specify changes over time in some economic characteristics of households.

Calibrating the household side of the PET model requires two types of data that we estimate from nationally representative household surveys: (i) shares of total household expenditures on the consumption goods that we use in the model (energy, food, transport, and other), and (ii) labor income. These quantities are estimated for a large number of household types defined by age of the householder, size of the household (number of members), urban/rural residence, and the education status of the householder. Household expenditure shares are used in the PET model to calibrate the consumption preference parameters in the household utility function in the base year and also, to calculate changes in these parameters over time as the composition of the population changes. We use labor income as a measure of labor supply by household type and calculate changes in total labor supply over time as population composition changes, which is an exogenous input to the model.

The current version of the PET model employs 9 world regions: China, European Union (EU), India (IND), Latin America and Caribbean (LAC, Transition Economies (TC), Sub-Saharan Africa (SSA), Other Developing Countries (ODCs), Other Industrialized Countries (OICs) and the USA. For each of the nine PET model regions, we identified one or more countries that well-represent the region in terms of current GDP, population size, and CO2 emission levels. Globally, the survey data are representative of over 60% of the population, 65% of emissions, and 75% of GDP. For most of the regions, we were able to cover more than one-half of the region according to at least one of these measures. For sub-Saharan Africa (SSA), we had insufficient data to represent the region, and in the PET model we do not include any demographic heterogeneity for this region

Labor income and expenditure shares in the EU, TC, OIC, and USA regions are disaggregated by household age, size, and urban/rural residence. In the China, India, LAC, and ODC regions we disaggregate by education of the householder rather than by urban/rural residence. Education of the household head is classified according to the categorization used in the education projections, described above.

The current version of the PET model requires data from household surveys on consumption shares of four main goods: Energy, Food, Transport and Other goods and services. Energy comprises all direct energy consumption excluding transport fuels (in transport). Income is disaggregated into labor and asset income and transfers.

As can be seen in Figure 6, the patterns of earnings vary quite significantly across education and age of the householder in both Brazil and India. In general, middle-aged and the most educated households earn the highest labor income per capita. Asset income is also higher among the better educated, but is highest for those in the oldest age groups. Given the differences in labor income in the data, shifts in the population across these households over time will produce changes in labor supply (in units of effective labor, accounting for productivity) in the PET model.

In addition, budget shares for categories of consumption also vary across household types and regions. Figure 7 displays shares of expenditures on food, energy, transport and other as a percent of the total expenditures for households differing by education level in Brazil, Indonesia and India. Given these differences, shifts in the population across household types over time will produces changes in consumption preference parameters in the PET model.

Results

Using the seven population-education-household projections, as well as the household survey data differentiating economic characteristics of households across types, we produced seven global energy and emissions scenarios with the PET model. These scenarios take as a starting point a long-term PET model scenario patterned after the well-known “B2” scenario developed by the Intergovernmental Panel on Climate Change (IPCC; Nakicenovic et al., 2001). The B2 scenario describes a relatively moderate future development path (relative to other scenarios in the literature) in terms of economic growth, energy use, and CO2 emissions, and is a baseline scenario in the sense that it does not include any climate policies. Details of our implementation of the B2 scenario in the PET model can be found in O’Neill et al. (2010). We adjust rates of labor productivity growth, and growth in the productivity of other inputs to production (including energy), to reproduce the growth of GDP, primary energy use, and carbon emissions from fossil fuel combustion in large world regions found in recent implementations of the B2 scenario in other energy and emissions models (Riahi et al., 2007).

The seven scenarios produced here modify our B2 baseline scenario by accounting for the (varying) effects of education on labor productivity and consumption preferences in four world regions. Figure 8 shows results for total carbon emissions. In all scenarios, there is strong growth in emissions of a factor of three or more by mid-century, in India as well as in the four-region area as a whole. In all cases, an increase in the rate of education transition, relative to one of our three baseline scenarios, leads to an increase in emissions, despite the fact that population size is lower in scenarios with more education. Note that, as is true for effects on population size, effects on emissions do not become apparent until about 2025, and scenarios diverge after that. A delayed effect on emissions is to be expected not only because of a delayed effect on population size, but also because any effects on labor productivity or consumption preferences will require shifts in the education composition of the working age population, which takes a few decades to occur.

Figure 9 focuses on the difference between the FT and GET education scenarios, for each of our three approaches to defining a baseline population scenario. Results depend somewhat on the approach to defining the baseline, but in all cases the upward effect on per capita emissions outweighs the downward effect on population size. Aggregated over the four regions as a whole, moving from the GET to the FT scenario increases per capita emissions by 13-14% in 2050, while it decreases population size by 2-5%, leading to a 9-11% increase in total emissions.

The effects on emissions are predominantly driven by the effect of education on labor productivity, and therefore on economic growth. Figure 10 shows the difference between the FT and GET scenarios in terms of GDP in 2050. The figure is quite similar to Figure 9, showing effects on emissions. For example in India, a shift from the GET to the FT scenario increases GDP per capita by about 13% in 2050, and the increase in emissions per capita is nearly identical. This indicates that growth effects explain the emissions increase, with little role of education-induces shifts in consumption patterns across goods. For our four regions as a whole, there is a small consumption effect: the shift from GET to FT increases per capita GDP by about 1% more than the increase in emissions per capita, so there is a small compensating effect in consumption patterns, which shift toward less carbon-intensive goods.

To examine the source of the growth effect, Figure 11 shows labor productivity per capita over time in India according to all seven scenarios. In these figures, productivity increases due both to changes in demographic (and educational) composition, as well as due to exogenous productivity growth assumptions that apply to all demographic groups. Overall, productivity increases by a factor of about eight by 2050. However, the differences across the scenario are due only to differences in demographic composition driven by the change in education scenarios. The seven scenarios therefore produce three distinct paths of per capita labor supply: one each for the CER, GET, and FT scenarios. In 2050, per capita labor supply increases by about 15% when moving from the CER scenario to the GET scenario, and by about another 15% when moving from the GET to the FT scenario. It is these labor supply increases that increase economic growth rates and emissions.

Discussion

Our results indicate that a very aggressive, optimistic scenario for increasing enrollment rates would lead to significant shifts toward more highly educated populations in major world regions. These improvements in education would likely have multiple benefits for well being. At the same time, they could have effects on environmental impact, including on the carbon emissions that drive climate change. However the direction and magnitude of these effects has been unclear. Education can lower fertility and slow population growth, but it can also increase economic growth which, all else equal, would tend to increase emissions.

We find that the effect of a shift toward more educated populations tend to increase emissions. While there is an offsetting effect due to slower population growth, that effect is not large enough to reverse an upward effect on economic growth and emissions. However, on balance the increase in emissions is relatively small, about 10% by 2050.

There are several caveats to our conclusions. First, there is uncertainty on the effect of education on economic growth, and we have so far only investigated a single set of model parameter values that lead to this effect. A more thorough assessment of uncertainty, and comparison of the education-growth relationship we find in the model to estimates from the empirical growth literature, is a high priority. Second, we have not accounted for the potential effect of changing the education composition of the labor force on the structure of the economy. A more skilled labor force could be expected to lead to a shift toward less energy-intensive sectors, a possibility we plan to investigate in future work. Third, some of the potential effects of education on consumption patterns may be masked by the relatively high degree of aggregation into four categories of goods. Shifts in consumption within these categories, which could have significant effects, are not included in this analysis. Finally, we have limited our analysis to the first half of the century. However, the effects of lower fertility driven by increasing education would have longer-term, and compounding, effects on population growth. It could well be that fertility effects would be more significant in the long term, leading to a net decrease (rather than increase) in emissions due to increases in education.

Our results are also not intended to support any particular policy position. For example, the fact that we find that more education leads to higher emissions does not imply that education should be limited in order to reduce emissions. It is worthwhile to understand the emissions implications of increasing education, and of increased economic growth, in order to better anticipate possible future emissions pathways and to improve understanding of emissions drivers. Education is likely to have benefits for adapting to climate change impacts, as well as many benefits unrelated to climate change or to environmental impact in general. Our result that consequences for carbon emissions appear to be relatively modest could be taken to imply that this potential environmental cost is small.

References

Bongaarts, J (1992) Population growth and global warming. Population and Development Review 18: 299–319.

Dalton, M, O'Neill, BC, Prskawetz, A, Jiang, L, Pitkin, J (2008) Population aging and future carbon emissions in the United States Energy Economics 30: 642-675.

Desai, Sonalde, Reeve Vanneman, and National Council of Applied Economic Research, New Delhi. India Human Development Survey (IHDS), 2005 [Computer file]. ICPSR22626-v4. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 2009-02-10. doi:10.3886/ICPSR22626.

Jiang, L, O'Neill, BC (2006)

Jiang, L, O'Neill, BC (2009) *Household Projections for Rural and Urban Areas of Major Regions of the World* (International Institute for Applied Systems Analysis (IIASA), Interim Report IR-09-026).

MacKeller, FL, Lutz, W, Prinz, C, Goujon, A (1995) Population, households, and CO2 emissions. Population and Development Review 21: 849-865.

Nakicenovic, N., et al. (2001) *Special Report on Emissions Scenarios* (Intergovernmental Panel on Climate Change, Geneva).

O'Neill, BC, Dalton, MD, Fuchs, R, Jiang, L, Pachauri, S, Zigova, K. Global demographic trends and future carbon emissions. Proceedings of the National Academy of Sciences – USA, 107 (41), 17521-17526.

Riahi K, Grübler A, Nakicenovic N (2007) Scenarios of long-term socio-economic and environmental development under climate stabilization. Technol Forecast Soc Change 74:887–935.

Samir KC, Bilal Barakat, Anne Goujon, Vegard Skirbekk, Warren Sanderson, Wolfgang Lutz (2010). Projection of populations by level of educational attainment, age, and sex for 120 countries for 2005-2050. *Demographic Research* 22(15): 383-472.

United Nations Population Division, 2008. World Population Prospects 2008.

Zigova, K, Fuchs, R, Jiang, L, O'Neill, BC, Pachauri, S (2009) Household survey data used in calibrating the Population-Environment-Technology model. (International Institute for Applied Systems Analysis (IIASA), Interim Report IR-09-046).

Figure 1. Total fertility rates in India during 2000-2050 under different demographic and education scenarios. Scenarios 1 and 4 are identical, and both reproduce the assumptions from the UN medium scenario (UN, 2008).

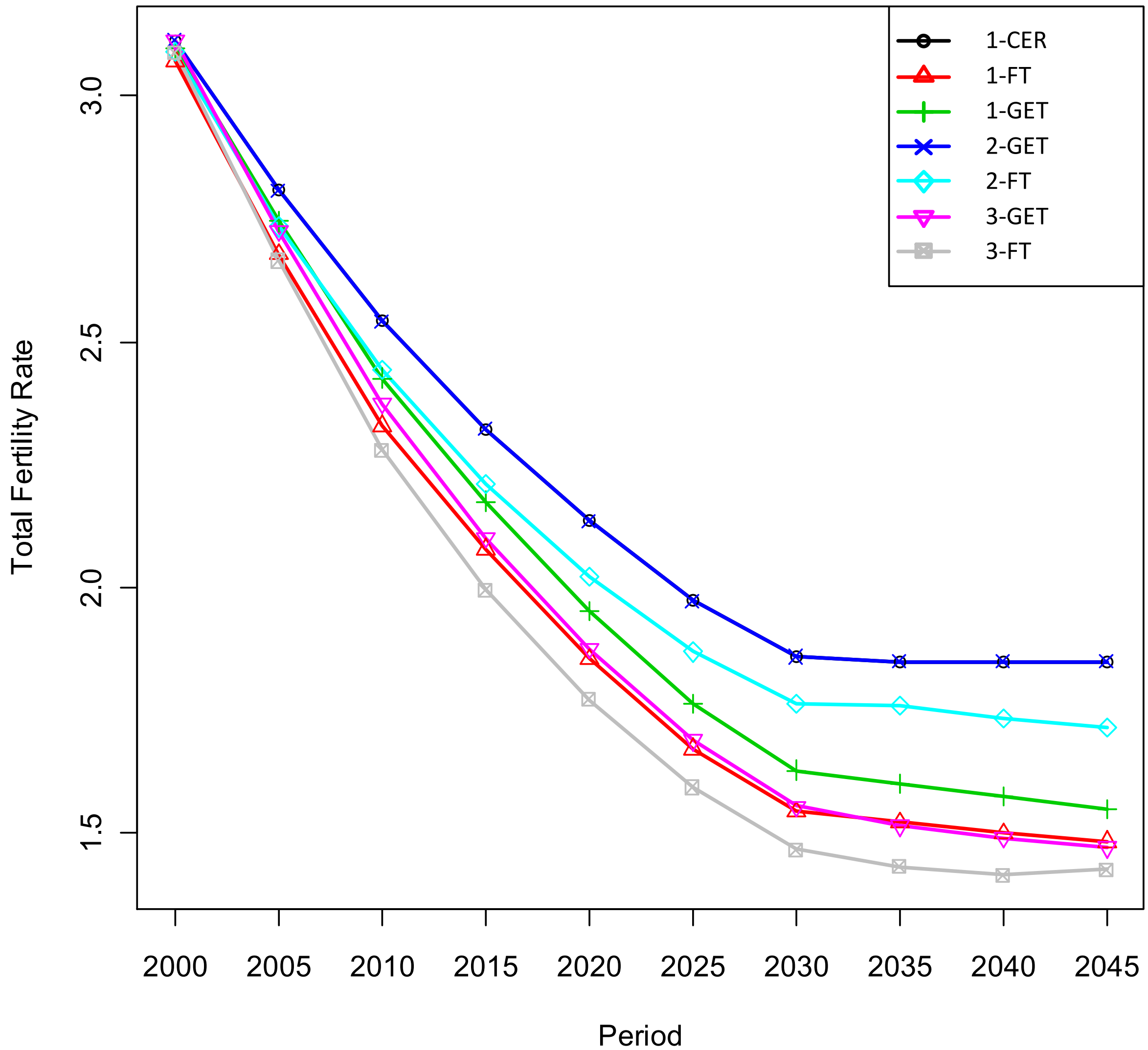
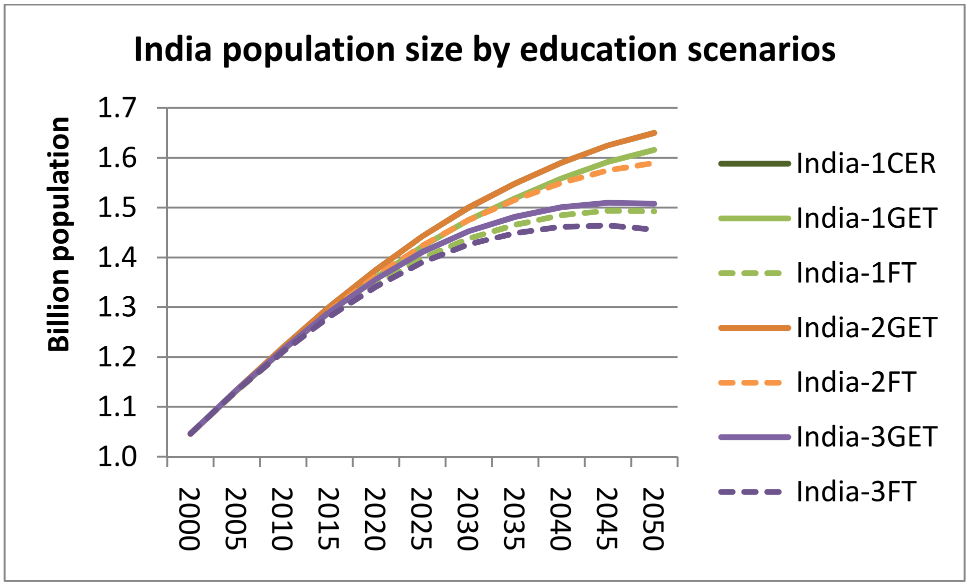


Figure 2: Population size in India (a) and in four regions combined (India+China+ODC+LAC) (b), for seven population-education scenarios.

(a)



(b)

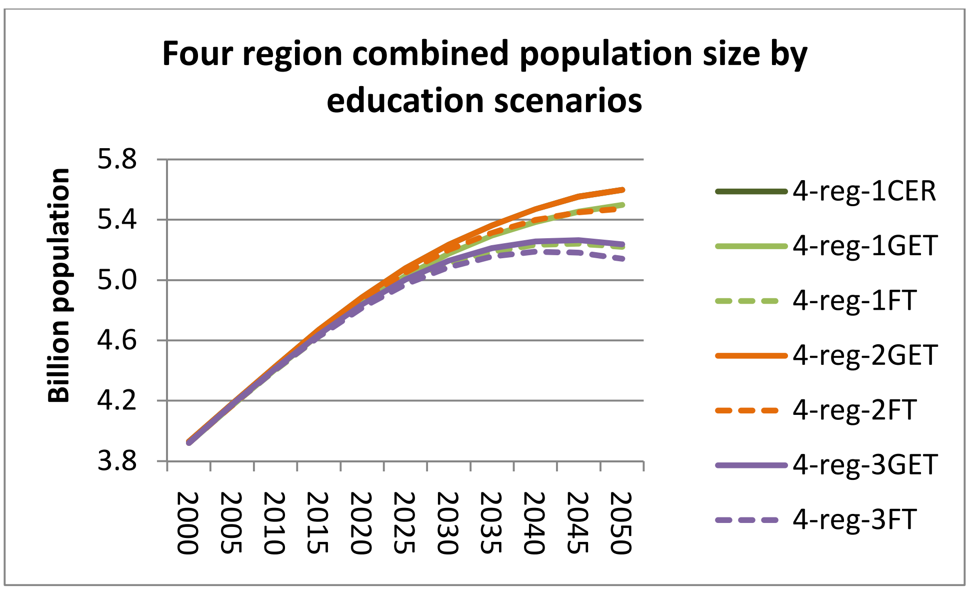
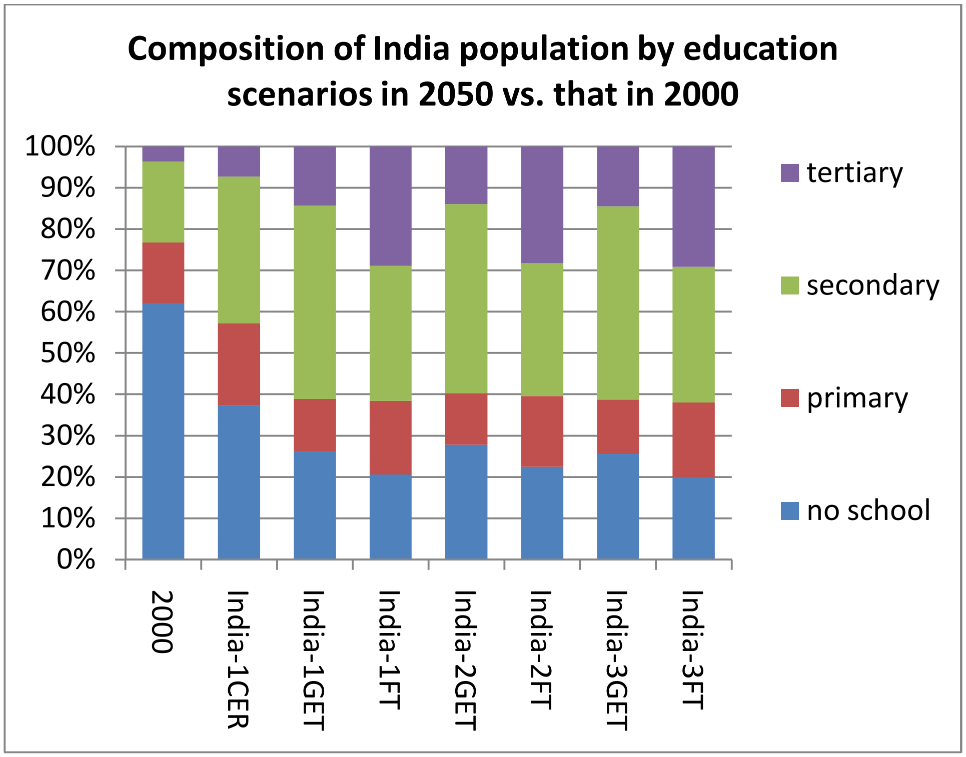


Figure 3: Proportion of the population across four education categories in 2000 and in 2050, for seven population-education scenarios, in India (a) and in four regions combined (India+China+ODC+LAC) (b).



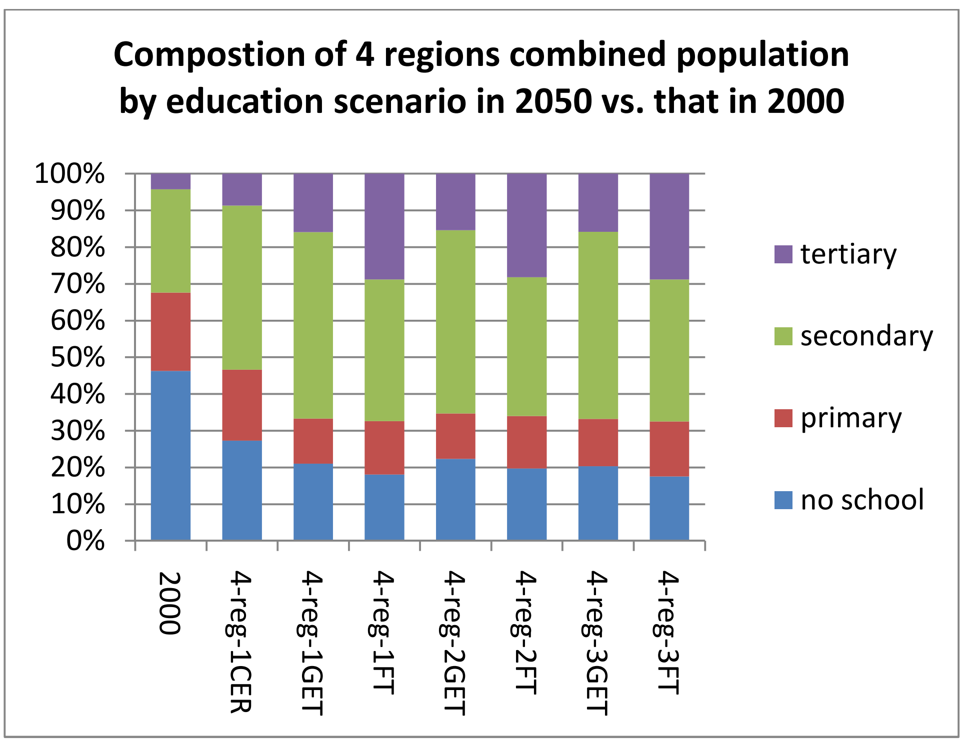


Figure 4 Age-size-education specific headship rate for China. The vertical axis shows the proportion of people by age and education heading a household by size. The horizontal axis display the age categories (1: -15; 2: 20-24; 3: 25-29; 4: 30-34; 5:35-39; …; 16: 85+)

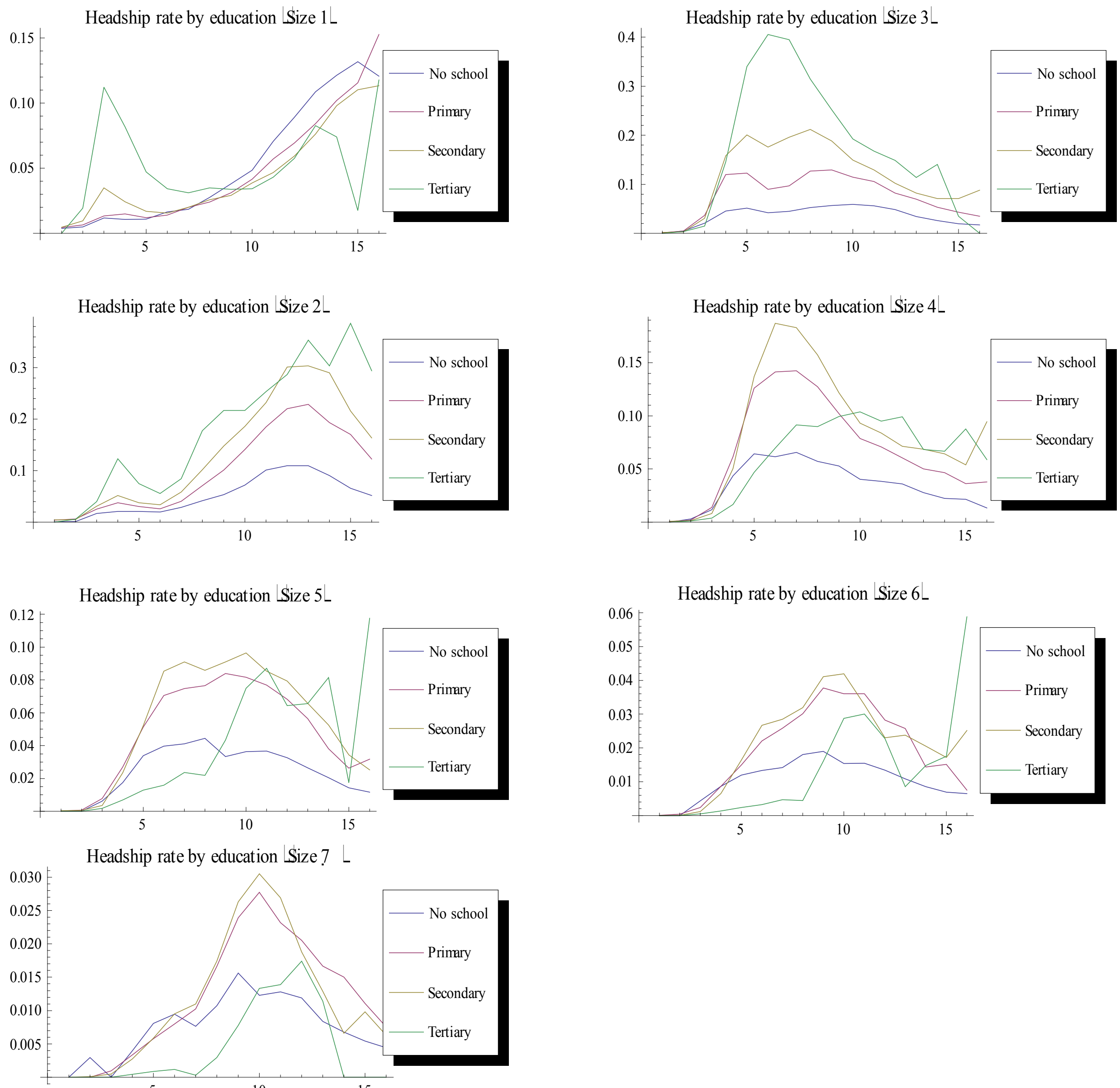


Figure 5 Indian population living in households by age and education of the head, for two education scenarios.

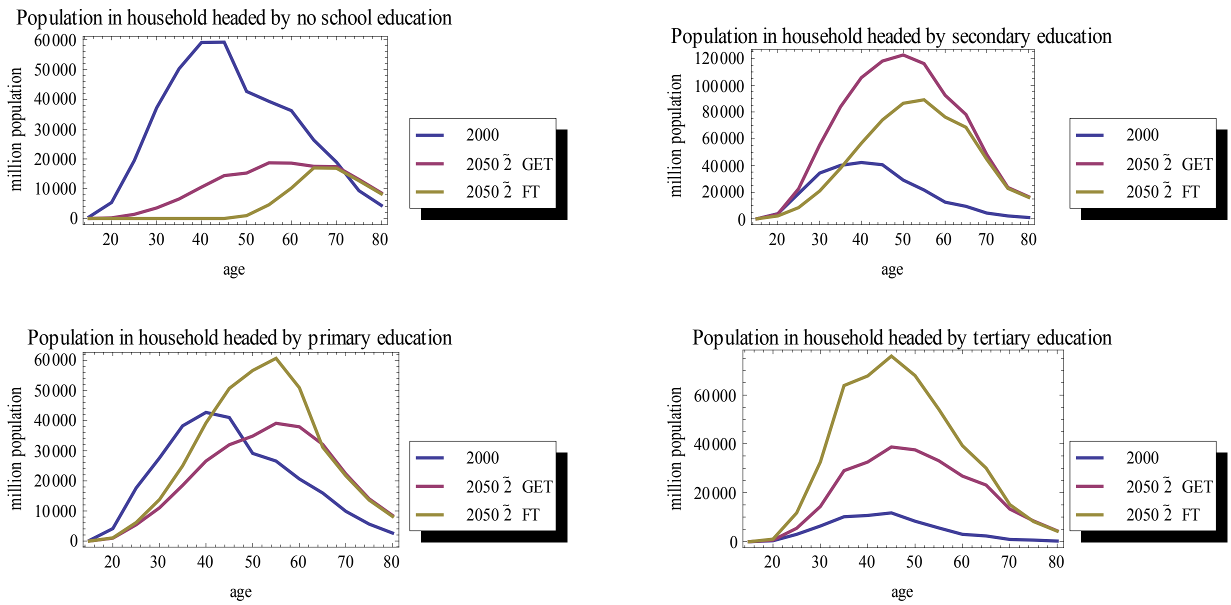
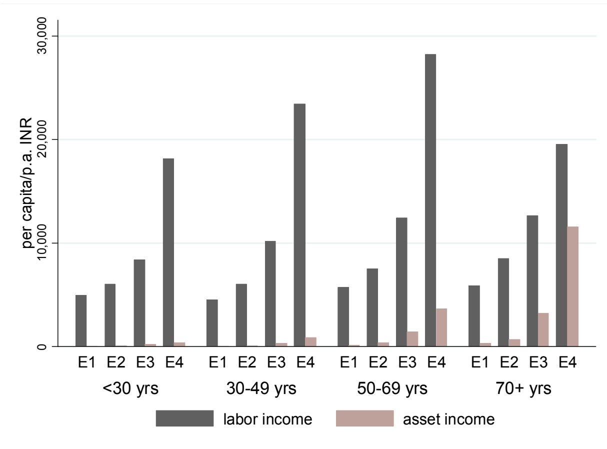


Figure 6: Pattern of labor and asset income in households distinguished by age and education of the householder in Brazil and India.



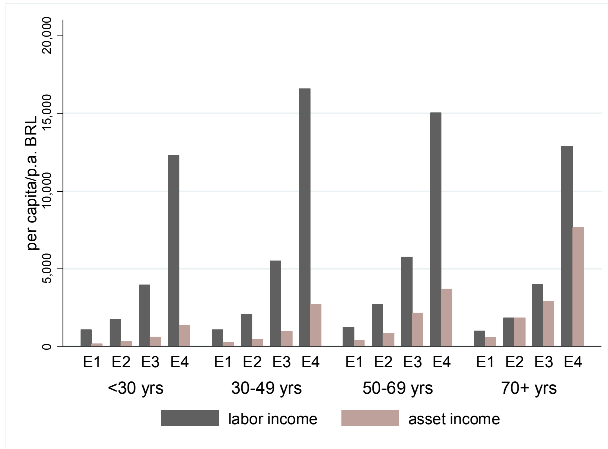


Figure 7: Expenditure shares on consumption goods as a percent of the total expenditures across households distinguished by education in Brazil, Indonesia and India.

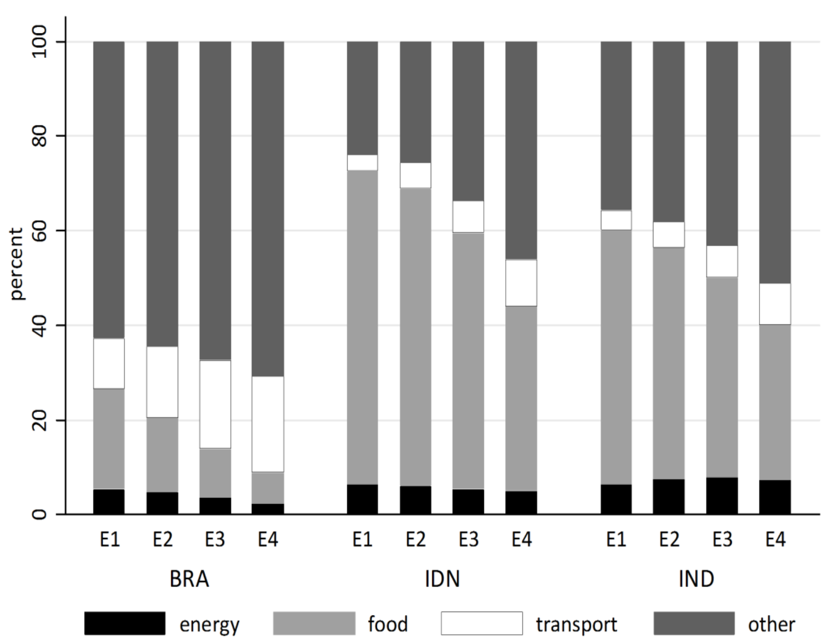
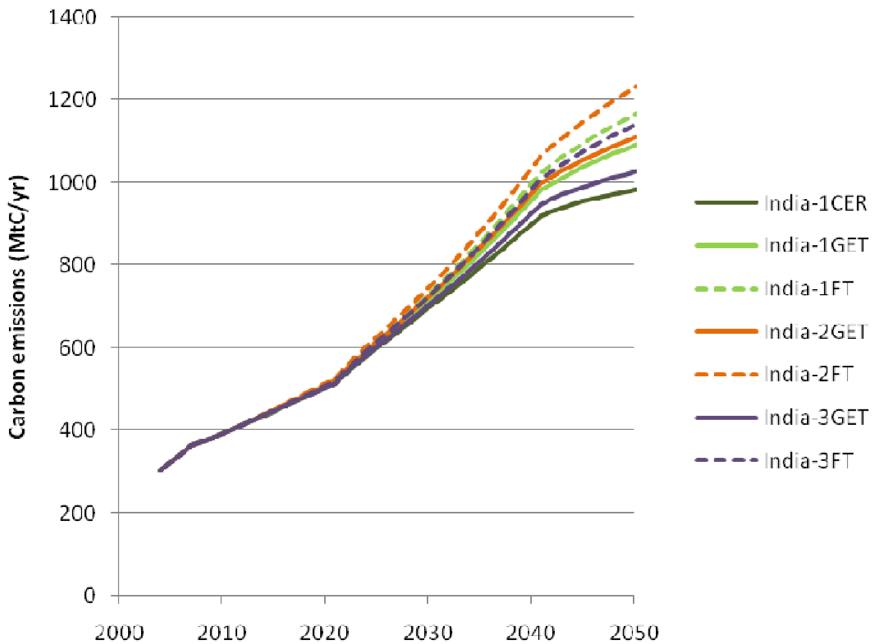


Figure 8: Total carbon emissions in India (a) and in the four regions combined (India+China+ODC+LAC) (b) for all seven education scenarios.

(a)



(b)

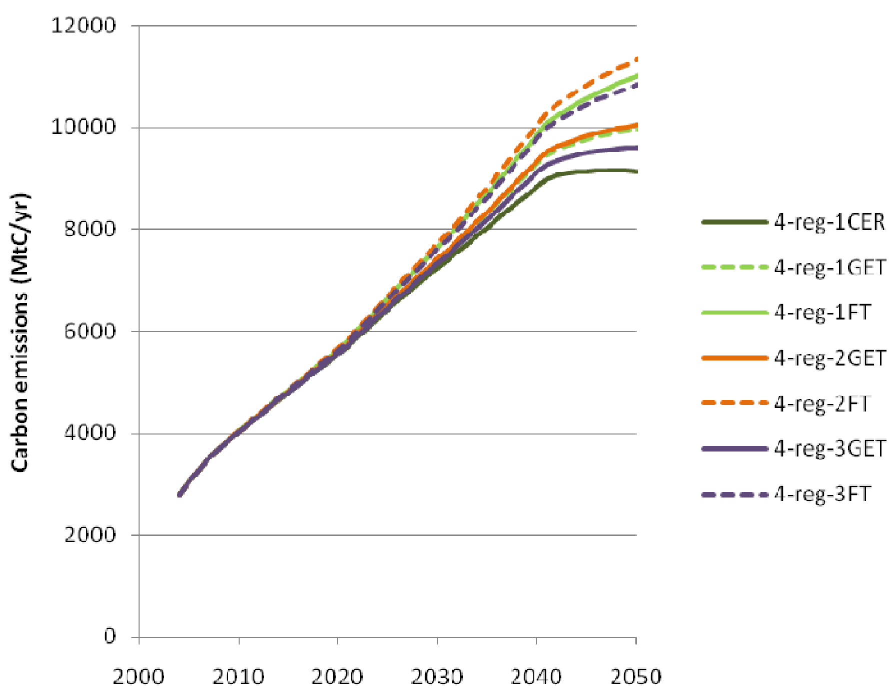
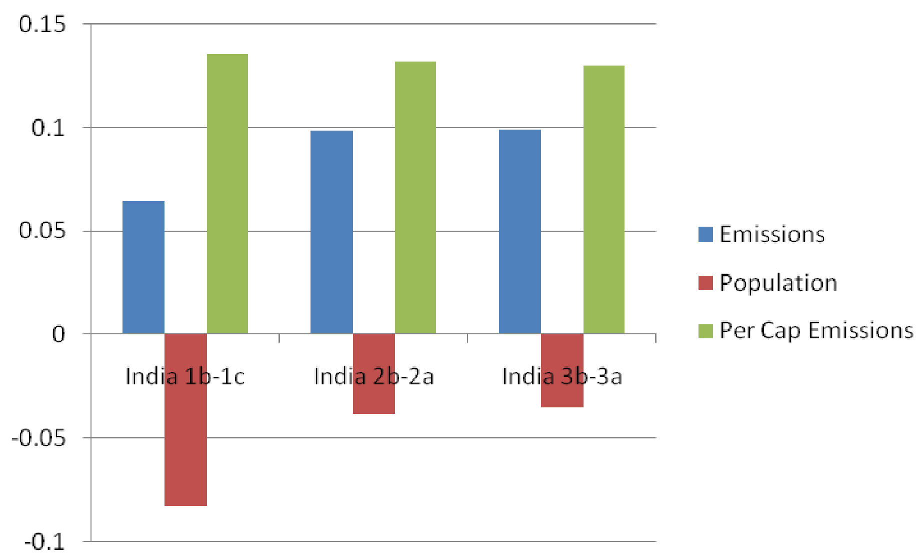


Figure 9: Proportional differences in 2050 in carbon emissions, population, and per capita emissions in India (a) and in the four regions combined (India+China+ODC+LAC) (b).

(a)



(b)

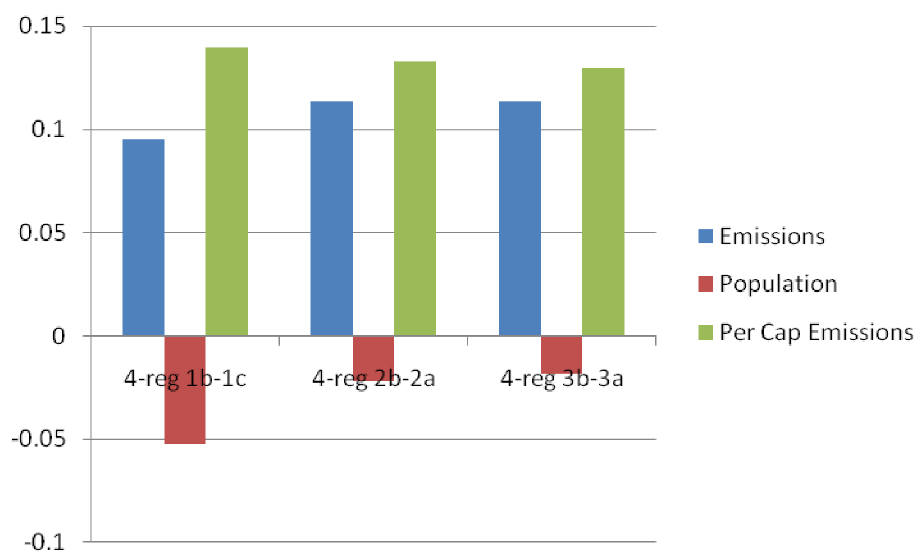
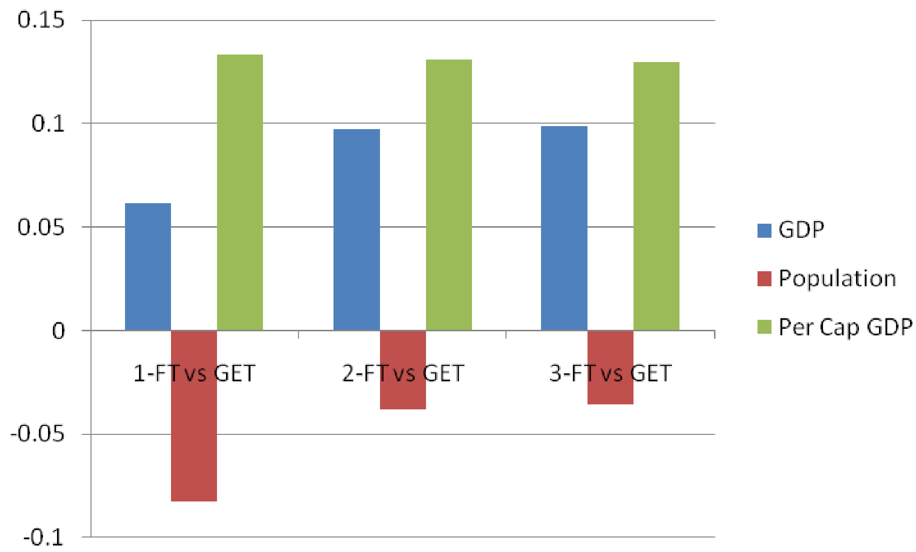


Figure 10: Proportional differences in 2050 in GDP, population, and per capita GDP in India (a) and in the four regions combined (India+China+ODC+LAC) (b).

(a)



(b)

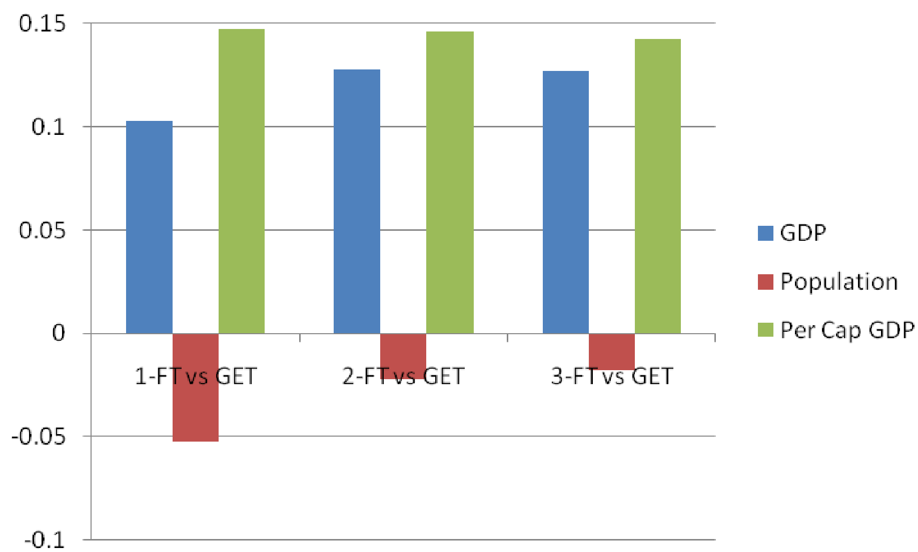


Figure 11: Per capita labor supply in India, all education scenarios. Scenarios 1-GET and 2-GET lie directly beneath the curve for 3-GET, and 1-GT and 2-FT lie directly beneath 3-FT.